HMCTS First Avenue House – Replacement of Chillers & BMS

Mechanical Vibration Analysis – New Chiller Plant

SWIFTLINE
ENGINEERING LIMITED

Contents

1. Introduction.

Swiftline Engineering have been employed to carry out the Mechanical Vibration analysis and equipment selections for the New Chillers and associated pumps.

The Vibration analysis identifies the existing Chilled water plant vibration equipment and provides the vibration control solutions for the new plant including calculations and selections.

2.Existing Chiller & Pumps Vibration isolation

Existing CHW Pumps - Baseplate

The existing secondary chilled water pumps located in the 8th floor Plantroom consist of 2No. Holden & Brooke 100 - 315 Starflex (Belt & Pulley) serving the courts and 2No. Holden & Brooke 80 - 315 Starflex (Belt & Pulley) serving the offices. Vibration isolation is provided via manufactures Baseplate and rubber anti - vibration mountings.

Existing Chiller – Anti -vibration mounts

The 3No. existing trane chillers model RTAA 322 mounted on the roof are supplied with manufactures spring type anti - vibration mountings.

3. New Chilled Water - AVM's, Inertia Bases & Flexible Connections

Inertia Base Explanation

The important thing about an Inertia Base is that to be efficient there has to be a Minimum Inertia Ratio of 1.5:1and the angle between the centre of the securing bolt on the top of each Anti-Vibration Mount and the Centre of Gravity of the pump is no more than 60 Degrees.

We specifically custom Design each Inertia Base for the Pump that is going to sit on it to ensure that it is the correct minimum size and has an Inertia Ratio of at least 1.5:1.

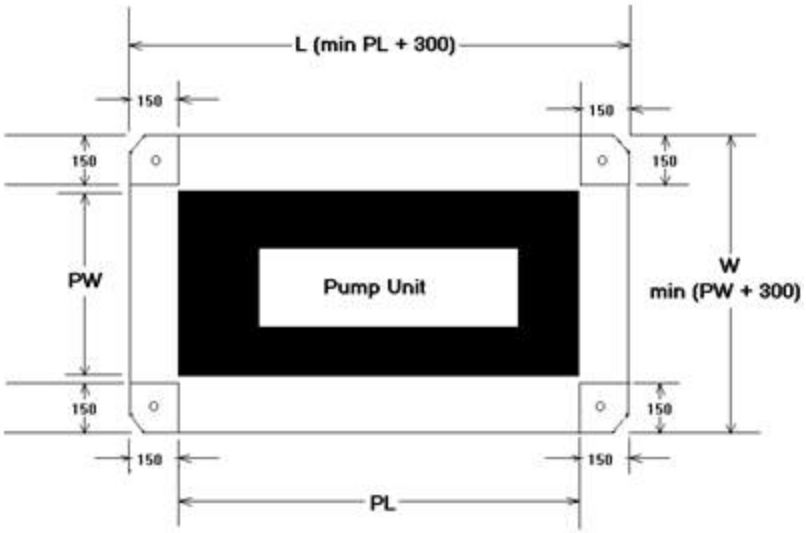
Our Inertia Bases have the AV Mounts situated inboard so there are no protruding dangers and the sizes we quote are the actual footprint of each Inertia Base.

Also we only offer 2 no depths of Inertia Base as standard, 150mm or 300mm. As the weight of the base is dictated by the volume of concrete in it this can affect the area.

There will be potential differences for all of the above reasons.

When calculating the size of each inertia base our starting point is the maximum footprint of the specific Pump i.e. maximum length and width dimensions. Because the AV Mounts are inset we add 300mm to each dimension to ensure that all of the pump is within the centres of the AV Mounts as below.

Inertia Base Explanation

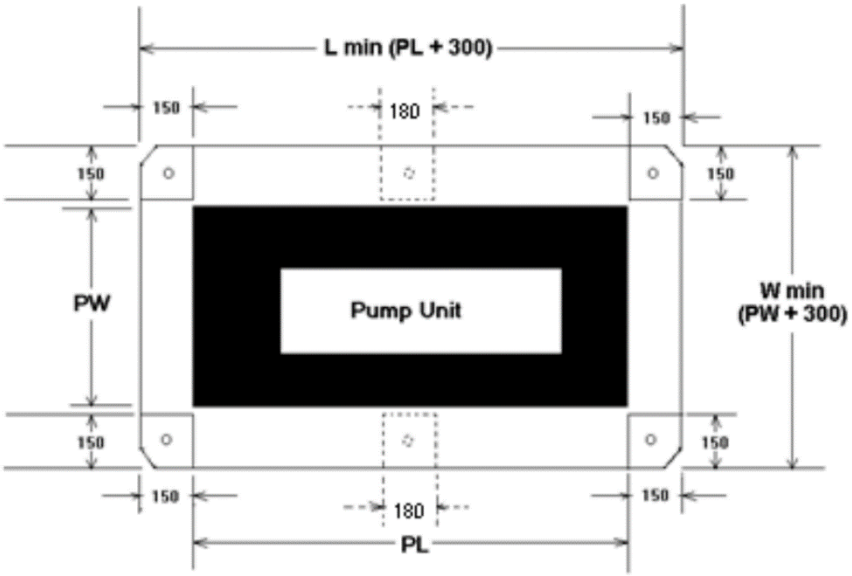


From here we would select either 150mm or 300mm depth depending on the weight of the pump and then if necessary, increase either/or, or both the length and width until s minimum Inertia Ratio of 1.5:1 is achieved.

Hopefully this will help understand, the basic rule of thumb is that the Inertia Ratio must be a minimum of 1.5:1 anything over this is fine.

Contract Reference:	First Avenue House, Holborn
Pump Manufacturer:	Wilo
Pump Reference:	Secondary Courts CHW

Inertia Base Size and Load Calculator



Number of Pumps	1
Pump Model Number	IL-E 80/200-22/2

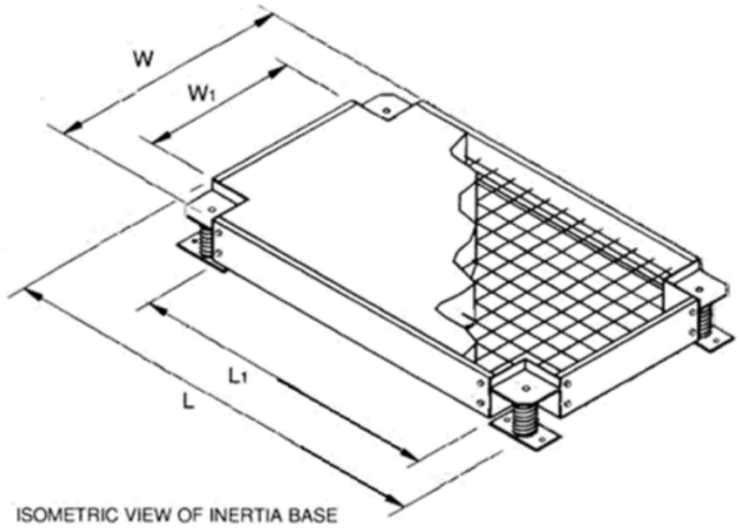
Pump Size in mm	
Length (PL)	**Width (PW)**
713mm	400mm

Pump Weight in Kgs	258

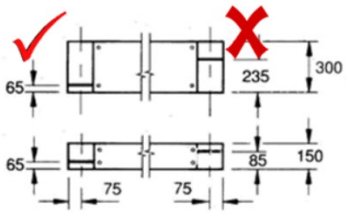
Inertia Base	
Part Number	IB/FPF-4 : 1050 x 700 x 330

Length (L) mm	**Width (W) mm**	**Depth mm**	**Weight Kgs**	**Inertia Ratio**	**Plan Perimeter**
1050	700	300	529.2	2.1:1	3500

Anti-Vibration Mount	
Part Number	OS/O – 500
Qty	4
Shipping Weight Kgs	45.02



ISOMETRIC VIEW OF INERTIA BASE



END VIEW - Showing typical thicknesses and bracket heights

Inertia Base Specification	
Pump Model Number:	IL-E 80/200-22/2
Dimensions	**Anti-Vibration – Mount:**
Length (L): 1050 **L^1: 750** **Width (W): 700** **W^1: 400** **Depth: 300**	**OS/O - 500** **Concrete Spec:** **24N Concrete With Preferred Aggregate @ 20mm**

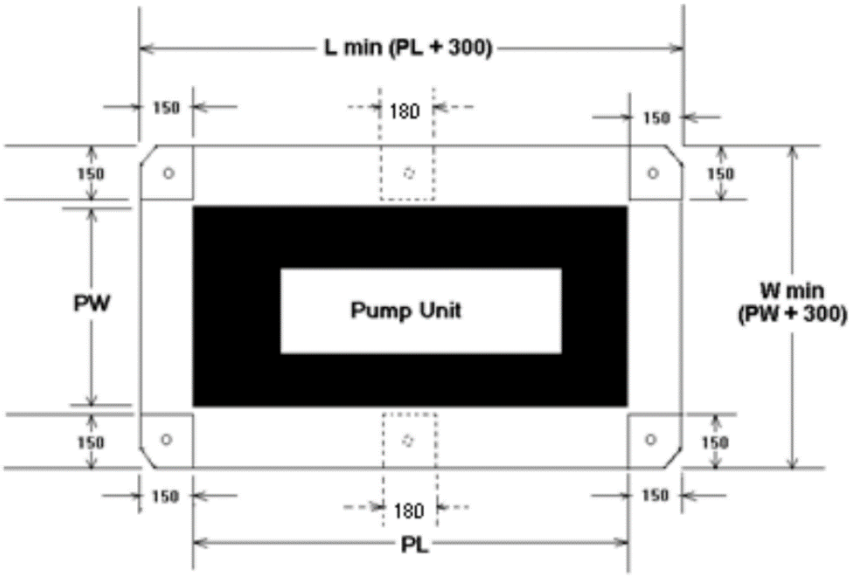
EMFLEX®

Certificate Number: 3973/03

Reg No: 1387785

Contract Reference:	First Avenue House, Holborn
Pump Manufacturer:	Wilo
Pump Reference:	Secondary Offices CHW

Inertia Base Size and Load Calculator



EMFLEX®

ISOQAR REGISTERED UKAS MANAGEMENT SYSTEMS 0026

Certificate Number: 3973/03

Reg No: 1387785

Number of Pumps	1
Pump Model Number	IL-E 100/150-15/2

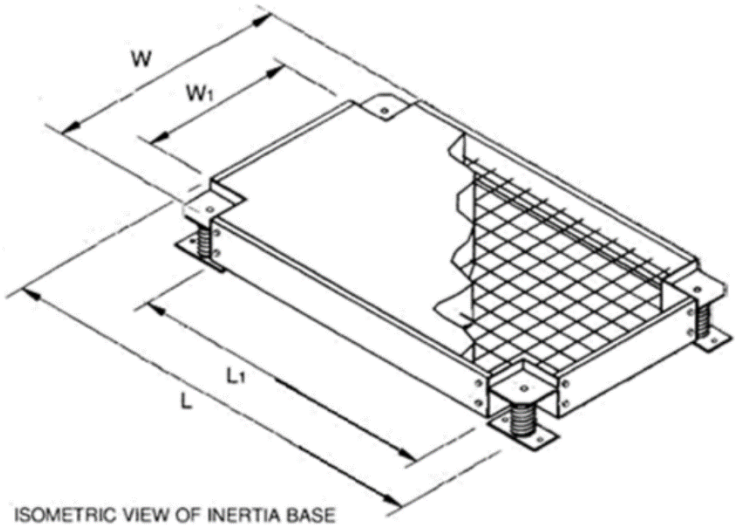
Pump Size in mm	
Length (PL)	**Width (PW)**
713mm	400mm

Pump Weight in Kgs	200

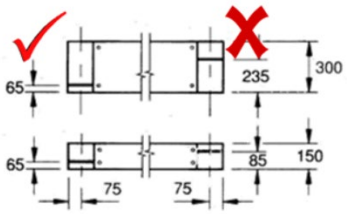
Inertia Base	
Part Number	IB/FPF-4 : 1050 x 700 x 330

Length (L) mm	**Width (W) mm**	**Depth mm**	**Weight Kgs**	**Inertia Ratio**	**Plan Perimeter**
1050	700	300	529.2	2.6:1	3500

Anti-Vibration Mount	
Part Number	OS/O – 500
Qty	4
Shipping Weight Kgs	45.02



ISOMETRIC VIEW OF INERTIA BASE



END VIEW - Showing typical thicknesses and bracket heights

Inertia Base Specification	
Pump Model Number:	IL-E 100/150-15/2
Dimensions	**Anti-Vibration – Mount:**
Length (L): 1050 **L^1: 750** **Width (W): 700** **W^1: 400** **Depth: 300**	**OS/O - 500** **Concrete Spec:** **24N Concrete With Preferred Aggregate @ 20mm**

EMFLEX®

Certificate Number: 3973/03

Reg No: 1387785

Technical Notes: - Reasons to use Inertia Bases

We do occasionally come across manufacturers that claim their equipment does not require any vibration isolation hardware. This might well be true for some situations but would be wholly fortuitous and is equally untrue for others.

This judgement cannot be made until factors such as the acceptable level of vibration in the structure are known; how the structure itself will react when exposed to the disturbing frequency of the equipment; how well the associated pipe or duct work is dynamically designed; the locations and positions of dampers and valves in the system; what part of the efficiency curve the equipment is operating at; how well balanced the equipment is and indeed remains; the size/ duty/ performance characteristics of other plant within the plant room (i.e. a single pump in a non critical location is quite a different matter to many items of plant located in a plantroom over a Board Room).

It would be true to say that new equipment does generally create less vibration than old but the associated vibration hardware required should be designed to cope with vibration levels once the equipment has aged, not just when it is brand new out of the box.

The fact remains that standard good practice for isolating a pumped system is to mount the pumps on anti-vibration mounts or hangers usually in association with an inertia base.

There are several reasons why an inertia base may be employed and we detail these below:

- To give more stability to the system.
- To lower the centre of gravity of the system.
- To give a more even weight distribution.
- To minimise the effects of external forces.
- To add rigidity to equipment.
- To reduce problems of coupled modes of vibration (particularly important with vertically mounted motors where the C of G of the equipment is relatively high).
- To minimise the effects of errors in the position of the C of G of the equipment.
- To act as a local acoustic barrier.

To expand on the above points in further detail: -

1) **To give more stability to the system**
   With many machines the mounting locations originally intended for attachment to a rigid concrete slab are too close together to provide adequate stability when the equipment is mounted on vibration isolators. The concrete inertia base provides a means of widening the support and a more stable geometry.

2) **To lower the centre of gravity of the system**
   Mounting equipment on a substantial concrete base has the effect of lowering the centre of gravity of the complete assembly. As mentioned this adds to the improvement of stability

provided by extending the width of the base, but also has the effect of reducing the likelihood of rocking motion.

3) **To give a more even weight distribution**
In many cases, equipment items are much heavier at one end than the other. This means that, if they are mounted directly on vibration isolators, very different arrangements are needed at opposite ends of the equipment to cope with the uneven weight distribution. If the equipment is mounted on a concrete block, providing the block is heavy enough, a symmetrical mounting arrangement can be used.

4) **To minimise the effects of external forces**
Although the use of inertia bases does not improve the transmittabillity for a given static deflection, it does mean that very much stiffer isolators can be used for the same static deflection, i.e. if the mass of the equipment is doubled the stiffness of the isolators will double. This means the equipment is far less susceptible to the effects of external forces such as transient torques due to changes in speed.

5) **To add rigidity to equipment**
An inertia base can be used to provide rigidity for the mounted equipment. This consequently leads to reduced wear.

6) **To reduce problems of coupled modes of vibration**
The higher of the two rocking sideways movements for a tall item of equipment may occur at two to three times the frequency of the vertical natural frequency. This can lead to problems. Adding an inertia base has the effect of lowering the rocking natural frequency which helps to avoid the problem.

7) **To minimise the effects of errors in the position of the C of G of the equipment**
If a concrete inertia base is used, the centre of gravity of this is known accurately, and if the mass of the base is compared with the mass of the equipment, it means that, even if the information about the equipment c of g is inaccurate, the possible inaccuracies in the final centre of gravity are small. This reduces the likelihood of inaccurate isolator selection.

8) **To act as a local acoustic barrier**
Where very noisy equipment is mounted directly on the floor of an equipment room, the floor immediately under the equipment may be subject to very high sound pressure levels in the immediate vicinity of the equipment. This local area where the floor is exposed to these high levels may cause problems of noise transmission into the room below. A concrete inertia base can act as an effective barrier, protecting the vulnerable areas of floor.

Added to the above, the final pipe connections should then be via flexible pipe connectors.

This methodology is followed throughout both C.I.B.S.E. and A.S.H.R.A.E. and is present in the majority of large project specifications.

First Avenue House

Project Name: **Holborn Anti-vibration Equipment**

Technical Selection & Details

Product Code	Quantity	Nominal Size (mm)	Product Description	Design Movement (mm)	Length or Dimension (mm)				
Secondary CHW Offices									
IBMP	2	-	EMFLEX Type IBMP Inertia Base and Mount Package **Includes 4No. OS/O-500 Spring Mounts**	-	1050mm x 700mm x 300mm				
ET16100	4	100mm	EMFLEX Type EE Tied Flexible Connector	PN16	130mm				
Secondary CHW Courts									
IBMP	2	-	EMFLEX Type IBMP Inertia Base and Mount Package **Includes 4No. OS/O-500 Spring Mounts**	-	1050mm x 700mm x 300mm				
ET16080	4	80mm	EMFLEX Type EE Tied Flexible Connector	PN16	130mm				

EPDM Rubber Flexible Connectors (130mm long)

EMFLEX EPDM (Ethylene Propylene Diene Monomer) rubber flexible connectors are comprised of a synthetic rubber membrane reinforced with nylon. The collars are wire reinforced and the unit is complete with carbon steel flanges. They are capable of absorbing movement in several directions; axial compression, axial elongation and lateral deflection. A small amount of angular movement may also be allowed. They are normally installed in the pipework to isolate various items of plant which produce noise and vibration. These flexible connectors effectively dampen the transmission of sound and vibration from plant items in building services installations.

TYPE EE

EPDM rubber membrane reinforced with a nylon textile cord and fitted with 'untied' or 'tied' carbon steel flanges. Suitable for use with hot water and chilled water.

Nominal Size	Installed Overall Length	Untied & Tied Units Axial Compression	Untied Units Only Axial Elongation	Untied & Tied Units Lateral Deflection
mm	mm	mm	mm	mm
25	130	12	9	12
32	130	12	9	12
40	130	12	9	12
50	130	12	9	12
65	130	12	9	12
80	130	12	9	12
100	130	14	9	12
125	130	14	9	12
150	130	14	9	12
200	130	14	9	12
250	130	14	9	12

Vacuum support rings are available.

Working Pressure:
4 bar (400 kPa) for 'untied' units, unless the pipe is secured.10 bar (1000 kPa) for 'tied' units with top hat washers.16 bar (1600 kPa) for 'tied' units with hemispherical washers.
Test Pressure: 1.5 x Working Pressure.
Working Temperature: -10ºC to 90ºC.

Key Features:
Fully traceable and has the date of manufacture, nominaldiameter, manufacturer, and type permanently moulded into the membrane.

Noise and vibration reduction capabilities. Tied units are fitted with noise absorbing top hat washers.

Design Consideration:
Rubber flexible connectors are subject to the same internal pressure force as metal expansion joints and the force is equal to the internal pressure multiplied by the maximum internal area. This force causes the connector to lengthen and tied units are recommended where the working pressure exceeds 4 bar, unless the pipework is secured to restrict movement.

Tie-rods are fitted through oval flanges and to isolate the tie-rods from the flanges special neoprene top hat washers are used to prevent any metal to metal contact whatsoever, effectively preventing noise transmission.

After installation of TIED UNITS the tie-rod nuts should be checked to have 1mm clearance over the steel washers.

When using with items of plant mounted on vibration isolators, such as springs or inertia bases, then TIED UNITS must be installed.

Inertia Base & Mount Packages

EMFLEX inertia base and mount packages are used beneath mechanical equipment to improve stability and to minimise the vibratory movement and noise transmission due to equipment start-up, operation and run-down.

They are designed and manufactured to meet with individual requirements and are suitable for mechanical equipment such as pumps, air handling units, chillers, booster sets, compressors, etc.

They are supplied to site ready for filling with concrete. We recommend that a concrete mix ratio of 4 parts gravel : 2 parts sand : 1 part cement is used to give a concrete density of 2,400 to 2,500 kg/m3.

We request that our engineers are contacted for assistance with this type of equipment.

TYPE IBMP

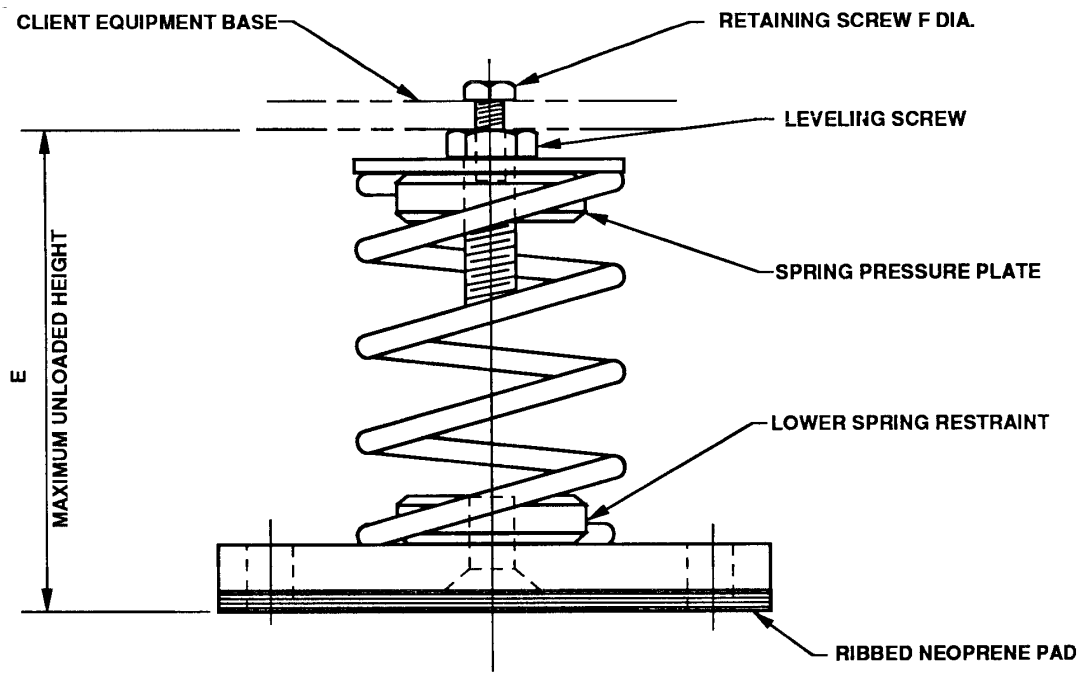
A package consisting of a pre-galvanised formed steel inertia frame, zinc plated steel reinforcing bars, zinc plated steel 'outrigger' mounting brackets and suitable anti vibration mounts to suit the mechanical equipment being isolated. Heavy steel channel sections and steel angle section may be used where necessary.

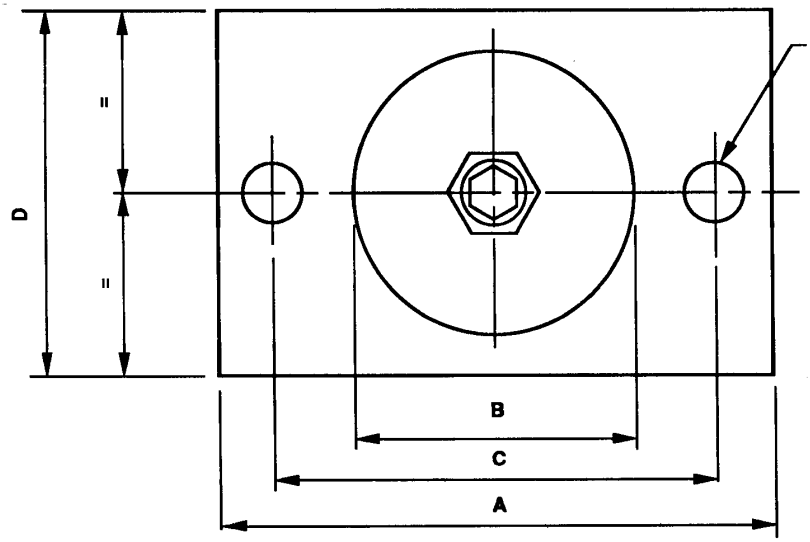
The approximate concrete weight is calculated from:-
Weight (kg) = A x B x C x D

Where,
A = Frame Length (m)
B = Frame Width (m)
C = Frame Depth (m)
D = Concrete Density (2400kg/m3)

The weight of the inertia base should be between 1.5 and 2.0 times that of the equipment being supported.
To reduce rocking modes, the height of the centre of gravity above the top of the isolators for the combined base and equipment must be less than the horizontal distance to the isolators.

Allow 150mm between equipment hold down bolts and the edge of the frame so as not to crack the concrete.
The guidance tables above show sizes of inertia bases that utilise 4 isolator mounting positions. Larger sizes are available and generally utilise more isolators.





DIMENSIONAL DATA						
TYPE	A	B	C	D	E	F
OS/0	130	70	92	80	130	10
OS/1	165	82	120	90	188	12

ALL METAL PARTS ZINC PLATED
ALL MOUNTS TO BE INSTALLED ON A COMMON LEVEL BASE

NOTE: ALL DIMENSIONS IN MM

STANDARD ENGINEERING TOLERANCE +/-1 MM, UNLESS OTHERWISE STATED.
RESEARCH AND DEVELOPMENT IS ONGOING & UNLESS STAMPED CERTIFIED (VALIDITY 3 MONTHS) THIS DATA SHEET IS ONLY CORRECT AT DATE OF ISSUE.

GENERAL ARRANGEMENT DRAWING

TYPE OS 30 MM DEFLECTION OPEN SPRING MOUNT

Drawing No: GA/005/296/REV2 | Date: MAY 1999

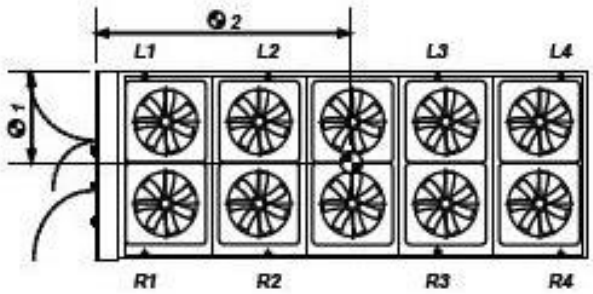
PRODUCT CODE	WEIGHT RANGE KG.	NOMINAL DEFLECTION mm
OS/O - 50	11 - 23	30
OS/O - 80	18 - 37	30
OS/O - 130	30 - 60	30
OS/O - 200	45 - 91	30
OS/O - 300	68 - 137	30
OS/O - 500	114 - 228	30
OS/O - 630	143 - 287	30
OS/O - 800	182 - 364	30
OS/O - 1100	250 - 500	30
OS/1 - 425	97 - 194	30
OS/1 - 600	136 - 273	30
OS/1 - 750	170 - 341	30
OS/1 - 1000	227 - 455	30
OS/1 - 1400	318 - 637	30
OS/1 - 1700	386 - 773	30
OS/1 - 2000	455 - 910	30
OS/1 - 2400	545 - 1091	30

4. New Chiller – Anti – Vibration Mounts

Chiller Manufacturers - AV Mount Selections & Data

AVM Type		Accompanying Loose Parts Instruction
ISL		LPI_AV MOUNTS_SPRING_TYPE_6986251

AMC



Standard Unit without Pumps

Unit Nomenclature	L1	L2	L3	L4	L5	L6	L7	R1	R2	R3	R4	R5	R6	R7
DCC043DR-08LXX0	2 - 1080	1 - 612	2 - 1080					1 - 803	2 - 1080	1 - 803				
DCC048DR-09NXY0	2 - 1080	1 - 612	1 - 803	1 - 612				1 - 803	1 - 612	1 - 803	1 - 612			
DCC056DR-10NYY0	2 - 1080	1 - 612	1 - 803	1 - 612				1 - 803	1 - 612	1 - 803	1 - 612			
DCC057DR-10NYV0	2 - 1080	1 - 612	1 - 803	1 - 612				1 - 803	1 - 612	1 - 803	1 - 612			
DCC062TR-11PNXX	2 - 1080	1 - 803	2 - 1080	1 - 803				2 - 1080	1 - 803	2 - 1080	1 - 803			
DCC063TR-12PXXX	2 - 1224	1 - 803	2 - 1224	1 - 803				2 - 1080	1 - 803	2 - 1080	1 - 803			
DCC068TR-13PXXY	2 - 1080	1 - 803	2 - 1080	1 - 803	2 - 1080			1 - 612	2 - 1080	1 - 803	1 - 803	1 - 612		
DCC076TR-14SXYY	2 - 1080	1 - 803	2 - 1080	1 - 803	2 - 1080			1 - 803	2 - 1080	1 - 803	2 - 1080	1 - 803		
DCC083TR-15SYYY	2 - 1224	2 - 1080	2 - 1080	1 - 803	2 - 1080			1 - 803	2 - 1080	1 - 803	1 - 803	1 - 803		
DCC086TR-15SYVV	2 - 1224	2 - 1080	2 - 1080	1 - 803	2 - 1080			1 - 803	2 - 1080	1 - 803	1 - 803	1 - 803		
DCC088TR-15SVVV	2 - 1224	2 - 1080	2 - 1080	1 - 803	2 - 1080			1 - 803	2 - 1080	1 - 803	1 - 803	1 - 803		
DCC092TR-15SVVW	2 - 1224	2 - 1080	2 - 1080	1 - 803	2 - 1080			1 - 803	2 - 1080	1 - 803	1 - 803	1 - 803		
DCC095TR-15SVWW	2 - 1224	2 - 1080	2 - 1224	1 - 803	2 - 1080			1 - 803	2 - 1224	1 - 803	2 - 1080	1 - 803		
DCC098TR-15SWWW	2 - 1224	2 - 1080	2 - 1224	1 - 803	2 - 1080			1 - 803	2 - 1224	1 - 803	2 - 1080	1 - 803		
DCC043DR-10LXX0	1 - 803	1 - 612	1 - 803	1 - 612				1 - 803	1 - 612	1 - 803	1 - 612			
DCC049DR-11NXY0	2 - 1080	1 - 803	2 - 1080	1 - 803				2 - 1080	1 - 803	1 - 803	1 - 803			
DCC056DR-12NYY0	2 - 1080	1 - 803	2 - 1080	1 - 803				2 - 1080	1 - 803	1 - 803	1 - 803			
DCC058DR-12NYV0	2 - 1080	1 - 803	2 - 1080	1 - 803				2 - 1080	1 - 803	1 - 803	1 - 803			
DCC063TR-14PNXX	2 - 1080	1 - 803	2 - 1080	1 - 803	2 - 1080			1 - 803	2 - 1080	1 - 803	1 - 803	1 - 612		
DCC063TR-15PXXX	2 - 1080	1 - 803	2 - 1080	1 - 803	2 - 1080			1 - 803	2 - 1080	1 - 803	1 - 803	1 - 612		

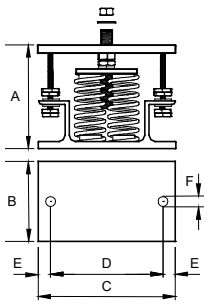
Point load numbering starts from the control panel end of the chiller.
Illustration above is for a 8 mount configuration.

Installation Data

Anti Vibration Mounting

ISL Spring Type

Each mount is coloured to indicate the different loads, refer to instructions supplied for correct allocation.

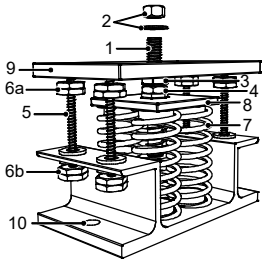


Dimensions

	A(1)	B	C	D	E	F
mm	162	130	225	186	20	16

(1) Unloaded dimension

The ISL range of AV mounts have an optimum deflection of around 38mm (product dependent) and a maximum of 50mm.



Components

1	Locating screw.	6b	Lower retaining nuts.
2	Retaining nut & washer.	7	Spring assembly.
3	Levelling screw.	8	Pressure plate.
4	Levelling lock nut.	9	Top plate.
5	Retaining studs.	10	Fixing holes.
6a	Upper retaining nuts.		

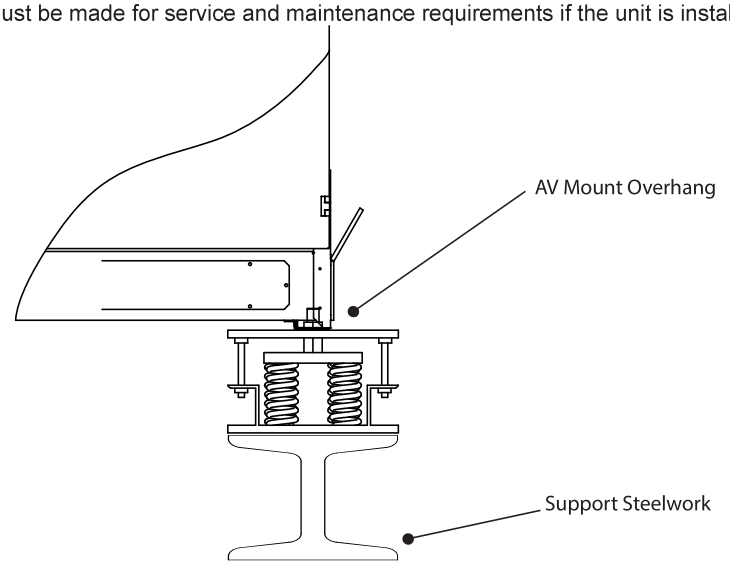
Installation

1. Locate and secure mount using fixing down holes (10) in base plate.
2. Ensure mounts are located in line with the unit base.
3. If applicable, remove compressor enclosure covers to allow access to mount fixing holes in the unit base.
4. Lock the upper retaining nuts (6a) to the underside of the top plate (9) before a load is applied.
5. Slacken levelling lock nut (4); the levelling screw will not move if this is not slackened.
6. Remove retaining nut and washer (2), lower the unit onto the mounts and replace retaining nut and washer.
7. Beginning with the mount with the largest deflection adjust the height of each mount using the levelling screw (3). Mountings must be adjusted incrementally in turn.
8. Do not fully adjust 1 mount at a time as this may overload and damage springs.
9. When all mounts are level, lock each into place using the levelling lock nut (4).
10. Lock all retaining nuts (6a and 6b) to the extreme ends of the retaining studs (5).

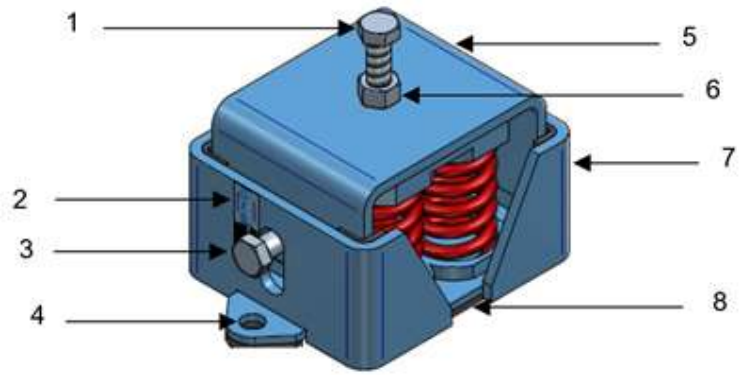
⚠CAUTION	Do not connect any services until all anti vibration mounts have been fully adjusted.

Anti Vibration Mount location to Unit and Plinth

The Anti Vibration mount is larger than the unit base. Consideration must be made with regard to steelwork / concrete plinth sizes. Full information is available on the approved General Arrangement drawings. The base of the unit is open. Considerations must be made for service and maintenance requirements if the unit is installed on a gantry.

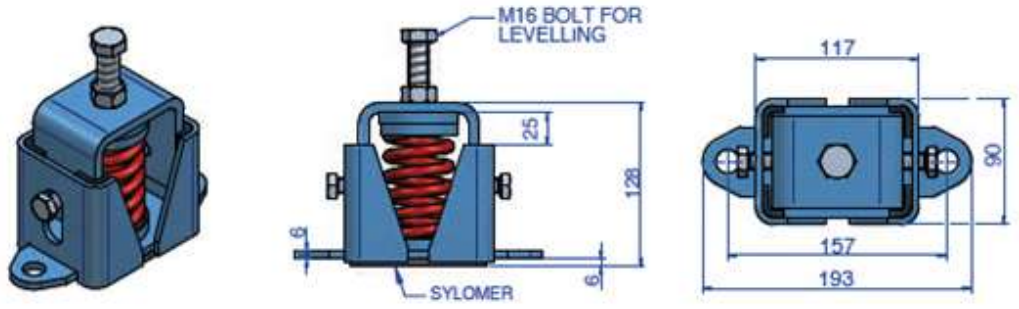


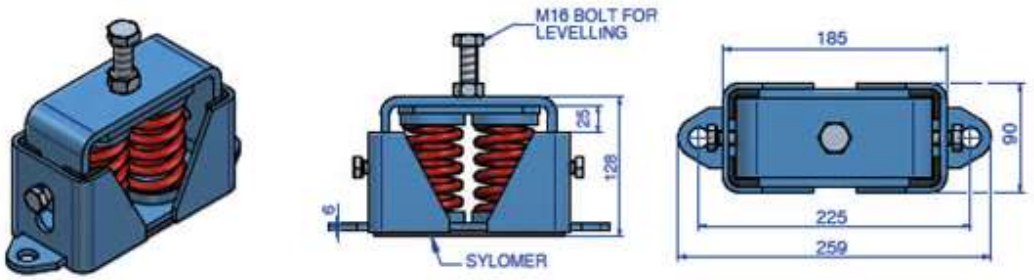
AMC AV Mount Fitting Instructions

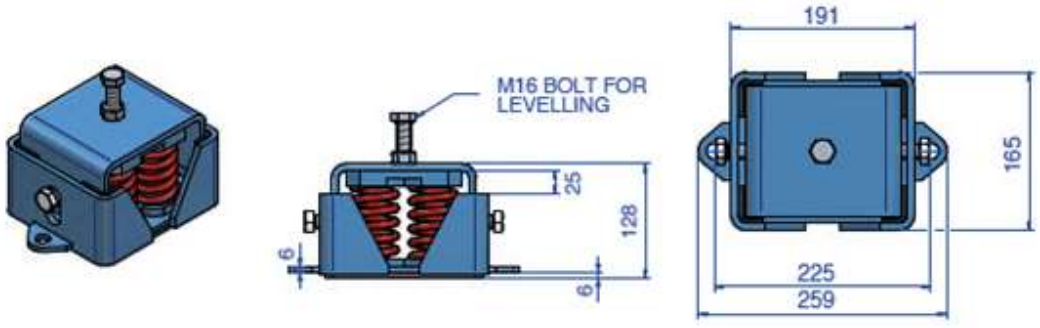


1. Levelling Screw
2. Displacement Gauge
3. Anti-traction Screw
4. Mounting Holes
5. Mount Top Hot
6. Fixing Nut
7. Mount Body
8. Sylomer Base

Mounts may be supplied in either a one, two or four spring variation.
All variations have an optimum deflection of 15mm and a maximum of 22cm.







AMC AV Mount Fitting Instructions

	1 Spring	2 Spring	4 Spring
Mounting Hole Spacing (mm)	157	225	225

Installation

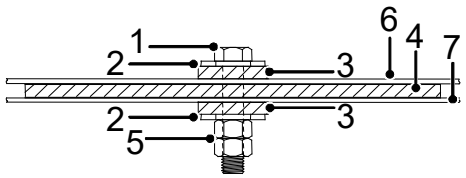
1. Position and secure mount using mounting holes, with displacement gauge facing away from the chiller.
2. Ensure mounts are located in line with the unit base.
3. If applicable, remove compressor enclosure covers to allow access to mount fixing holes in the unit base.
4. Remove the levelling screw and fixing nut from the top housing of the mount.
5. Lower the unit onto the mounts and replace the levelling screw and nut.
6. Starting with the most deflected mount, adjust the height of each mount using the levelling screw.
7. When all mounts are level, lock each into place using the levelling lock nut.

⚠CAUTION	Mountings must be adjusted incrementally in turn. Do not fully adjust 1 mount at a time as this may overload and damage springs. Do not connect any services until all anti vibration mounts have been fully adjusted.

Pad Type

Components

1. M16 Bolt (not supplied).
2. Washer (not supplied).
3. Fixing pad 6173231.
4. Anti vibration pad 6173223.
5. 2 x M16 nut (not supplied).
6. Unit base.
7. Unit mounting plinth.



Installation (steel plinth)

1. Locate the pad type anti vibration mount between the unit base and the unit steel mounting plinth.
2. Locate the M16 bolt through the hole in the unit, AV mount pad and steel mounting plinth.
3. Tighten the M16 nut to the underside of the steel mounting plinth.
4. Tighten the second M16 nut (locking nut) to the underside of the steel mounting plinth.

Installation (concrete plinth)

1. Locate the pad type anti vibration mount between the unit base and the unit concrete mounting plinth.
2. Locate the concrete fixing anchor through the AV mount pad and the hole in the unit.
3. Tighten the anchor bolt.

5 . Summary

The existing Chiller installation comprises of manufacturer's supplied Helical spring vibration mountings providing the most reliable device for vibration control.
As stated in the report the New Chillers will also be installed with the manufacturer's selected Spring anti-vibration mountings providing optimum deflection of 38mm and vibration efficiency (VIE) of up to 95%.

The existing Chilled water pumps in the Plantroom are provided with Pipework flexible connections and baseplate / isolation pads.
The new Pump installations will have enhanced vibration control comprising of Pipework flexible connections and selected Inertia bases complete with spring vibration mountings.

To summarise the New Chiller plant vibration control selections are in accordance with CIBSE Guide B4 ; the vibration controls for the Chillers match the existing installation and the pump controls are enhanced with the Inertia bases providing improved vibration isolation and a reduced resonant frequency.