TECHNICAL DATA SHEET DS 055		
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	ISSUE	5
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TITLE.	General Guidance notes for the selection of Vibration Control Systems for Building Services Applications.

1.0 INTRODUCTION

The selection of the most appropriate type of vibration isolator for the item of plant or equipment to be isolated is critical if an effective and economical result is to be achieved. Whilst the selection procedure can become involved requiring the use of complex mathematical analysis for the more critical applications, there are some simple guidelines which the designer/specifier can use to provide a first estimate of the type of vibration isolator system that may be required. This is helpful when detailed information required to conduct a full design analysis is not available, particularly at the start of a project.

The graph Figure 1 (Page 2) illustrates the vibration isolator deflection required to reduce the transmission of vibration to a given percentage of the vibratory forces generated by the item of plant or equipment concerned. To use the graph, consider the disturbing frequency to be the lowest rotational speed of the equipment. Move vertically to the slanted line corresponding to the percentage transmissibility which can be tolerated. Then move horizontally to determine the minimum static deflection and corresponding vertical natural frequencies of the required vibration isolator. For guidance, the graph indicates the maximum permissible transmissibility for typical situations encountered in building services installation, as follows:

I - NON CRITICAL :e.g.. Basement and ground floor locations not adjacent to noise critical spaces.

II - GENERAL :e.g.. First floor and other suspended floor locations with less than a 10m span not adjacent to noise critical spaces.

III - CRITICAL :e.g.. Suspended floor with greater than 10m span or locations immediately adjacent to noise critical spaces.

Figure 1. provides preliminary guidance for the vibration isolator characteristics required, although it presupposes that the vibration isolator is a “perfect spring” and is therefore linear over the deflection range considered. It ignores non-linear effects which are normally present in “real springs” at higher frequencies which may detrimentally affect the isolation efficiency actually achieved. This simple presentation also assumes that the vibratory forces are vertical and does not give consideration to horizontal forces or couples

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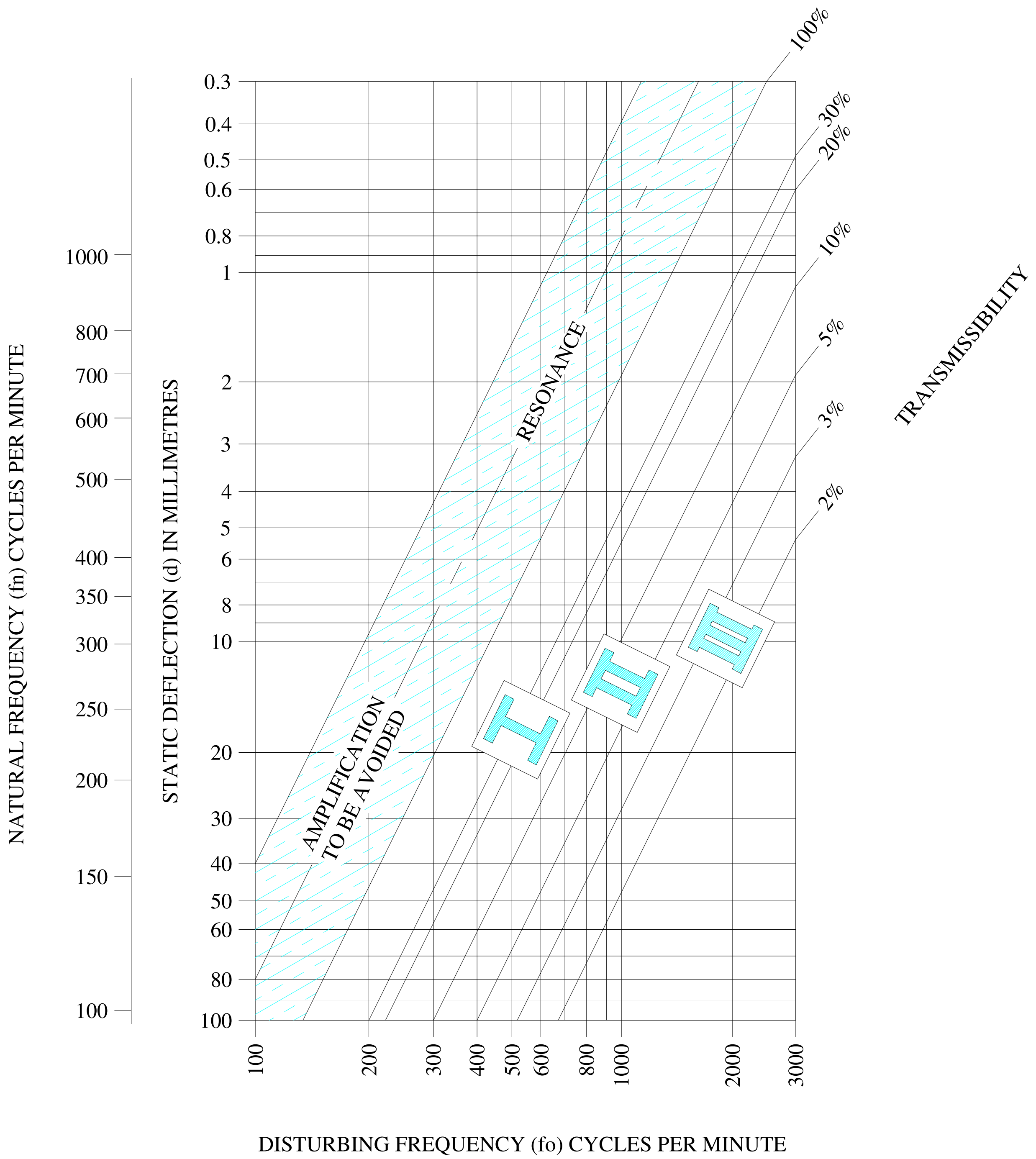

which create motion in the other linear and rotational modes. If in doubt, please contact our Applications Engineering Department for advice.

The table Figure 2 gives general guidance for the isolation of common items of plant or equipment in typical situations as described above and in subsequent sections of this Data Sheet.

This Data Sheet is for general guidance only, particularly for use when full details of plant and equipment and their precise locations may be unknown. Prior to final selection of vibration isolation systems, please consult our Applications Engineering Department who, upon receipt of full details, will be pleased to recommend/vet final vibration isolator selections.

Figure 2.

Data Sheet Section	Plant	Location					
		I		II		III	
		Mounting Type. See Section 3.0	Minimum Deflection (mm)	Mounting Type. See Section 3.0	Minimum Deflection (mm)	Mounting Type. See Section 3.0	Minimum Deflection (mm)
2.1	Pumps-Base Mounted	IPF & RM	6	IPF+OS	10	IPF+OS	25
	Pumps-Belt Driven	IPF + RM	6	IPF+OS	10	IPF+OS	25
	Pumps-Close Coupled	RM (+FSB)	3	RM (+FSB)	6	IPF+OS	25
	Pressurisation Units	RM (+FSB)	3	RM (+FSB)	6	IPF+OS	20
2.2	AHU's	ES	15	ES	25	ES + RP (2 stage)	25+3
2.3	Centrifugal Fans	RM	10	ES	15	ES	25
	Axial Flow Fans	RM	10	ES	15	ES	25
	Suspended Fans, etc	RH	10	SH	15	SH	25
2.4	Chillers Reciprocating	Genflex	10	Genflex	15	ES	25
	Chillers Centrifugal	Genflex	6	Genflex	10	Genflex	15
2.5	Cooling Towers & Air Cooled Condenser	- / -	- / -	ORS/ES	25	ORS/ES	50
2.6	Boilers	RP	3	RP	6	-	-
2.7	Internal Combustion Engines & DG Sets	Genflex	15	ES	20	ES + Genflex (2 stage)	25+15

2.0 GENERAL GUIDANCE NOTES FOR THE SELECTION OF VIBRATION CONTROL SYSTEMS FOR COMMON TYPES OF BUILDING SERVICES PLANT

2.1 PUMPS

2.1.1 These are normally direct drive units running at 1450/2900 rpm or belt driven from a motor mounted on top of the pump at variable speeds but normally in the range 800 - 1300 rpm.

2.1.2 In **basement plantrooms** most pumps can be successfully isolated using rubber pad type isolators “sandwiched” in a builders work plinth. Select to give 2-3mm deflection. This should have a weight equal to the pump for direct drive pumps and twice the weight for belt driven sets with maximum plan dimensions for stability. Minimum depth 150mm.

2.1.3 For installation in **plantrooms above or adjacent to occupied areas** concrete filled inertia bases with open or enclosed spring mountings with nominal 25mm deflection should be used. These can be replaced with rubber mountings with 6mm nominal deflection for pumps running at 2900 rpm. Base weight should not be less than the pump weight but ideally a 1:1.5 or 1:2 ratio is advisable for top heavy belt driven units.

2.1.4 A large shallow base will always be more stable than a small deep base of the same weight. An economic and technically preferable method of using a large base is to **mount the duty and standby pumps on a common base.**

2.1.5 Pipework should always be **supported independently** and connected to the pump using **non-metallic flexible connections** after the mountings have been adjusted to support the pump and base at the required height.

2.2 AIR HANDLING UNITS

2.2.1 Generally air handling units will be supplied to site with **internal vibration isolators** supporting the fans and motors. For fan speeds below 1500 rpm these will probably be open or enclosed spring devices at 25mm nominal deflection and above this speed rubber mountings at 6mm deflection.

2.2.2 **In noise critical areas** it is a wise precaution to mount the complete AHU on rubber compression stud pads or waffle pads (2-3mm deflection). Steel spreader plates may be required with a friction pad if the support frame channel is very narrow.

2.2.3 For installations on raised steel structures, it is sometimes necessary to use external spring mountings with additional rigid steel subframes. Where the motor is mounted outside the AHU casing the fan/motor section may be externally mounted and coupled to the other sections with a flexible section.

2.2.4 All ductwork and pipework connections to AHU's must include **flexible sections.**

2.3 FREE STANDING FANS

2.3.1 The two general types used are axial direct driven and centrifugal belt driven units. The former usually operate at 1450 or 2900 rpm and are located in horizontal or vertical ductwork runs with flexible connections on either side. Centrifugal units are mainly floor mounted and can operate at a fixed speed between 200 and 3000 rpm or they may have a dual speed drive system and more often recently an infinitely variable speed TASC drive.

2.3.2 **Axial fans** may be suspended from the ceiling using rubber hangers with 6mm nominal deflection. However a more satisfactory method is to provide a rigid steel cradle from the ceiling with Rubber Turret mountings between the underside of the fan and frame. This avoids the pendulum effect of hangers with drop rods. In extreme cases where low frequency vibration may be a problem 25mm deflection spring hangers or mountings may be used on larger fans operating at 1450 rpm. Vertical fans can be supported from cantilever brackets using rubber or spring mountings as appropriate.

2.3.3 **Centrifugal fans** with their generally lower operating speed range should be isolated using Enclosed spring Mountings with nominal 25mm deflection. It is not normally necessary to use 50mm deflection mountings unless the fan is likely to be operated at less than 500 rpm. Open Spring Mountings can be used but these are more susceptible to "short circuiting" by the ingress of site debris if not enclosed in an AHU.

2.3.4 **Flexible connections** to ductwork must be used.

2.4 WATER CHILLERS/CONDENSERS

2.4.1 These are either roof mounted Air Cooled units or Water Cooled sets located in plantrooms at any level in a building.

2.4.2 **Air Cooled** models produce vibration from the large propeller type fans and internal reciprocating compressors. The fan speeds can be very low, e.g. 360 rpm, however the vibration produced is negligible and therefore a high degree of isolation at these frequencies is not necessary. The Genflex High Deflection rubber mounting is best suited to the larger units with deflections between 10 and 16mm. However, for small units the Enclosed Captive Spring mounting is more economic.

2.4.3 **Water cooled chillers** are generally larger with higher power compressors. These can be reciprocating (usually 1450 rpm) centrifugal or screw type, the former being the most severe in terms of vibration. The latter two types normally run at high speeds, e.g. 2900 rpm and above producing high frequency vibration and noise. The Genflex HD mounting again is the best selection for most applications. Pad type mountings can be used on the high speed centrifugal and screw type units in some basement areas with no noise sensitive areas in close proximity.

2.4.4 **Stability problems** can be experienced when tall, slender chillers are located directly on mountings. To avoid such problems steel subframes or even inertia pouring frames may be required. The mounting transverse centres should be greater than the vertical distance to the units centre of gravity position.

2.4.5 As with isolated equipment, pipework connections must incorporate **flexible sections**, non metallic where practical.

2.5 <u>COOLING TOWERS</u>

2.5.1 These units which are generally roof mounted incorporate integral axial or centrifugal fans. However, some designs now have the fan mounted independently with a flexible connection to the water tower. For the latter refer to Section 3.0 for methods of isolation.

2.5.2 Towers with **integral fans** have the disadvantage of being extremely heavy when full of water making isolation of fan vibration expensive. The weight does, however, work rather like an inertia base for the fans. Quite often vibration from the usually low speed fans (200 - 900 rpm) is negligible compared to the unit weight. High deflection spring mountings are often specified to give high isolation of the low speed fans which is quite unnecessary in most cases. The use of these devices gives rise to practical problems with installation resulting in the springs being “short circuited”. Also excessive motion can result in high winds and vertical movement when draining down requires restraint to avoid over stressing flexible pipework connections.

2.5.3 To avoid all the problems in paragraph 2.5.2 high deflection rubber mountings should be used giving reasonably vibration isolation down to 500 rpm, but more importantly vastly superior isolation in the audible frequency range. If a specifier is inflexible then the Open Restrained Spring should be used preferably at not more than 25mm nominal deflection.

2.6 BOILERS

2.6.1 As with cooling towers, boilers have a high weight with negligible vibration which emanates from the burners and associated fan/motor. The vibration, however, is high frequency and thus creates mainly airborne noise problems.

2.6.2 Structural transmission of the vibration/noise can be most practically and economically avoided using Compression Stud pads with steel spreader plates for narrow channel construction frames. A deflection of 2-3mm is adequate. Where for acoustic reasons a concrete slab is required beneath the boiler this can be cast on a layer of rubber pads covered with steel sheets.

2.7 DIESEL GENERATING SETS

2.7.1 These are usually for emergency power supply only and are therefore sometimes located in unsuitable areas where extreme annoyance is caused during regular test running periods. Effective vibration isolation is therefore required.

2.7.2 Enclosed Captive Spring mountings (nominal 25mm deflection) or Genflex HD rubber mountings will be suitable for the majority of applications which operate at a standard speed of 1500 rpm. For installations directly above or adjacent to noise critical areas, a complex two stage mounting system may be necessary. These applications together with those which produce continuous power supply to a building should be referred directly to Christie & Grey Limited.

2.8 PIPEWORK

2.8.1 Vibration emanating from pumps, compressors etc. will be present in most systems despite flexible connections. This is because the flexibility is compromised by the liquid flowing through it, the tie bars and the strength required to withstand the liquid pressure. Vibration is also produced by fluid pressure surges and turbulence created by change of direction etc.

2.8.2 All **pipework of 50mm dia** and above in plantrooms below occupied areas should be isolated using spring hangers with 25mm nominal deflection. In less critical areas it is normally sufficient to isolate the first 12m of pipe from the vibration source. Where pipework passes through noise sensitive areas rubber hangers or mountings with nominal 6mm deflection should be used. Open Spring mountings or rubber mountings can be used for vertical pipe runs depending on location as mentioned above.

2.8.3 Small pipework, i.e. **below 50mm dia** in critical situations as Para 2.8.2 can be isolated with small range spring hangers with deflections of 10 - 20mm. In normal circumstances a 3 - 6mm thick rubber insert in the pipe clip will be sufficient.

2.8.4 **Engine exhaust pipework** with silencers will require isolation and Spring Hangers or Open Spring Mountings with nominal 25mm deflection will be necessary. Consideration must be given to pipe temperature and expansion particularly for tall vertical stacks. Please refer such applications to Christie & Grey Limited.

3.0 SPECIFICATION FOR VIBRATION ISOLATION DEVICES

3.1.0 GENERAL

3.1.1 All vibration isolators should be selected to provide the minimum static deflection required. Selection should allow for asymmetric load distributions such that the minimum static deflection can be achieved on all vibration isolators under normal operating conditions.

3.1.2 All vibration isolators must be suitable for the loading, operating and environmental conditions which will prevail. Special attention shall be paid to vibration isolators which will be exposed to atmospheric conditions and appropriate finishes must be applied to prevent excessive rusting or corrosion.

3.1.3 All vibration isolators shall be colour coded or otherwise clearly marked to indicate rated load and deflection capacity to facilitate identification during installation and service.

3.1.4 The efficiency of an isolator system can be seriously impaired if the system is connected to rigid pipes, electrical conduits, ducts or shafts. It is essential that such external connections be as flexible as possible not only to prevent transmission of vibration through the connections and allow the system freedom of movement but also to avoid possible failure of the connections.

3.1.5 The vibration isolator system should be selected to support the operating weight of the plant and equipment to be isolated only. All associated pipework, valves, filters, ductwork etc. and their contents must be supported independently so as not to impose additional forces on the isolator system and all flexible connections must be selected and arranged to accommodate this requirement.

3.1.6 Where it is proposed to support AHU/enclosed fan units on vibration isolators, it is recommended that flexible connections are fitted to any external connecting ductwork, pipework, conduits etc. regardless of whether or not the internal fan and motor assembly is supported on vibration isolators and has internal flexible connections to the unit casings.

3.1.7 All pipework of 50mm diameter and above and high pressured ductwork should be isolated within a mechanical plant room for a minimum distance of 15 metres from the motor driven plant.

3.2 <u>OPEN SPRING MOUNTINGS WITH HEIGHT ADJUSTMENT</u> (TYPE OS)

3.2.1 Each mounting shall consist of a helical steel spring as the principal isolation element and shall incorporate a built-in levelling device.

3.2.2 The spring will be permanently fixed under both free and working conditions to fabricated top and bottom plates. The method of fixing the spring to the top and bottom plates shall incorporate high frequency attenuation devices preventing direct contact between spring and end plates. Therefore fixing by loose location metal clips or welding will NOT be permitted.

3.2.3 Each helical steel spring shall be permanently colour coded to denote rated load and deflection capacity and, by design, to have an outside diameter at least equivalent to 85% of its working height with a minimum 50% overload capacity before becoming coil bound.

3.2.4 A 6mm thick ribbed Neoprene pad shall be bonded to the underside of the bottom plate except where bolting to flat steel surfaces is required.

3.3 <u>OPEN RESTRAINED SPRING MOUNTING WITH HEIGHT ADJUSTMENT</u> (TYPE ORS)

3.3.1 Each mounting shall consist of one or more helical steel springs as the principal isolation element fixed to a cast or fabricated bottom housing.

3.3.2 The bottom housing shall incorporate restraining studs which pass through clearance holes in the top support plate/housing attaching to adjustable restraint washers. The spring top spigot shall be attached to the top support plate/housing to which the machine is fixed.

3.3.3 The spring top spigot shall incorporate a high frequency attenuating device preventing direct contact between the spring and top spigot. Alternatively, this may be beneath the spring providing that the spring location pins are also protected.

3.3.4 Levelling and adjustment shall be achieved by adjustment of a nut on the central stud bearing on the spring top spigot.

3.3.5 Each helical steel spring shall be permanently colour coded to denote rated load and deflection capacity and be designed to have an outside diameter at least equivalent to 85% of its working height with a minimum 50% overload capacity before becoming coil bound.

3.3.6 A 6mm thick ribbed Neoprene pad shall be bonded to the underside of the bottom plate except where bolting to flat steel surfaces is required.

3.4 **ENCLOSED SPRING MOUNTING WITH HEIGHT ADJUSTMENT (TYPE ES)**

3.4.1 Each mounting shall consist of a helical steel spring as the principal isolation element retained within a totally enclosed telescopic housing and shall incorporate a built-in levelling device.

3.4.2 The spring will be located within a Nitrile rubber cup and be permanently fixed to a fabricated baseplate in such a manner that the base of the Nitrile rubber cup will prevent direct contact between the spring and the baseplate thus providing high frequency attenuation control.

3.4.3 The open end of the Nitrile rubber spring retaining cup will be formed with a lip which is engaged by a co-operating lip in a pressed metal cover thus limiting the upward movement of the metal cover.

3.4.4 Height adjustment will be affected by an adjusting screw passing through the screwed insert in the metal cover and bearing on a dished spigot located on the top of the spring.

3.4.5 Each helical steel spring shall be designed to have an outside diameter at least equivalent to 85% of its working height with a minimum 50% overload capacity before becoming coil bound.

3.5 NATURAL RUBBER TURRET MOUNTINGS (TYPE RM)

3.5.1 Each mounting shall be moulded in durable oil resistant Natural Rubber with integral steel base and upper fixing boss. The Natural Rubber shall be colour coded to denote rated load and deflection capacity.

3.5.2 Each mounting shall be supplied with a standard fitting bolt or optional height adjuster as required.

3.6 UNRESTRAINED RUBBER MOUNTINGS (TYPE GENFLEX)

3.6.1 Each mounting shall consist of a pair of natural rubber springs as the principle isolation element bolted between SG Iron Top and Base Castings. The rubber springs shall be arranged in the castings to ensure that they are loaded in a combination of shear and compression.

3.7 RESTRAINED RUBBER MOUNTINGS (TYPE GENFLEX MARINE)

3.7.1 Each mounting shall consist of a pair of natural rubber springs as the principle isolation element bolted between SG Iron Top and Base Castings. The rubber springs shall be arranged in the castings to ensure that they are loaded in a combination of shear and compression.

3.7.2 The SG Iron Top Casting shall be retained by a central stud assembly which passes through a clearance hole in the base casting and is connected to a combined overload and rebound buffer.

3.8 HELICAL STEEL SPRING HANGERS (TYPE SH)

3.8.1 The hangers shall incorporate a Helical Steel Spring Assembly permanently located in a steel frame. The Hanger Steel frame shall have been designed and tested to 5 times the maximum rated load.

3.8.2 The Helical Steel Spring Assembly shall incorporate a rubber insert for high frequency attenuation, together with an assembly stud and drop rod permitting pre-compression of the spring prior to installation. The clearance hole in the bottom of the steel frame shall allow a lateral movement of the assembly stud at least equivalent to a 15 degree included angle.

3.8.3 The Helical Steel Spring shall be permanently colour coded to denote rated load and deflection capacity and be designed to have an outside diameter at least equivalent to 85% of its working height with a minimum 50% overload capacity before becoming coil bound.

3.9 NATURAL RUBBER HANGERS (TYPE RM)

3.9.1 The Hangers shall incorporate a Natural Rubber Turret Mounting as described in section 5.0 as a principle isolation element.

3.9.2 The Hanger Steel Frame shall be as described in section 3.8.0.

3.10 SPRING ISOLATED CONCRETE INERTIA BASE (TYPE IPF)

3.10.1 These shall be of a fully welded steel construction with integral concrete reinforcement mesh fixed at 40mm above bottom of frame. The depth of frame shall not be less than L/12 where "L" is the longest side of the frame or 150mm whichever be the greater.

3.10.2 Four recessed height reducing corner brackets will be provided to accept height adjustable open spring mountings. For frame lengths in excess of 2400mm a minimum of six mounting brackets should be provided, the additional mounting brackets should be recessed into the frame sides as appropriate.

3.10.3 The frame shall be finished with a single coat of primer on external surfaces only.

3.10.4 The weight of the inertia frame including concrete at 2245 kg/m^3 should be equal to at least twice the weight and certainly not less than 1.5 times the weight of the equipment to be supported. The equipment and any ancillary weights shall be arranged on the inertia base so as to distribute the load as evenly as possible over the mounting positions and NOT to overhang the frame. Holding down bolt positions must NOT be less than 100mm from the edge of the frame.

3.11 FABRICATED STEEL BASEFRAMES

3.11.1 These shall be of fully welded steel construction of sufficient rigidity to provide the required support for the equipment on vibration isolators. The top of the frame shall not be less than L/10 where "L" is the longest side of the frame or 100mm whichever be the greater.

3.11.2 Fixing positions for mountings shall be provided either as fixing holes in the lower flanges of the frame or by recessed height reducing corner brackets as appropriate. For frame lengths in excess of 1600mm it will be normal for a minimum of six mounting positions to be provided.

3.11.3 The equipment and any ancillary parts shall be arranged on the baseframe so as to distribute the load as evenly as possible over the mounting positions and NOT to overhang the frame.

3.12 RUBBER CARPET FOR CONCRETE INERTIA BASE (TYPE RP)

3.12.1 Studded type rubber carpet isolators shall be the principal isolation element laid in single (or double) layer on a raised plinth beneath the concrete inertia base. Each carpet isolator shall be a flat rubber mat with circular moulded studs.

3.12.2 Steel sheeting will be supplied in standard sections to be cut to size on site for covering rubber carpet isolators before pouring concrete.

3.12.3 Self adhesive waterproof tape shall be supplied for sealing joints between steel sheets and also for sealing joints between steel sheets and shuttering for the sides and ends of the concrete inertia base.

3.12.4 Drawings showing details of the concrete inertia base, layout of isolating material and giving instructions for laying material will be provided.

3.13 RUBBER PAD TYPE ISOLATORS FOR SECONDARY ISOLATION OF AHU'S ETC (TYPE SRP)

3.13.1 Rubber pad type isolators shall be sections cut from Rubber Carpet Isolators as detailed in Section 3.12.

3.13.2 A suitable thickness mild steel spreader plate will be supplied adhered to the isolator for applications where the equipment does not locate over the full area of each pad. A Neoprene pad shall be adhered to the steel plate to provide friction location for the equipment.

3.13.3 Rubber Pad Type Isolators shall be free standing with friction location only. The use of fixing screws/bolts will not normally be permitted.