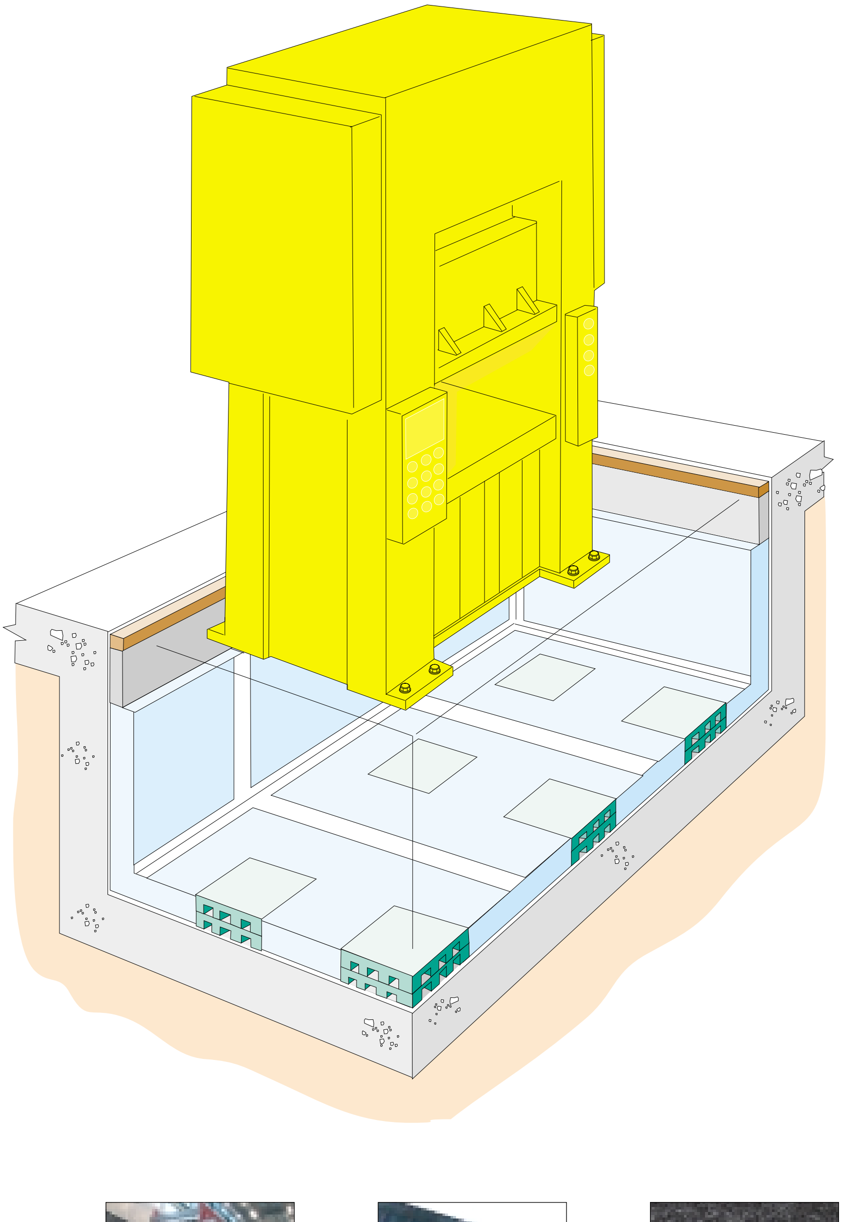
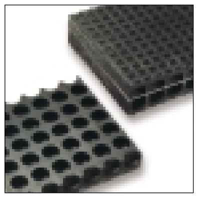
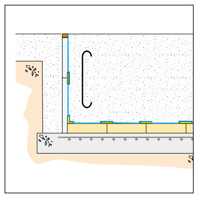
CAT 4.07

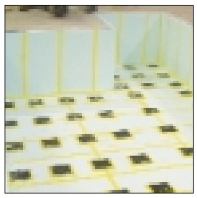
Farrat Isolevel

Foundation Shock and Vibration Isolation Systems for Structures, Machinery and Equipment









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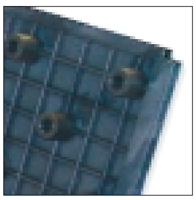
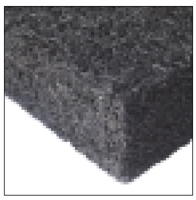




Farrat

Reasons for using isolated foundations

- Increasing machine frame stiffness to maintain alignment during changes in applied static and dynamic loads.
- Minimising changes in level due to alterations in static load distribution
- Increasing inertia mass of the machine and reducing vibration through mass damping.
- Lowering the centre of gravity to improve stability.
- Distributing static and dynamic loads over a greater ground area.
- Isolating low frequency of shock and vibration using more elastic vibration isolators than could be used between machine and foundation.
- Low frequency disturbing vibration requires low frequency, high deflection vibration isolators. On machinery requiring low operating motion amplitudes an isolated foundation is essential if low frequency vibration isolation is required.

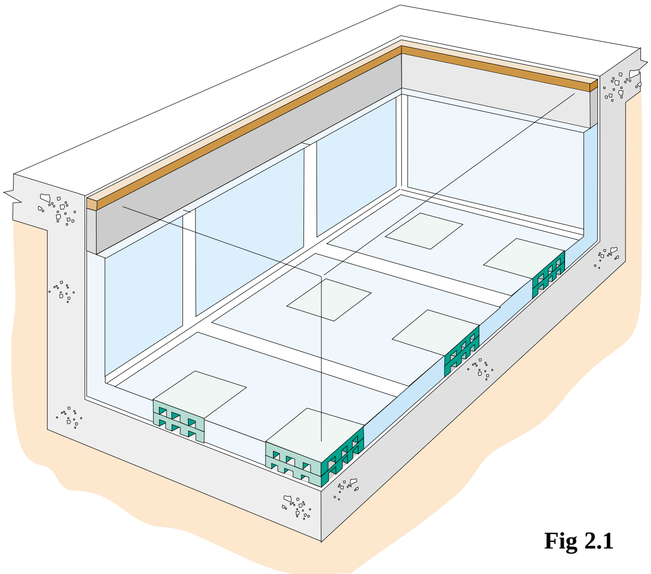
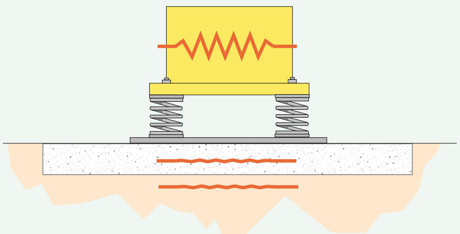


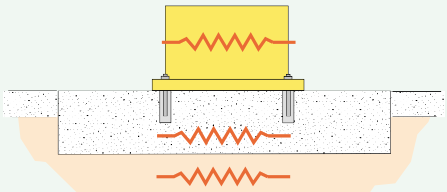
Fig 2.1

Fig 2.2



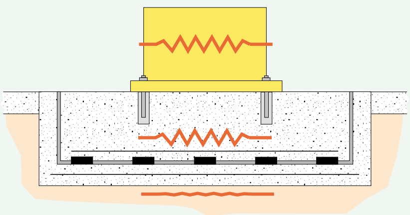
Machine on isolators on the floor, no foundation

Fig 2.3



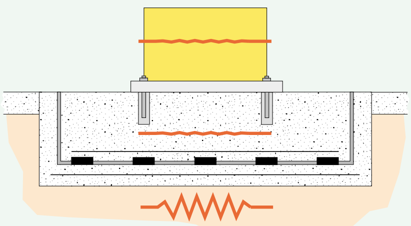
Machine on foundation, no isolation

Fig 2.4



Machine on isolated foundation, active shock and vibration

Fig 2.5



Machine on isolated foundation, passive shock and vibration

Vibration Control/Isolation
Vibration Control involves the correct use of a resilient mounting or material in order to provide a degree of isolation between a machine and its supporting structure. A condition should be achieved where the amount of vibration transmitted from, or to, the machine is at an acceptable level.

To achieve efficient vibration isolation it is necessary to use a resilient support with sufficient elasticity so that the natural frequency fn of the isolated machine is substantially lower that the disturbing frequency fe of vibration. The ratio fe/fn should be greater than 1.4 and ideally greater than 2 to 3 in order to achieve a significant level of vibration isolation

Damping provides energy dissipation in a vibrating system. It is essential to control the potential high levels of transient vibration and shock, particularly if the system is excited at, or near, to its resonant frequency.

Active Shock and Vibration Isolation
A foundation block for a dynamic machine should be isolated in order to reduce the effects of vibration and shock on nearby machines, people and the building structure. Controlling the source of a structural disturbance is known as active isolation.

Applications include: isolation of foundations for: power presses, pumps, drop hammers, forging machines, metal forming and cutting machines, compressors, gensets, engines and test rigs, printing machines and rolling roads.

Passive Shock and Vibration Isolation
When it is not possible to prevent or sufficiently lower the transmission of shock and vibration from the source a resiliently supported foundation block can be used for the passive isolation of sensitive equipment.

Applications include: isolated foundations for: machining centres, grinding machines, measuring and inspection equipment, laser cutters and microscopes.

Vibration Sources and Control www.farrat.com

Sources of vibration in rotating machines	
Source	**Disturbing Frequency *fe* Hz**
Primary out of balance	1 x rpm x 0.0167
Secondary out of balance	2 x rpm x 0.0167
Shaft misalignment	2 x rpm x 0.0167
Bent Shaft	& 2 x rpm x 0.0167
Gears(N=number of teeth)	N x rpm x 0.0167
Drive Belts (N=belt rpm)	N,2N,3N,4N x 0.0167
Aerodynamic or hydraulic forces	(N=blades on rotor) N x rpm x 0.0167
Electrical (N=synchronous frequency)	N x rpm x 0.0167

Significant problems occur when the disturbing frequency *fe* is near to or coincident with the natural frequency of the supporting structure (floor, foundation or subsoil).

Typical support natural frequencies (*fn*)

Structures	Natural Frequency *fn* Hz	Isolator Frequency *fni* Hz	Isolator type
Suspended concrete floor	10-15	3-5	Helical, Air Springs
Ground Floor	12-34	6-8	Helical, Air Springs, Elastomeric
Soft Clay	12	6-8	Helical, Air Springs, Elastomeric
Medium Clay	15	6-8	Elastomeric Isolators
Stiff Clay	19	8-10	Elastomeric Isolators
Loose Fill	19	8-10	Elastomeric Isolators
Very dense mixed grain sand	24	10-12	Elastomeric Isolators
Limestone	30	10-12	Elastomeric Isolators
Hard Sandstone	34	10-12	Elastomeric Isolators

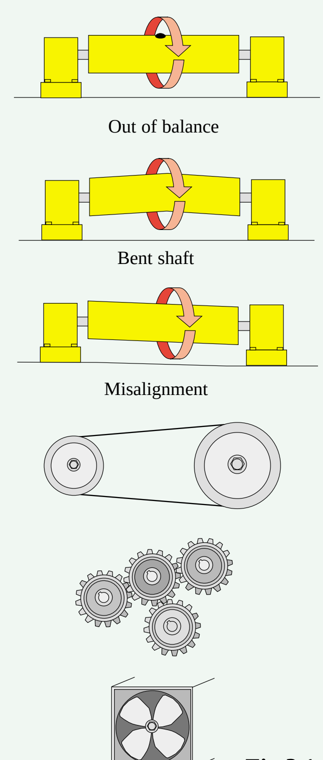


Fig 3.1

Theory of Vibration Isolation www.farrat.com

Vibration Isolation
Vibration Isolation reduces the level of vibration transmitted to or from a machine, building or structure from another source.

The degree of isolation achieved depends on the ratio:

$$\frac{\text{Frequency of disturbing vibration}}{\text{Natural frequency of isolator}} = \frac{fe}{fn}$$

2: The level of isolator damping C/Cc
Referring to the diagram 3.07, the degree of isolation is given as Transmissibility (i.e. amount of vibration transmitted at a specific frequency *fe* as a fraction of the disturbing vibration at the same frequency *fe*).

Transmissibility:

- > 1 = Increased transmitted vibration
- = 1 = No vibration isolation
- < 1 = Vibration isolation

Transmissibility T can be read from diagram 3.2 or calculated as follows: If no damping present in isolators i.e. **C/Cc = 0**

Undamped systems:

$$\textbf{Transmissibility } T = \frac{1}{1 - R^2}$$

Damped systems:

$$\textbf{Transmissibility } T = \sqrt{\frac{1 + \frac{R^2}{Q^2}}{(1 - R^2)^2 + \frac{R^2}{Q^2}}}$$

$$R = \frac{fe}{fn} \qquad Q = \frac{1}{2\,C/Cc}$$

fe - disturbing frequency can be determined by measurement. The isolator natural frequency ***fnd*** is given by:

$$fnd = \frac{1}{2\pi}\sqrt{\frac{Ktd}{M}} \text{ Hz}$$

Ktd = Sum of Isolator Dynamic Spring Constants ($K_1+K_2+K_3$...) N/m
M = Supported system mass kg.

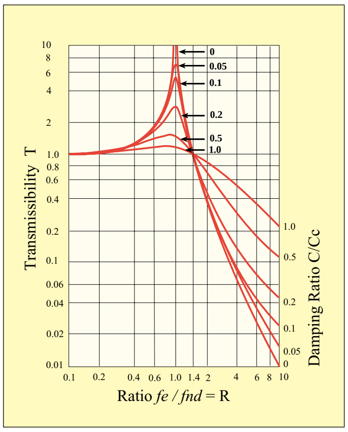


Fig 3.2

For natural rubber and coil spring isolators static and dynamic spring constants are the same.

Damping Factor	frequency ratio R *fe/fn*							
C/Cc	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**	**4.5**	**5.0**
0.05	20	66	80	87	91	93	94	95
0.10	19	64	79	85	89	91	93	94
0.15	17	62	76	83	87	90	91	93
0.20	16	59	74	81	85	87	89	91
0.30	12	52	67	75	80	83	85	87
	Percentage Isolation Efficiency							

Farrat are certified to TUC UKQA ISO 9001/2000

Reasons for isolating the effects of shock

Shock is created by impact of one mass against another e.g. during operation of power presses, forging machines, drop hammers etc. The shock impulse caused by the impact travels through the machine structure as a deflection wave. If the machine is rigidly connected to its foundation this deflection wave enters the foundation and the surroundings. The shock will generally cause the affected masses to vibrate at their own natural frequencies.

Reduction in shock severity by use of suitable isolators is achieved by the isolators storing the energy of the shock through isolator deflection and subsequent release in a smoother form over a longer period with lower overall amplitude.

A shock pulse may contain frequency components from 0-∞. It is therefore not possible to avoid resonance with the isolator/mass. If however the duration of the shock pulse is less than one half period of the isolation system resonance may not be serious.

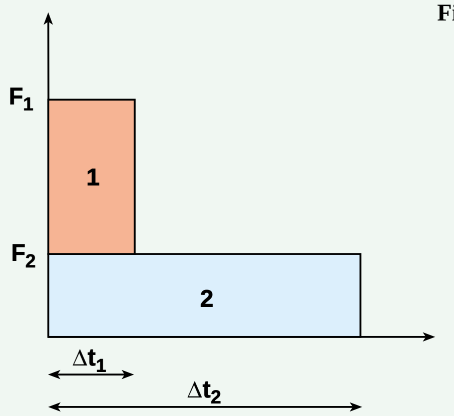
Figure 4.1
Shows the output force (into the supporting floor) v time levels from a machine produced shock wave. In case 1 the machine under consideration is connected directly to the supporting floor. Case 1 shows a high level of force over a relatively short duration. Case 2 typifies a machine installed on spring or elastomeric isolators in conjunction with a foundation block. It can be seen that the same amount of energy is transmitted in both instances. However in case 2 the energy is transmitted over a much larger time scale resulting in a substantially lower peak force. In reality the force transmitted will present itself as noise and structure borne vibration detectable by humans, it is therefore desirable in most instances to keep the peak value of transmitted force as low as possible by using on spring or elastomeric isolators between the machine and foundation or an elastically supported foundation block.

Figure 4.2
Shows a machine/structure that is rigidly connected to its foundation. The peak force into the structure is very high and of relatively short duration. Essentially all the force that occurs in the machine is transferred to the structure with the exception of that which is absorbed by the machine.

Figure 4.3
Illustrates the use of elastomeric or spring isolators between the machine and the supporting foundation. In this scenario with the correct isolator specification the peak force transmitted to the supporting foundation is significantly reduced resulting in reduced structure borne noise and transmitted vibration.

Figure 4.4
Illustrates the use of spring or elastomeric isolators supporting a foundation block. In this instance the peak force transmitted is reduced to virtually zero. The foundation block increases the system mass and reduces machine vibration and movement through mass damping.

Fig 4.1



F_1 = Shock force
F_2 = Transmitted force
Transmitted force only becomes less than the input shock force where :

$\Delta t_1/T_n$ <0.167 for rectangular pulses
$\Delta t_1/T_n$ <0.267 for half sine pulses

T_n= Period of isolator supports =1/*f*n
f_n = Isolator Natural Frequency Hz
Δt_1= Period of pulse
Δt_2 = Period of transmitted shock

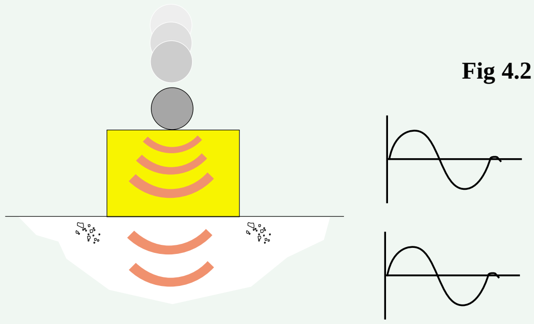


Fig 4.2

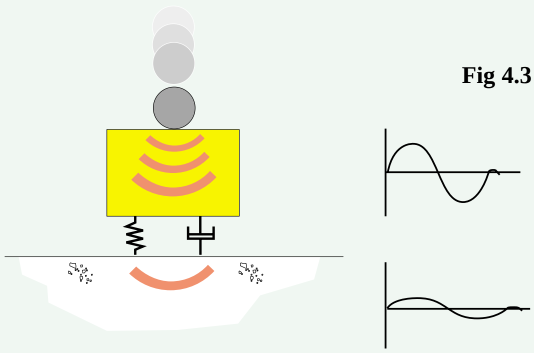


Fig 4.3

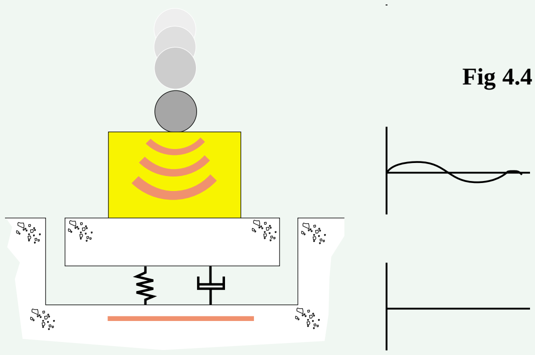
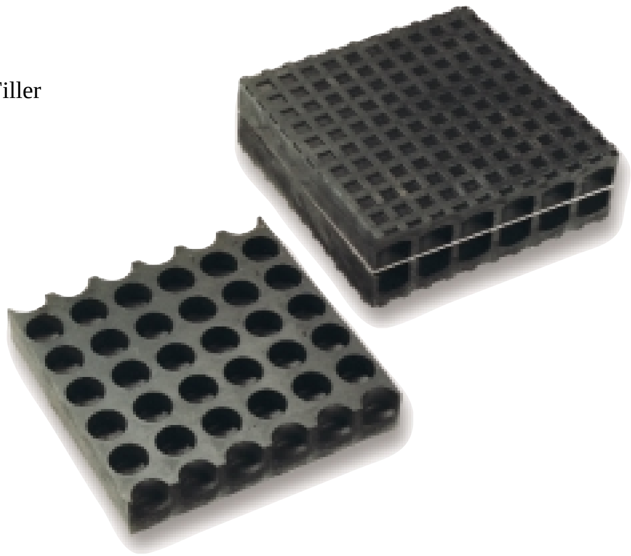


Fig 4.4

High precision machine foundation vibration isolation



Description
ISOMAT foundation isolators used in conjunction with **FVF** Farrat Base Void Filler and **LVI** and/or **ISF** Sidewall Vibration Isolation materials provide highly predictable performance characteristics over many years of service.

ISOMAT is produced in three rubber types

IM CR Neoprene for high elasticity, moderate damping and self extinguishing properties. Conditional oil and chemical resistance
IM NR Natural Rubber for maximum elasticity and low damping (passive isolation) Poor oil and chemical resistance
IM BR Nitrile Rubber for excellent combination of elasticity, damping and excellent oil and chemical resistance.

Working Temperature Range: ^{o}C: -30 to +120
Creep: Very Low

Building materials class: B2

Complete chemical resistance tables available on request.
Farrat would advise on most suitable **ISOMAT** grade for each application and provide full specification, predicted natural frequencies, damping, layout drawings and installation instructions.

Description of Diagram
1) Polymeric Sealant (eg Sikaflex Pro-3WF) or rubber sealing strip to prevent moisture ingress.
2) Top strip **Vidam VM** or **ISF**.
3) Reinforced concrete foundation block.
4) Sidewall Isolation: **ISF**, **FVF 15-50** or **LVI**.
5) **JLT** Joint line tape to all joints.
6) Reinforced impermeable concrete forming tank
7) Damp proof membrane DPM. Minimum 1000gsm.
8) **ISOMAT** Isolators.
9) Base void filler, **FVF-10-50.**
10) Consolidated hardcore to firm ground.

* Reinforced concrete foundation blocks and associated structures to be designed by qualified consulting engineers and constructed by contractors of proven ability and experience.

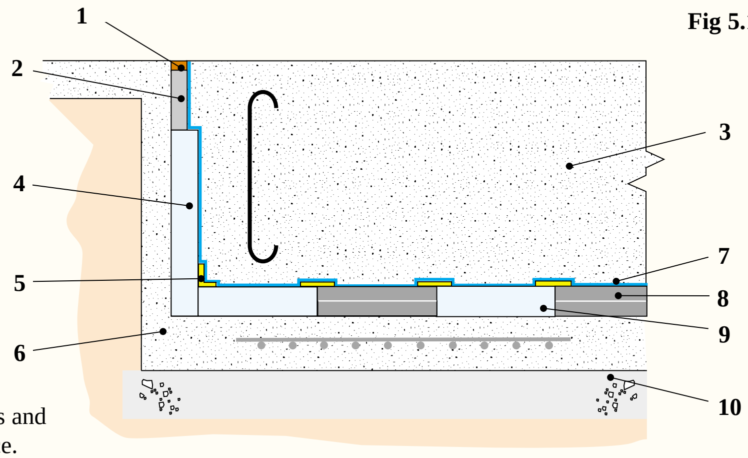


Fig 5.1

Isomat Foundation Shock and Vibration Isolators	Thickness	Comp. Modulus Ec	Isomat	Units	ISOMAT Isolator Standard Sizes – Other sizes available to suit application						Static Deflection Max load δ	Damping C/Cc	Vert. Nat. Freq. Static fsv	Vert. Nat. Freq. Dynamic fdv
			Length	mm	**150**	**200**	**250**	**325**	**500**	**500**				
			Width	mm	**150**	**200**	**250**	**250**	**250**	**500**				
			Area	m^2	0.0225	0.04	0.0625	0.08125	0.125	0.25				
Product	mm	N/mm^2	Max Pres. N/mm^2		**Maximum Static Loadings per ISOMAT**						mm		Hz	Hz
ISOMAT IM CR 40	25	2.7	0.35	kN	6	10	16	21	33	66	2.4	0.05	10.2	12.5
	50	2.7	0.35								4.9	0.05	7.2	8.8
ISOMAT IM NR 45	25	3.7	0.45	kN	8	14	21	27	42	84	2.3	0.01	10.5	10.5
	50	3.7	0.45								4.6	0.01	7.5	7.5
ISOMAT IM BR 40	25	3	0.4	kN	7	12.0	19	24	38	75	2.5	0.1	10.0	15.0
	50	3	0.4								5.0	0.1	7.0	10.5
ISOMAT IM BR 50	25	3.7	0.5	kN	8	15	23	30	47	94	2.5	0.1	9.7	14.5
	50	3.7	0.5								5.1	0.1	6.8	10.0
ISOMAT IM BR 70	25	6	1.2	kN	20	36	56	73	112	225	3.8	0.1	9.3	14.0
	50	6	1.2								7.5	0.1	6.6	10.0

FAVIM FVM-100 Full Area Shock and Vibration Isolation Material

Full area vibration damping and sound deadening materials for foundations, plinths and floating floors can be applied to either a concrete base or consolidated hardcore

Applications include: Machinery, HVAC, lifts and elevators, workshops, pumps, compressors and generators, industrial storage and working areas, expansion joints, helicopter pads.
Ideally suited for **medium pressure** applications.

Construction: Recycled rubber particles with a polyurethane PUR binder.
Properties: Mildew and moisture proof
Permanently elastic / Low long term creep
Temperature range ^{o}C: -30 to +110
Density: 550 kg/m^3

Building materials class: B2

Standard Sheet: 1.25m x 1.0m, 1.0m x 1.0m, 1.0m x 0.5m.
Other sizes, pads and strips available on request.

Favim can be applied either direct to a consolidated hardcore base or a reinforced concrete pit base depending upon the site conditions

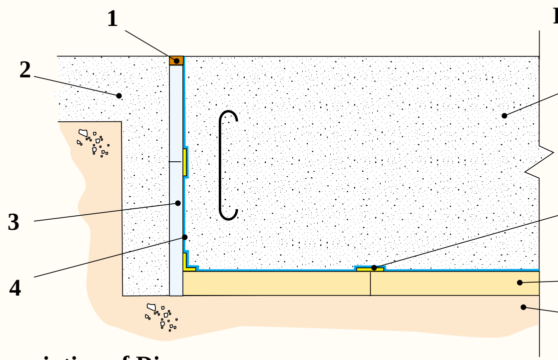


Fig 8.1

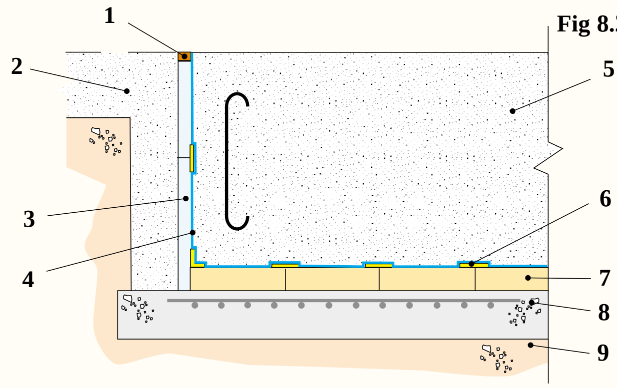


Fig 8.2

Description of Diagram

1) Polymeric sealant or sealing strip (Not supplied by Farrat).
2) Reinforced impermeable concrete to sides and base of pit. (Fig 8.2) Thickness and concrete specification to be determined by ground and loading conditions.*
3) Farrat **LVI** or **ISF** side wall vibration isolation material, spot bonded to pit walls using WB Adhesive.
4) Damp proof membrane DPM. Minimum 1000gsm.
5) Steel cage reinforced concrete foundation block designed to support imposed dynamic and static loads and suitable for elastic support.*
6) **JLT** Joint line tape to all joints.
7) **Favim 100** full area vibration isolation material to the pit base.
8) Reinforced concrete pit base.* (Fig 8.2)
9) Consolidated hardcore base.

Favim 100
Full area vibration isolation material — Performance table to be used as a guide only.

Product	Favim	FVM	100-12	FVM	100-25	FVM	100-50
Static Loading Pressure **SLP** kPa	Dynamic Comp. Modulus **Edc** MPa	Static Deflection **δ** mm	Dynamic Vert. Nat. Frequency ***fvd*** Hz	Static Deflection **δ** mm	Dynamic Vert. Nat. Frequency ***fvd*** Hz	Static Deflection **δ** mm	Dynamic Vert. Nat. Frequency ***fvd*** Hz
25	2.57	0.2	43	0.5	30	0.9	22
30	2.63	0.3	41	0.7	29	1.3	20
40	2.63	0.5	37	1.1	26	2.2	19
50	2,64	0.8	31	1.5	22	3.0	16
60	2.65	1.0	29	2.0	20	4.1	14
70	2.65	1.3	27	2.5	19	5.1	13
75	2.65	1.4	26	2.8	18	5.6	13
80	2.70	1.6	25	3.1	18	6.2	12
90	2.70	1.9	24	3.7	17	7.5	12
100	2.71	2.2	23	4.4	16	8.7	11

Dynamic vertical natural frequency	***fvd***	Hz	= (1/(N)^0.5)* *fvd* (for one layer)
Static deflection	**δ**	mm	= N x deflection for one layer
Specific spring constant	**Kss**	N/mm/mm^2	= Kss (for one layer)/N
Spring constant	**K**	N/mm	= Area mm^2 *Kss
Vertical natural frequency	***fvd***	Hz	= 15.76*(1/d)^0.5
Number of layers	**N**		

* Reinforced concrete foundation blocks and associated structures to be designed by qualified consulting engineers and constructed by contractors of proven ability and experience.

Product	Thickness mm
FVM 100-12	**12.5**
FVM 100-25	**25**
FVM 100-50	**50**

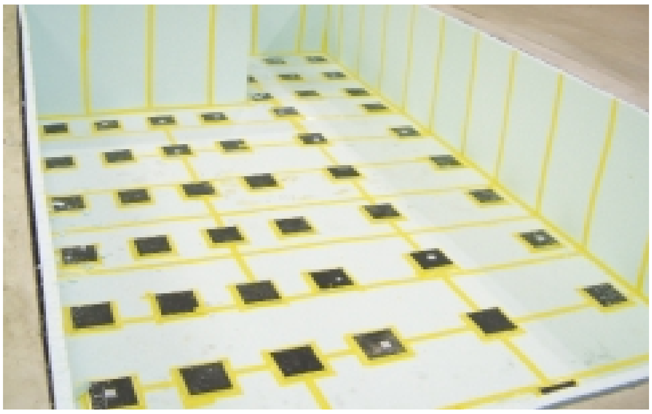
Other thicknesses available on request.

ISOLAY isolated foundation for CNC Machining Centre

CNC machining centre on **ISOLAY** isolated foundation

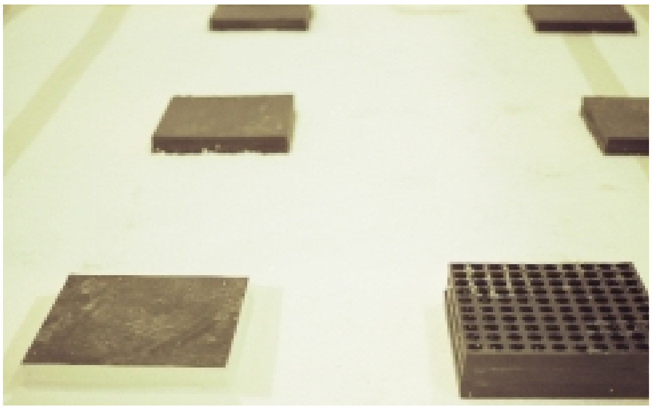
ISOMAT isolated foundation for large Cerutti printing press

Cerutti Printing Press on **ISOMAT** isolated foundation



ISOMAT isolated foundation for Rhodes 2500 kN Power Press

Rhodes 2500kN Power Press on **ISOMAT** isolated foundation



ISOMAT/FVF isolated foundation for metal recycling and crushing machine

Metal recycling and crushing machine on **ISOMAT/FVF** isolated foundation

Low Frequency Shock & Vibration for active and passive applications.

Fig. 14.1
In the case of spring and air mounts it is advisable to have an access gap around the foundation for maintenance reasons.

Fig 14.1

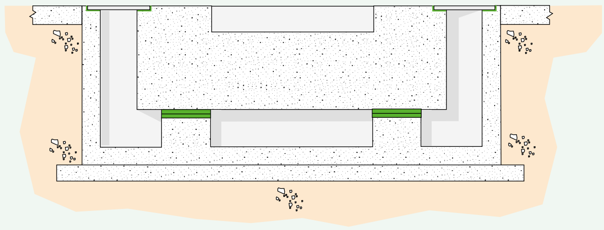


Fig. 14.2 a/b
Where a machine has a high center of gravity it is usually desirable to keep the centre of gravity as low as possible to avoid instability of both machine and foundation.

For this reason a stepped foundation block can be employed. By reducing the vertical distance between the anti vibration mount and the combined machine/foundation centre of gravity the stability of the entire system is dramatically increased.

Fig 14.2a

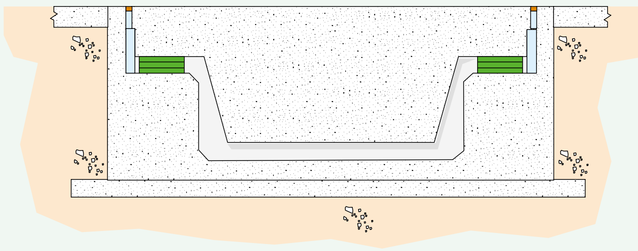
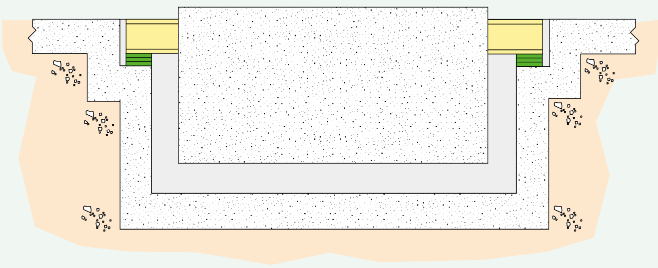


Fig 14.2b



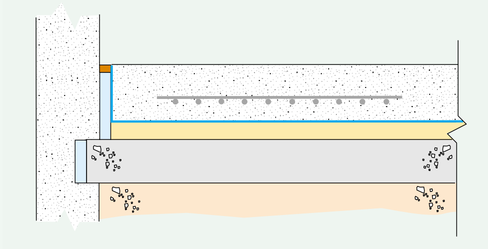


Fig. 14.3 Floating floor, **Isolay** or **Favim**

Fig 14.4

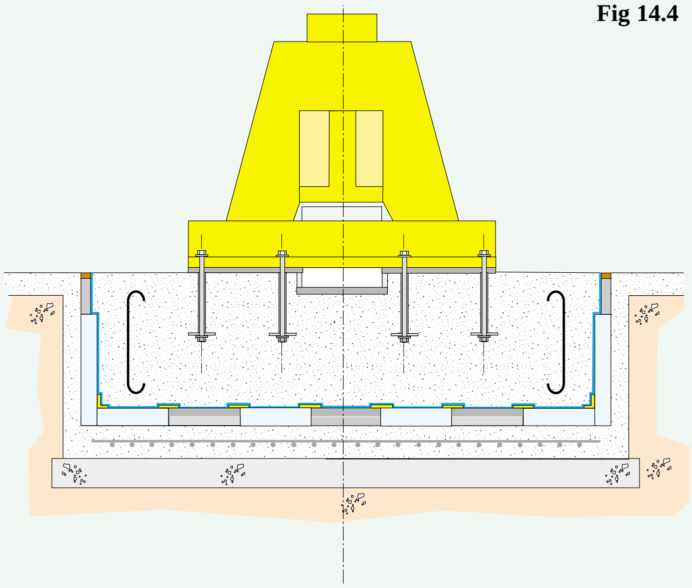
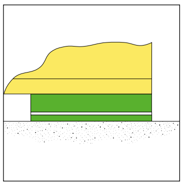
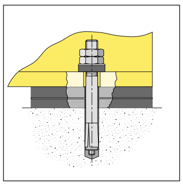


Fig. 14.5
Where forging hammers and other such shock creating machinery is used it is advisable to put vibration isolation systems both directly under the machine and beneath the foundation block.

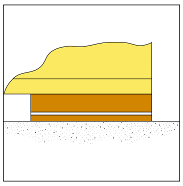
This has the effect of minimising the shock wave that is transmitted through the surrounding floor, thus reducing noise and structure borne vibration.



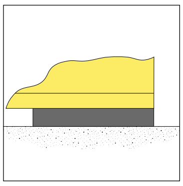
Squaregrip (SG)
High strength vibration damping material for machinery and equipment needing a stiff vibration damped support with minimum machine movement.



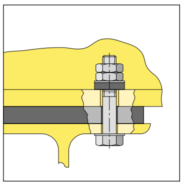
NBR
An elastic vibration isolation material with good shock and vibration isolation properties.



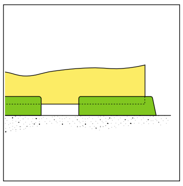
Vidam (VM)
General Purpose, rubber/cork based machine mounting material.



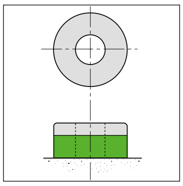
Isomat (IM)
High performance shock and vibration isolation material. Unique design provides increased elasticity and improved isolation efficiency.



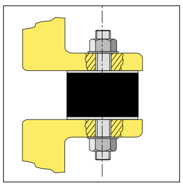
Hamamat (HM)
High impact, high strength and high stiffness shock and vibration absorbing material.



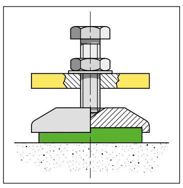
Corner / Side Foot (CF, SF)
General purpose machine mounting pads



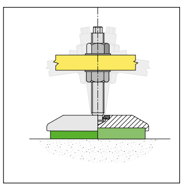
Anti Vibration Washers (AW, AWS)
To reduce vibration transmitted to, or from, holding down bolts



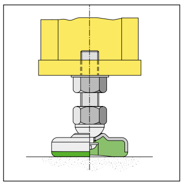
Rubber to Metal Bobbins (RM)
Versatile rubber-to-metal bonded vibration and shock isolators, available in a broad range of fixing configurations



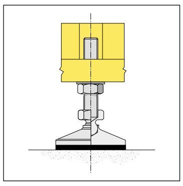
Jackmounts (JCM, JRM, JSM, JMS)
General purpose machine mounts.
Different anti vibration versions depending on applications.



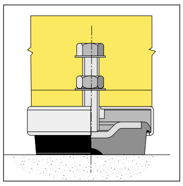
Captive Jackmounts (JMP, JMSP)
Machine mount with captive pendulum levelling screw. Cast iron and stainless steel versions.



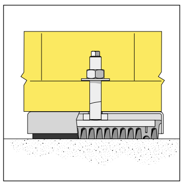
MF Mounts (MF)
Pressed Steel Mount fitted with Nitrile Rubber Pad for lighter applications.
MF P: Zinc Plated Steel,
MF S: Stainless Steel 304



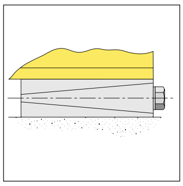
Levelling Mount (LF)
High precision stainless steel (304) levelling mounts with captive ball nosed levelling screws.



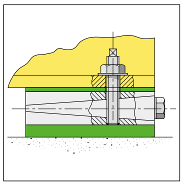
Isomounts (ISO)
Machine mount with vulcanized rubber base and built in levelling screws for height adjustment.



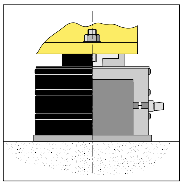
Isobloc (ISB)
High load capacity machine mount with vulcanized rubber base and built in levelling screws for height adjustment.



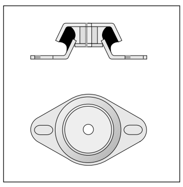
Wedge Levelling Elements (WLE)
Precision Wedge Levelling units for rigid machine support



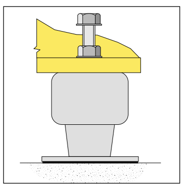
Wedgemounts (WL, WLF, WLB, WLT)
Height adjustable machine mounts based on screw driven three part machined cast iron wedges fitted with various types of vibration damping material.



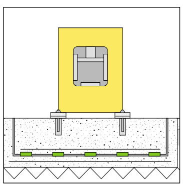
Air Mount (SLM)
Low profile, low frequency air spring suitable for both passive and dynamic applications where a support natural frequency of 3 - 5 Hz is required.



Equipment Mount (CCF, CCFQ, LTS)
All purpose vibration & shock isolators for the support of dynamic and rotating machinery



Spring Mounts (SM)
Low frequency anti-vibration mountings with damping control and adjustable levelling for efficient isolation of active and passive machinery.



Isolated Foundations (IF)
Shock and vibration isolation for machine foundations and structures.

Farrat

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