KINETICS® RIM
Roll-Out Floor Isolation System

Essentials
- Proven effectiveness over the lifetime of an installation
- Quick installation time
- Constant System natural frequency
- Flexible capacities allow design for any load; from light wood floors to heavy mechanical equipment rooms.
- When used in conjunction with ceiling and wall separation products, RIM is an essential component of “room-within-a-room” sound isolation construction.

Application
Kinetics Noise Control’s premier rollout system easily creates an airspace of 1 to 4 inches and incorporates a high-performance resilient decoupler. The isolation material with KIP isolators selected and spaced according to design criteria offers major advantages over other systems. Installation labor is substantially reduced, as it is easier to roll out batting with pre-spaced isolators versus measuring for and placing individual isolation mounts. This feature also ensures that the system will reach the high levels of expected performance. This system is designed to meet requirements for; load capacity, natural frequency/pad deflection, and acoustical performance.

Floor Isolation Theory
Floor isolation systems are incorporated into building design to minimize floor impact noise and airborne sound transmissions. A “floated” floor (or rooftop) is supported by resilient mounts installed on the structural floor or rooftop. The design of an effective isolation system is dependent on several factors including:

1. Stiffness and mass of the structural floor,
2. Isolation mount natural frequency and damping characteristics,
3. Airspace height and venting,
4. Mass and composition of the floated floor,
5. Sound absorption in the airspace,
6. Control of sound flanking paths.

Creating airspace between the structural and isolated floors while decoupling the two floors with the appropriate resilient mount effectively controls noise transmission. Maximum effectiveness of floating floor composite construction is achieved when the finished floor is fully isolated from the building structure and non-structural components, such as ductwork and piping. Accordingly, airborne and impact noise transmissions are greatly reduced between the room incorporating the floating floor system and other parts of the building. Additionally, floating floor systems are often used to prevent transmission of vibration and airborne noise from entering into the space in which the floating floor is installed.

Installation Sequence

1) Place Perimeter Board (PPI)

2) Roll-out RIM and cut as needed

3) Secure junction plates on plywood pouring form

4) Cover with poly layer. Ready to install reinforcement and pour concrete.

RIM for Concrete Floated Floors

Successfully installed for years under concrete floors found in mechanical rooms, studios, ballrooms, fitness centers, and theaters, Kinetics Noise Control's RIM System remains the leading formwork technique for isolating concrete slabs in any floor or roof system requiring sound abatement. An original, RIM System consistently provides continuous, high-performing noise control for critical applications. Our pour-in-place floor isolation system incorporates all critical components needed in a top-performing noise control system including: KIP isolators fixed in fiberglass batting, PPI Perimeter and Penetration Interface, spray adhesive, plywood junction plates, polyethylene sheeting and tape, and resilient, non-hardening perimeter sealant. KIP isolators spaced 12-, 16-, or 24-inches on center are available in different densities allowing for a multitude of load ranges under a single slab while maintaining a constant natural frequency. Factory-trained sales representatives can help designers determine which system to use based on dead and live load requirements. Kinetics Engineering Group will provide design submittals. The fiberglass batting with KIP isolators prespaced is rolled-up and delivered in poly bags along with the specified accessories to the jobsite.

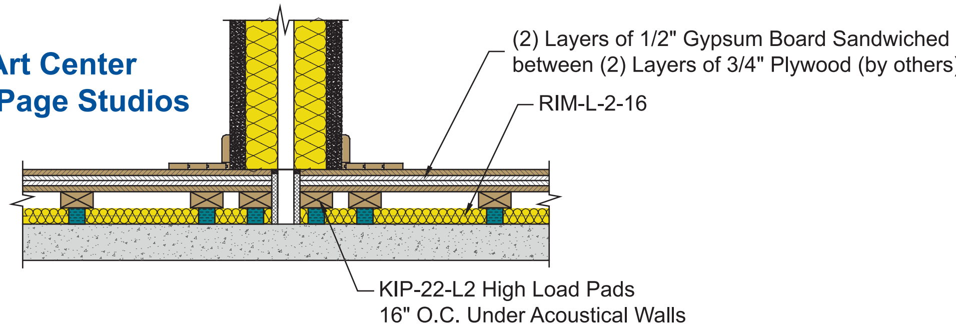
Benefits

- Greater load capacity at a lower cost
- Can be designed for any load range
- Easy to create 1", 2", 3", and 4" airspaces
- Fast, simple, inexpensive installation
- Factory installation and supervision available
- RIM System successfully installed for over 45 years
- Natural Frequency constant over a wide load range

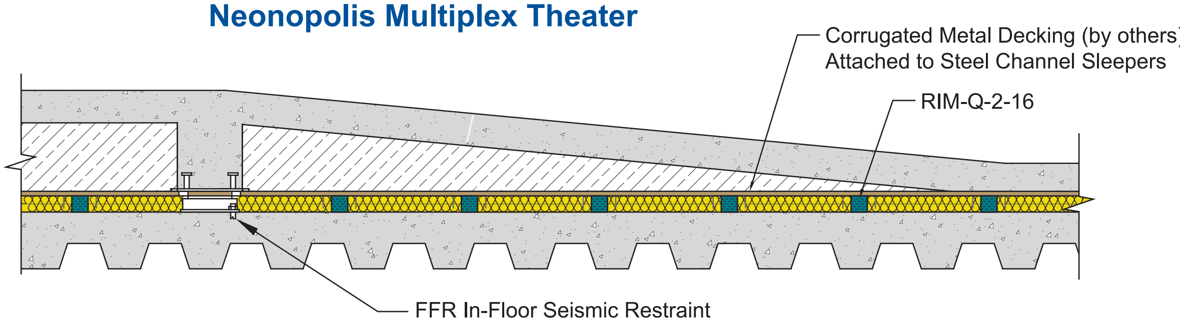
Installation Sequence

Installation of RIM is quick and easy. Decouple the area being treated by installing Perimeter and Penetration Interface (PPI) around the perimeter of the room. Additionally, PPI is used as a resilient break against any other non-isolated elements such as curbs, drains, ductwork, adjacent floors, pipe, and walls. The fiberglass batt with pre-spaced isolation pads is then rolled out over the structural floor. A pouring form is created by placing plywood on top of the isolators, and is held together using junction plates and screws. Two layers of 6-mil poly overlapped and taped at the seams cover the pouring form as temporary waterproofing. Concrete reinforcement is installed and then concrete poured in place. As dictated by the designer, trades can move about the floor to complete work in the space without the concrete having been cured to full strength – the floor is already positioned at final design elevation. There is no worry about keeping the floor clear for a second visit to "lift" the slab by an installation crew. The final installation step of the RIM System requires removing the PPI tear strip and sealing the perimeter of the floating floor with resilient, non-hardening caulk.

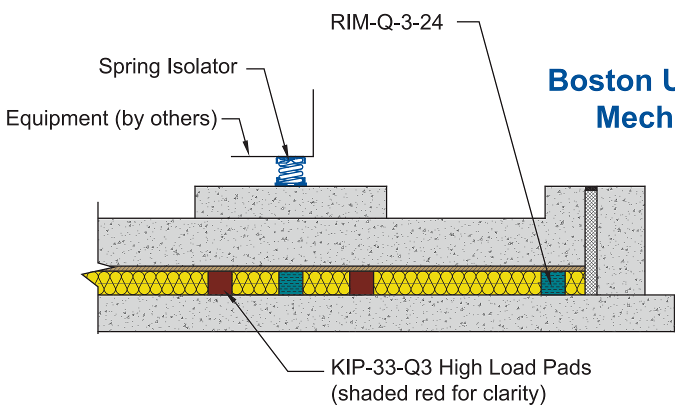
McAinch Art Center College of DuPage Studios



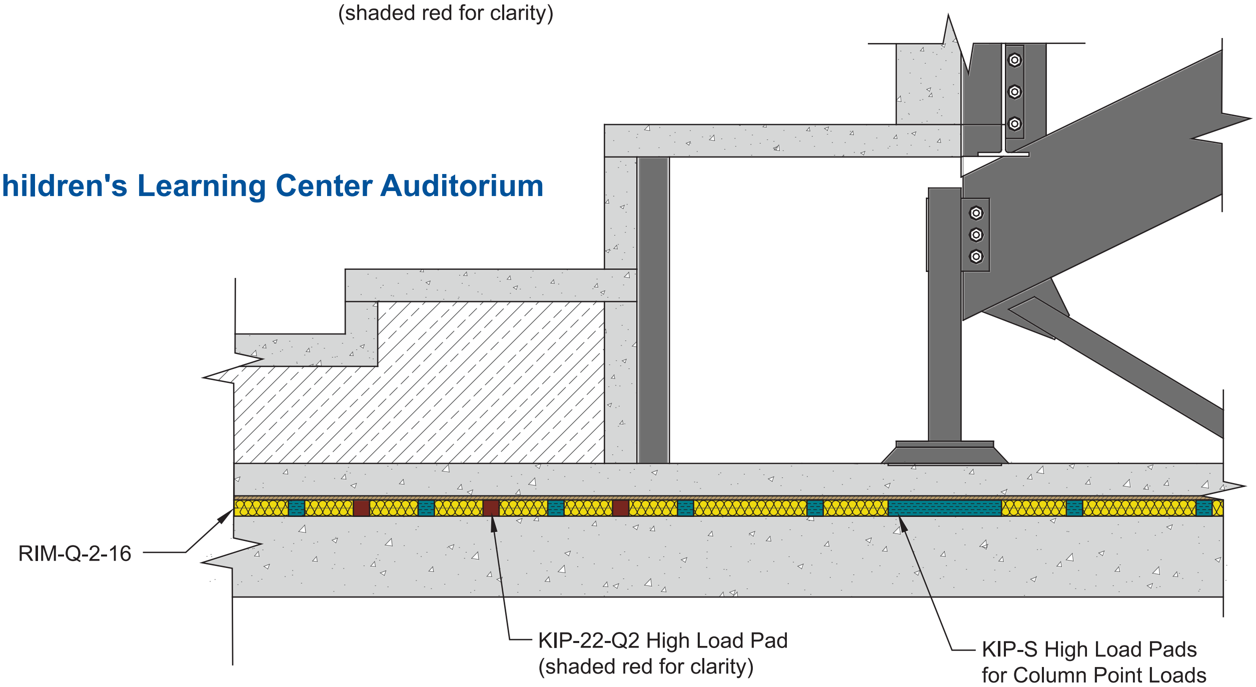
Neonopolis Multiplex Theater



Boston University Arena Mechanical Room



Children's Learning Center Auditorium



RIM for Wood Floated Floors

RIM System wood floated floors are ideally suited for dance studios, loft style condominiums, recording studios, and other applications where high performance noise control is required in conjunction with a lower profile, light weight assembly. A RIM System floated wood floor surpasses performance of continuous underlayments due to the airspace and lower natural frequency created by the KIP pads spaced at 12-, 16-, or 24-inches on center. RIM System can be supplied to fit any load condition. In the cases of free weight drops like those seen in fitness centers, please consider that lightweight composite floors can prove insufficient standing up to shock loads. Damage to the lightweight floor and isolators can occur depending on the impact/shock loads. Contact Kinetics for guidance when designing these projects.

Benefits

- Can be designed for any load range
- Easy to create 1", 2", 3", and 4" airspaces
- Fast, simple, inexpensive installation
- Optional channels or nailers can be used for stiffness and increased airspace

Installation Sequence

Installation of RIM System for a wood floated floor is similar to that of the isolated concrete slab. Starting with a level subfloor, a 3/8” thick strip of SRP (perimeter isolation board) is adhered to all non-isolated walls (the height of SRP is dictated by the height of the finished floor). The rolls of batting with secured pads are rolled out into place. If heavy point loads exist, individual KIP pads are then placed per submittal drawings. Typically, two layers of 3/4" plywood are laid (seams staggered) over the isolation pads, and the finished floor is installed according to the manufacturer’s instructions. While two layers of 3/4" plywood often proves suitable for most isolated wood floor composites, consider using three layers of plywood, glued and screwed together for added stiffness and mass, which aids in load distribution and noise control. Compare sound test AT001035 with AT001036 and discover how adding mass can boost STC results. The installation is completed by applying acoustical caulking to the top of the SRP board.

Installation Sequence

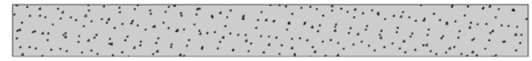
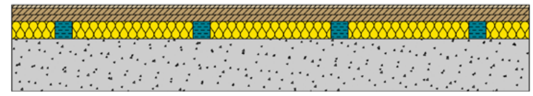
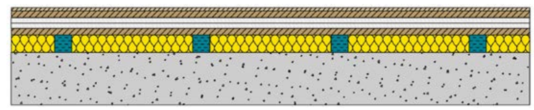
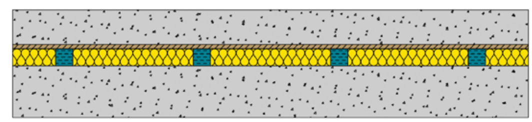
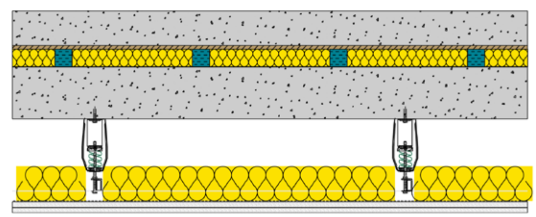
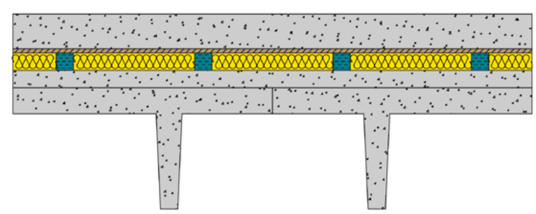
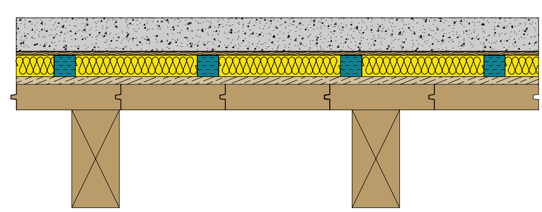
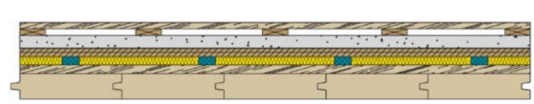
1) Place Perimeter Board (SRP)

2) Roll-out RIM

3) Build-up isolated subfloor

4) Apply finish floor per manufacturer instructions

Acoustical Tests

6" Concrete Slab	STC 53	IIC 27	 **KINETICS** Test #AT001049
3/8" Plywood 2 Layers 3/4" Plywood **KINETICS RIM I-2-16** 6" Concrete Slab	STC 66	IIC 63	 **KINETICS** Test #AT001035
3/8" Plywood 3/4" Plywood 2 Layers 5/8" Drywall 3/4" Plywood **KINETICS RIM I-2-16** 6" Concrete Slab	STC 71	IIC 64	 **KINETICS** Test #AT001036
4" Concrete Slab 1/2" Plywood **KINETICS RIM-Q-2-16** 6" Concrete Slab	STC 72	IIC 62	 **KINETICS** Test #AT001030
4" Concrete Slab 1/2" Plywood **KINETICS RIM-Q-2-16** 6" Concrete Slab **KINETICS ICC Isolation Hanger** Cold Rolled Channel (CRC) Drywall Furring Channel 3-1/2" Fiberglass Insulation 2 Layers 5/8" Gypsum Board	STC 94	IIC 82	 **KINETICS** Test #AT001031
4" Concrete Slab 1/2" Plywood **KINETICS RIM L-2-12** 2" Topping Slab Precast Concrete 14" Tee	STC 73	IIC 70	 **KINETICS** Test #AT001011 / AT001012
3" Lightweight Concrete (polished) 1/2" Plywood **2" KINETICS RIM L-2-16** 3-1/2" Wood Deck Subfloor Steel Beam and Glue Lam Joist Support No Ceiling	NNIC 62	FIIC 54	 **KINETICS** Test #AT001071
1" Oak Hardwood Floor 3" Subfloor LOFT		FIIC 15	 **KINETICS** Test #AT001033
3/4" Oak Hardwood Floor 3/4" Sleepers 1-1/2" Gypcrete 2 Layers 1/2" OSB **1" KINETICS RIM L-1-16** 1" Oak Hardwood Floor 3" Subfloor LOFT W/ 1" RIM	FSTC 50	FIIC 45	 **KINETICS** Test #AT001034

Noteworthy Projects

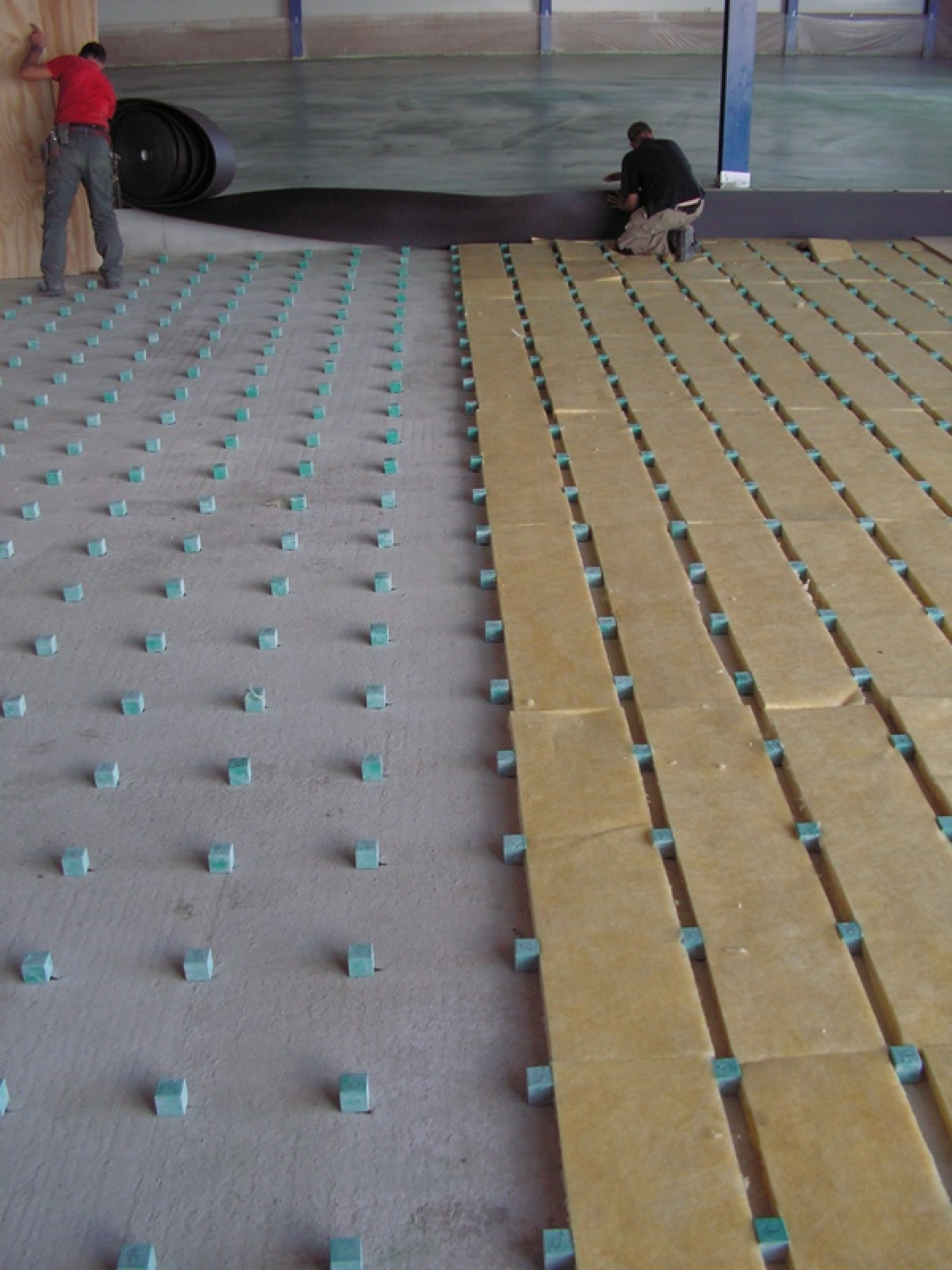
Thousands of **KINETICS RIM** systems have been installed successfully under mechanical equipment rooms, gymnasium floors, rooftops, aerobic and fitness centers, theater and cinema venues, recording and broadcasting studios, private residences, loading docks, gun ranges, and bowling centers around the world. Below, we've listed just a few of our noteworthy projects.

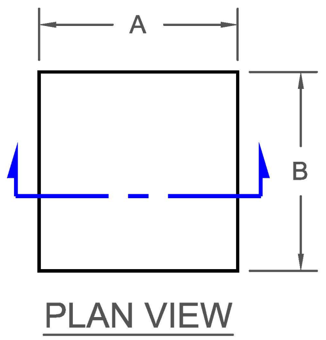
- University of Illinois Recreation Center
- Boston University Arena Mechanical Room
- 8th & I Marine Barracks Music Rooms
- Florida State University Communications Studios
- Cincinnati State Audio Studio and Control Room
- CNN Studios
- WWF Entertainment Studios
- ESPN Studios
- University of Akron Student Union Ballroom
- Naismith Basketball Hall of Fame Office and Projection Room
- Hibbing College Gun Range
- Ramsey County Law Center Gun Range
- National Underground Railroad Freedom Center Mechanical Rooms
- Soldier Field-Chicago Bears Stadium Renovation Rooftop
- Elder Shirt Lofts Condominums
- Gene Siskel Film Center Theater
- Navy Pier USO Lounge
- Lucky Strike Lanes at Gallery Place
- First Baptist Church of West Palm Beach Gymnasium and Fellowship Hall
- LA Fitness Centers
- Georgia International Convention Center Rooftop
- AMC Easton 30 at Easton Town Center
- Muvico Centro Ybor 20 Multiplex Theater
- LSU Music and Arts Building Percussion Studios
- Peabody Institute Rehearsal Hall and Percussion Room Renovation
- Brophy College Preparatory Gymnasium
- University of the Ozarks Tutoring Rooms
- IU Professional Medical Building Mechanical Room
- Cass Technical High School Mechanical Equipment Rooms
- Brown Camp Loft Condominiums

Call us to discuss your requirements for noise control, and learn how to employ the versatile, proven RIM System to solve your noise problems.

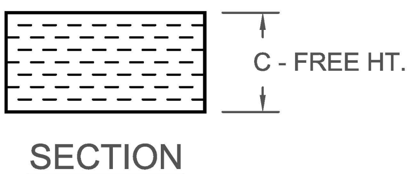
KINETICS Noise Control

kineticsnoise.com
sales@kineticsnoise.com
1-800-959-1229





All these 51mm KIP Pads high-lighted are within the $12-15 range



Christchurch Branch
International Seismic Application Technology, 18 Newnham St, Rangiora, 7440
T 64 3 310 6322 | richard@vaico.co.nz | www.vaico.co.nz
Richard How - Vaico Engineer © Vaico Ltd, March 2018

NOTE:

1. ALL PADS ARE COMPOSED OF PRECOMPRESSED FIBERGLASS.
2. ALL PADS ARE ELASTOMERICALLY COATED GREEN.
3. KIP PADS ARE AVAILABLE IN SIZES OTHER THAN THOSE SHOWN.
4. KIP PADS ARE AVAILABLE WITH STEEL LOAD PLATES.
5. FOR PAD GRAPHICAL DEFLECTION vs STATIC LOAD AND NATURAL FREQUENCY vs. STATIC LOAD CHARTS, SEE SALES CATALOG PAGE.
6. CERTIFIED PRINTS ARE AVAILABLE FOR ALL MOUNTS.

KIP PAD DATA

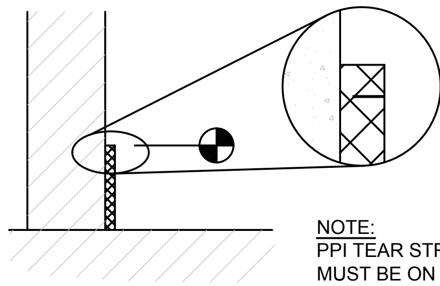
MODEL	LOADING RANGE (lb)	LOADING RANGE (kg)	STATIC DEFL. RANGE (in)	STATIC DEFL. RANGE (mm)	NATURAL FREQUENCY (Hz)	DIMENSION A (in)	A (mm)	B (in)	B (mm)	C (FREE HT.) (in)	C (mm)
~~KIP-22-G~~	20 - 100	9 - 45	~~0.17 - 0.35~~	~~4 - 9~~	~~13.1 - 15.0~~	~~2.00~~	~~51~~	~~2.00~~	~~51~~	~~1.00~~	~~25~~
KIP-22-G2			0.35 - 0.69	9 - 18	9.3 - 10.6	2.00	51	2.00	51	2.00	51
KIP-33-G1.25	45 - 225	20 - 102	0.22 - 0.43	5 - 11	11.7 - 13.4	3.00	76	3.00	76	1.25	32
~~KIP-22-I~~	29 - 140	13 - 64	~~0.16 - 0.32~~	~~4 - 8~~	~~14.1 - 14.7~~	~~2.00~~	~~51~~	~~2.00~~	~~51~~	~~1.00~~	~~25~~
KIP-22-I2			0.31 - 0.64	8 - 16	9.9 - 10.4	2.00	51	2.00	51	2.00	51
KIP-33-I3	66 - 315	30 - 143	0.47 - 0.96	12 - 24	8.1 - 8.5	3.00	76	3.00	76	3.00	76
KIP-44-I4	117 - 560	53 - 254	0.63 - 1.28	16 - 32	7.0 - 7.4	4.00	102	4.00	102	4.00	102
KIP-22-L	40 - 200	18 - 91	0.13 - 0.27	3 - 7	16.0 - 15.3	2.00	51	2.00	51	1.00	25
KIP-22-L1.5			0.20 - 0.40	5 - 10	13.1 - 12.5	2.00	51	2.00	51	1.50	38
KIP-22-L2			0.27 - 0.54	7 - 14	11.3 - 10.8	2.00	51	2.00	51	2.00	51
KIP-33-L	90 - 450	41 - 204	0.13 - 0.27	3 - 7	16.0 - 15.3	3.00	76	3.00	76	1.00	25
KIP-33-L2			0.27 - 0.54	7 - 14	11.3 - 10.8	3.00	76	3.00	76	2.00	51
KIP-33-L3			0.40 - 0.81	10 - 20	9.2 - 8.8	3.00	76	3.00	76	3.00	76
KIP-44-L	160 - 800	73 - 363	0.13 - 0.27	3 - 7	16.0 - 15.3	4.00	102	4.00	102	1.00	25
KIP-44-L2			0.27 - 0.54	7 - 14	11.3 - 10.8	4.00	102	4.00	102	2.00	51
KIP-44-L3			0.40 - 0.81	10 - 20	9.2 - 8.8	4.00	102	4.00	102	3.00	76
KIP-44-L4			0.53 - 1.08	13 - 27	8.0 - 7.6	4.00	102	4.00	102	4.00	102
~~KIP-22-Q~~	95 - 400	43 - 181	~~0.09 - 0.19~~	~~2 - 5~~	~~18.0 - 15.1~~	~~2.00~~	~~51~~	~~2.00~~	~~51~~	~~1.00~~	~~25~~
KIP-22-Q2			0.18 - 0.37	5 - 10	12.7 - 10.7	2.00	51	2.00	51	2.00	51
KIP-23-Q2	142 - 600	64 - 272	0.18 - 0.37	5 - 10	12.7 - 10.7	2.00	51	3.00	76	2.00	51
KIP-33-Q	213 - 900	97 - 408	0.09 - 0.19	2 - 5	18.0 - 15.1	3.00	76	3.00	76	1.00	25
KIP-33-Q2			0.18 - 0.37	5 - 10	12.7 - 10.7	3.00	76	3.00	76	2.00	51
KIP-33-Q3			0.28 - 0.56	7 - 14	10.4 - 8.7	3.00	76	3.00	76	3.00	76
KIP-3.38 3.38-Q2	270 - 1142	123 - 518	0.18 - 0.37	5 - 10	12.7 - 10.7	3.38	86	3.38	86	2.00	51
KIP-34-Q2	284 - 1200	129 - 544	0.18 - 0.37	5 - 10	12.7 - 10.7	3.00	76	4.00	102	2.00	51
KIP-44-Q	379 - 1600	172 - 726	0.09 - 0.19	2 - 5	18.0 - 15.1	4.00	102	4.00	102	1.00	25
KIP-44-Q2			0.18 - 0.37	5 - 10	12.7 - 10.7	4.00	102	4.00	102	2.00	51
KIP-44-Q3			0.28 - 0.56	7 - 14	10.4 - 8.7	4.00	102	4.00	102	3.00	76
KIP-44-Q4			0.37 - 0.75	9 - 19	9.0 - 7.6	4.00	102	4.00	102	4.00	102
KIP-66-Q	852 - 3600	387 - 1633	0.09 - 0.19	2 - 5	18.0 - 15.1	6.00	152	6.00	152	1.00	25
KIP-88-Q	1515 - 6400	687 - 2903	0.09 - 0.19	2 - 5	18.0 - 15.1	8.00	203	8.00	203	1.00	25
~~KIP-22-QR~~	200 - 800	91 - 363	~~0.09 - 0.16~~	~~2 - 4~~	~~18.4 - 17.2~~	~~2.00~~	~~51~~	~~2.00~~	~~51~~	~~1.00~~	~~25~~
KIP-22-QR2			0.18 - 0.32	5 - 8	13.0 - 12.2	2.00	51	2.00	51	2.00	51
KIP-33-QR2	450 - 1800	204 - 816	0.18 - 0.32	5 - 8	13.0 - 12.2	3.00	76	3.00	76	2.00	51
KIP-33-QR3			0.27 - 0.48	7 - 12	10.6 - 9.9	3.00	76	3.00	76	3.00	76
KIP-44-QR3	800 - 3200	363 - 1451	0.27 - 0.48	7 - 12	10.6 - 9.9	4.00	102	4.00	102	3.00	76
KIP-22-R	291 - 1200	132 - 544	0.07 - 0.12	2 - 3	22.0 - 19.4	2.00	51	2.00	51	1.00	25
KIP-22-R1.5			0.10 - 0.18	3 - 4	18.0 - 15.8	2.00	51	2.00	51	1.50	38
KIP-22-R2			0.13 - 0.23	3 - 6	15.6 - 13.7	2.00	51	2.00	51	2.00	51
KIP-33-R0.5	655 - 2700	297 - 1225	0.03 - 0.06	1 - 1	31.1 - 27.4	3.00	76	3.00	76	0.50	13
KIP-33-R2			0.13 - 0.23	3 - 6	15.6 - 13.7	3.00	76	3.00	76	2.00	51
KIP-33-R3			0.20 - 0.35	5 - 9	12.7 - 11.2	3.00	76	3.00	76	3.00	76
KIP-3.38 3.38-R2	832 - 3427	377 - 1555	0.13 - 0.23	3 - 6	15.6 - 13.7	3.38	86	3.38	86	2.00	51
KIP-44-R2	1165 - 4800	529 - 2177	0.13 - 0.23	3 - 6	15.6 - 13.7	4.00	102	4.00	102	2.00	51
KIP-44-R4			0.27 - 0.47	7 - 12	11.0 - 9.7	4.00	102	4.00	102	4.00	102
KIP-33-S0.5	900 - 4500	408 - 2041	0.02 - 0.03	0.4 - 1	43.4 - 32.5	3.00	76	3.00	76	0.50	13
KIP-66-S0.5	3600 - 18000	1633 - 8165	0.02 - 0.03	0.4 - 1	43.4 - 32.5	6.00	152	6.00	152	0.50	13
KIP-88-S0.5	6400 - 32000	2903 - 14515	0.02 - 0.03	0.4 - 1	43.4 - 32.5	8.00	203	8.00	203	0.50	13

KINETICS Noise Control

TITLE	LAST DATE REVISED	REVISED BY	DRAWING NO.
KIP PAD DATA	03/05/12	BB	S-21.00-1A

STRUCTURAL NOTE:
STRUCTURAL SLAB F- NUMBERS
FF -FLOOR FLATNESS NUMBER
SPECIFIED OVERALL VALUE = 38
MINIMUM LOCAL VALUE = 25

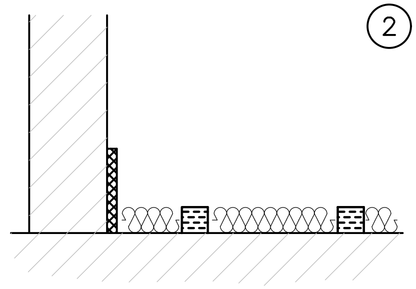
1



STRIKE FLOATING SLAB GRADE AND ADHERE PPI TO CONCRETE POURING FORM.

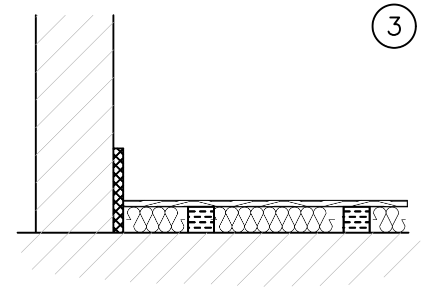
NOTE:
PPI TEAR STRIP MUST BE ON TOP WITH TEAR SLOT FACING TOWARDS FLOOR TO BE POURED.

2



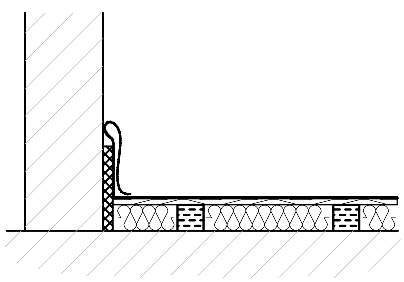
ROLL OUT THE RIM, CUTTING THE LOW DENSITY FIBERGLASS TO THE REQUIRED LENGTH, ALSO CUTTING TO MATCH ROOM CONTOUR.

3



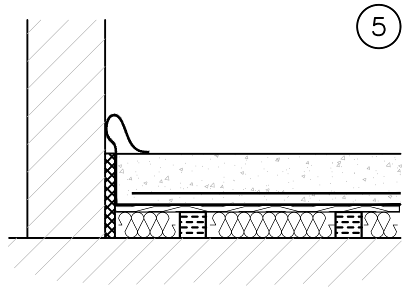
LAY PLYWOOD ON TOP OF RIM MATERIAL STAGGERING JOINTS 2'-0". SECURE TOGETHER USING JUNCTION PLATES AS DETAILED.

4



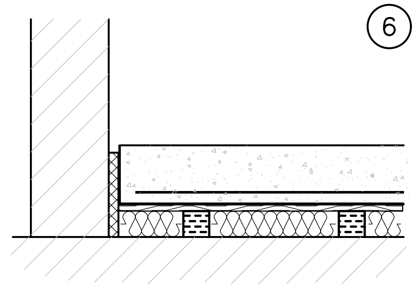
COVER FLOOR WITH 2 LAYERS OF 6 MIL POLY SHEETING OVERLAPPING SEAMS A MIN. OF 6". EXTEND POLY UP AND STAPLE TO WALL OR ROLL BACK ONTO PLYWOOD AND STAPLE. ENSURE ALL SEAMS ARE TAPED TO PRE-VENT CONCRETE FROM LEAKING THROUGH.

5



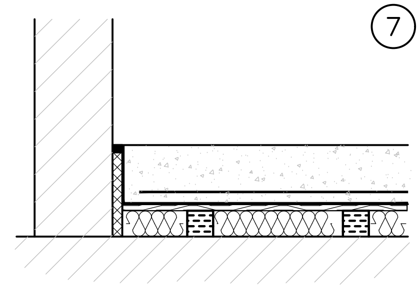
PLACE REINFORCEMENT AND POUR FLOATING SLAB PER PROJECT DESIGN AND SPECIFICATIONS.

6



AFTER CONCRETE HAS CURED, GC TO REMOVE PPI TEAR STRIP AND EXCESS POLY SHEETING AT SLAB PERIMETER.

7

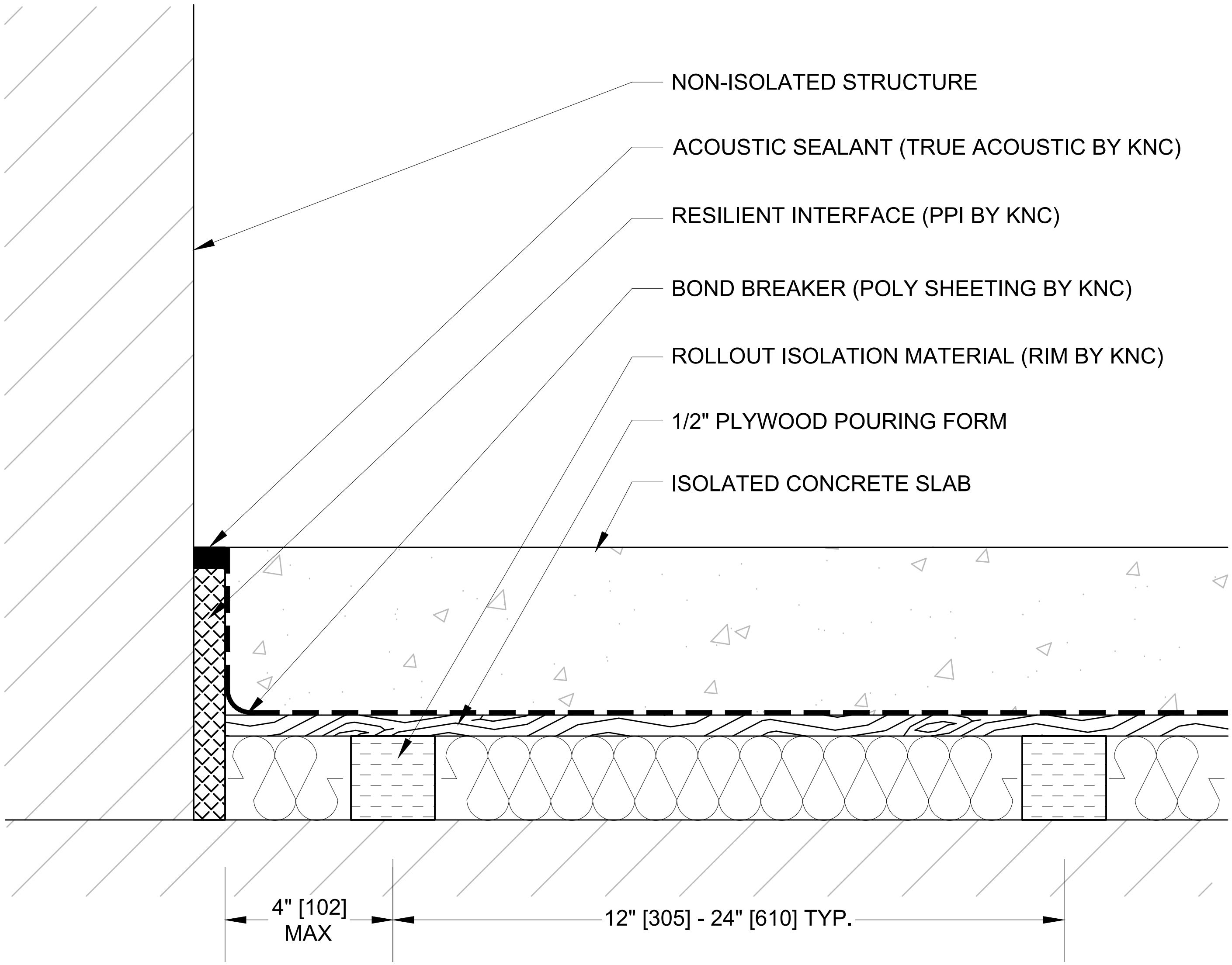


GC TO CAULK SLAB PERIMETER USING SEALANT PER SEALANT MANUFACTURER'S INSTRUCTIONS.

DIMENSION FORMAT: IN [mm]

SCALE: N.T.S.

KINETICS Noise Control	RIM ISOLATED SLAB: INSTALLATION SEQUENCE	Revised 9/1/2017	Drawing No. AA001967	kineticsnoise.com/rim

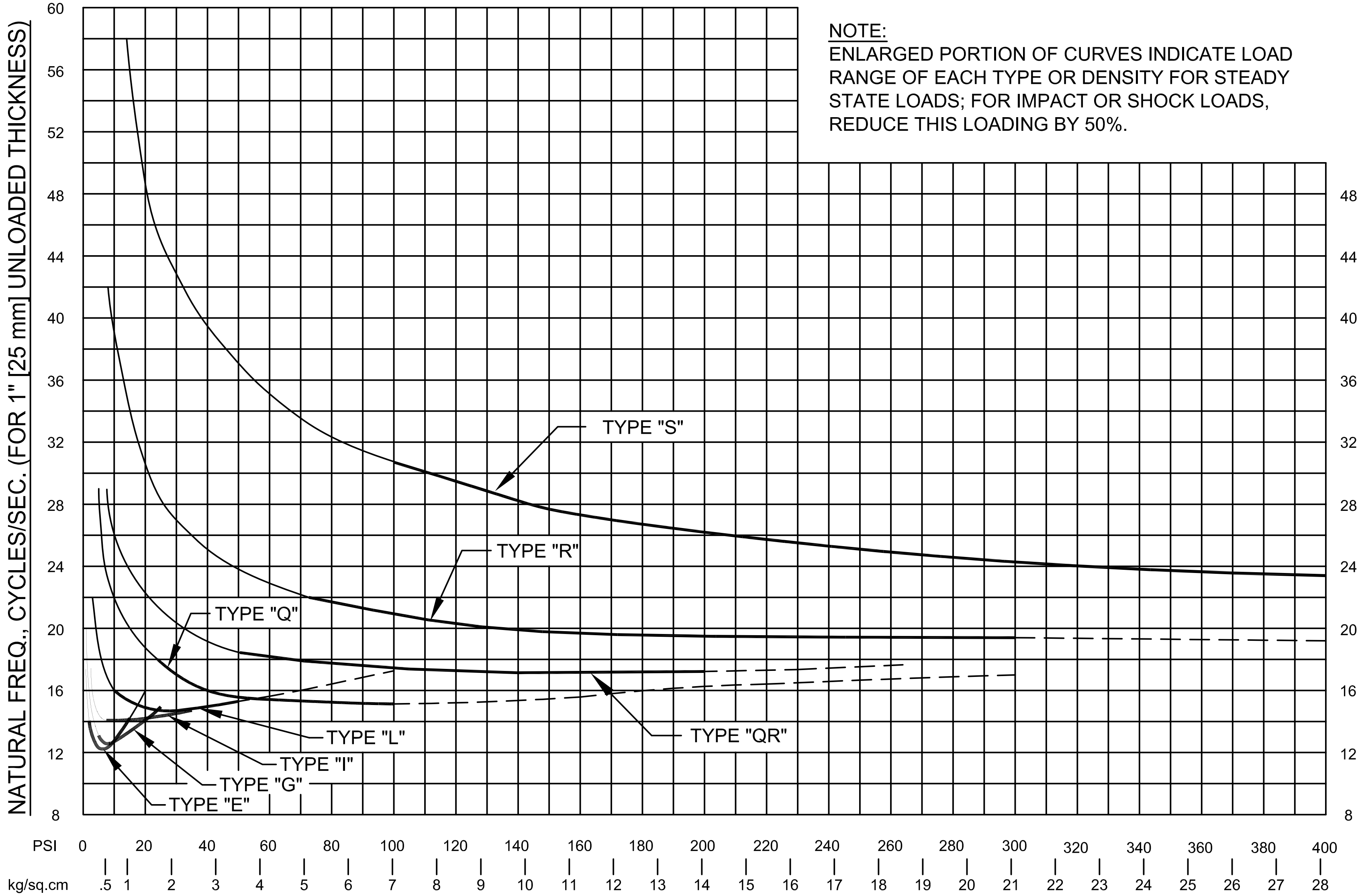


DIMENSION FORMAT: IN [mm]

SCALE: 3" = 1'-0"

KINETICS Noise Control	RIM ISOLATED SLAB: PERIMETER DETAIL	Revised 8/16/2017	Drawing No. AA001838	kineticsnoise.com/rim

NOTE:
ENLARGED PORTION OF CURVES INDICATE LOAD RANGE OF EACH TYPE OR DENSITY FOR STEADY STATE LOADS; FOR IMPACT OR SHOCK LOADS, REDUCE THIS LOADING BY 50%.



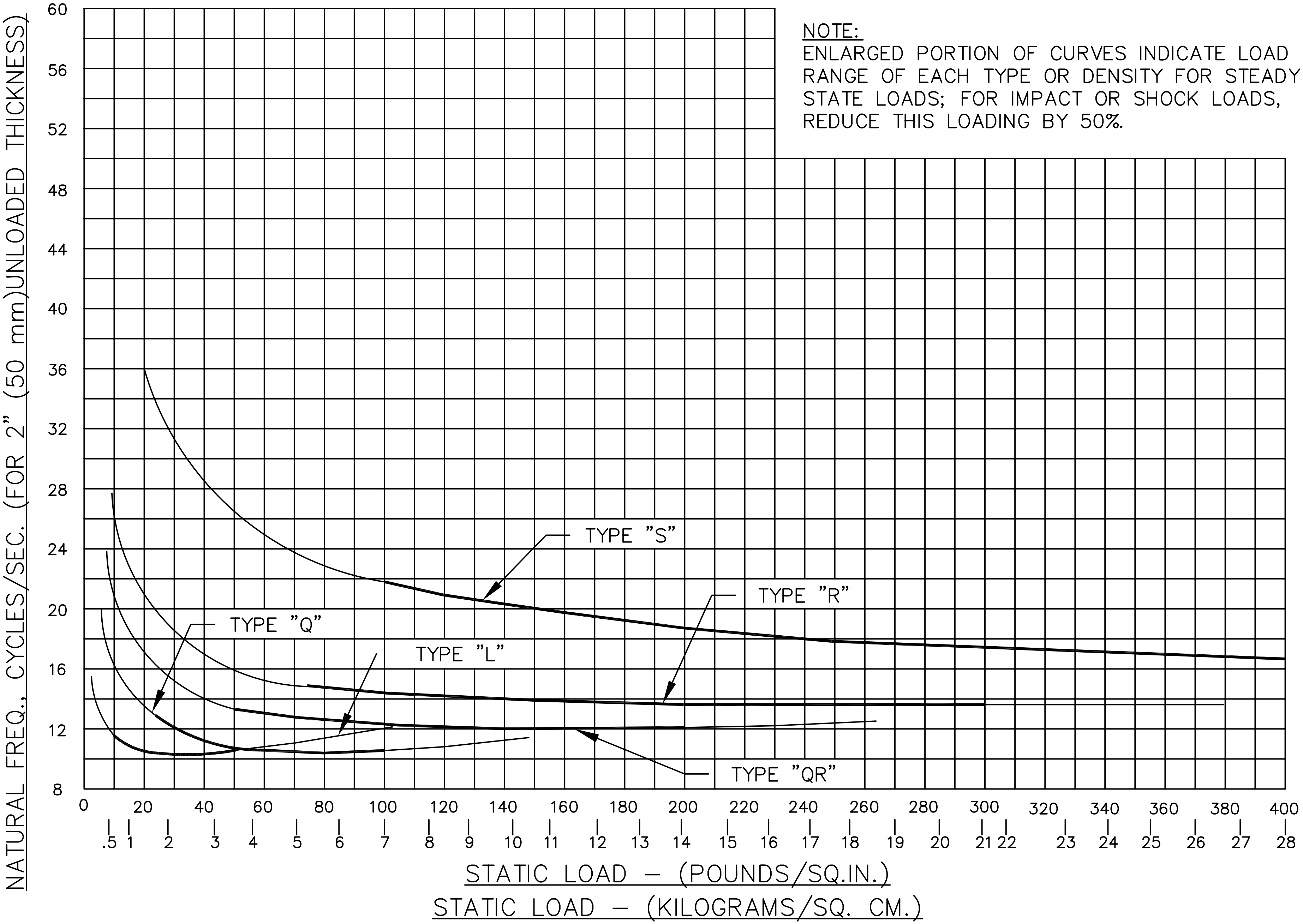
STATIC LOAD - (POUNDS/SQ.IN.)

STATIC LOAD - (KILOGRAMS/SQ. CM.)

To determine natural frequency for other thickess KIP pads.

for 1/4" (6 mm) pads, multiply 1" (25 mm) natural frequency by 2.00
for 1/2" (13mm) pads, multiply 1" (25 mm) natural frequency by 1.41
for 1 1/2" (38 mm) pads, multiply 1" (25 mm) natural frequency by .82
for 2" (51 mm) pads, multiply 1" (25 mm) natural frequency by .71
for 3" (76 mm) pads, multiply 1" (25 mm) natural frequency by .58
for 4" (102 mm) pads, multiply 1" (25 mm) natural frequency by .50

KINETICS Noise Control	TITLE NATURAL FREQ. vs STATIC LOAD KINETICS FIBERGLASS MATERIALS	LAST DATE REVISED 05/01/07	REVISED BY BB	DRAWING NO. FF 216



NOTE:
ENLARGED PORTION OF CURVES INDICATE LOAD RANGE OF EACH TYPE OR DENSITY FOR STEADY STATE LOADS; FOR IMPACT OR SHOCK LOADS, REDUCE THIS LOADING BY 50%.

KINETICS Noise Control

NATURAL FREQ. vs. STATIC LOAD CURVES FOR KINETICS FIBERGLASS MATERIALS

LAST DATE REVISED	DRAWING NO.
05/11/01	FF.215

Kinetics Noise Control, Inc.
6300 Irelan Place
Dublin, OH 43017-0655
www.kineticsnoise.com

The Effects of the Air Space on the Natural Frequency of an Acoustical Floating Floor

Richard Sherren P. E.[1]

Introduction:

Floating floors are used to reduce sound and vibration transmission between rooms. In some cases where the source room is the one above, the floating floor is intended to reduce the sound and vibration that passes to the receiver room below. The floating floor is typically supported on the structural floor by an array of discrete resilient isolators. There will be an air space between the floating floor and the structural floor surrounding the discrete isolators. For the floating floor to be most effective in reducing the sound transmission between the two rooms, it must be completely sealed around its perimeter to prevent the movement of air, and thus sound, between the rooms. Further, the structural floors and the interface with any walls are also sealed to prevent the passage of air and sound, flanking, around the structural floor. The sealing of the floors and walls creates a sealed air chamber between the floating floor and the structural floor. Any vertical displacement of the floating floor due to walking, aerobics, dancing, and etc. will compress and decompress the air in the air space causing it to act like a spring. The entrapped air between the two floors will have a stiffness that must be accounted for when determining the overall dynamic stiffness of the floating floor system in order to assess its effectiveness in mitigating sound and vibration transmission from the source room to the receiver room. This paper will present the current theory and assumptions used to compute the stiffness of the entrapped air and its effect on the natural frequency of the floating floor system.

[1] Richard Sherren is Chief Mechanical Engineer for Kinetics Noise Control in Dublin, Ohio. He holds a B.S.M.E. and an M.S.M.E. both from West Virginia University. He is a member of ASHRAE, and an Allied Professional Member of the AIA.

Kinetics Noise Control, Inc.
6300 Irelan Place
Dublin, OH 43017-0655
www.kineticsnoise.com

Basic Theory for Estimating the Stiffness of the Entrapped Air:

A section through a basic floating floor is shown in Figure 1 below. The isolators actually support the dead load of the floating floor and any objects that are resting on it. The floor is shown deflected to the static operating height of the isolators. Any motion of the floating floor due to activities in the source room will be about this static operating height.

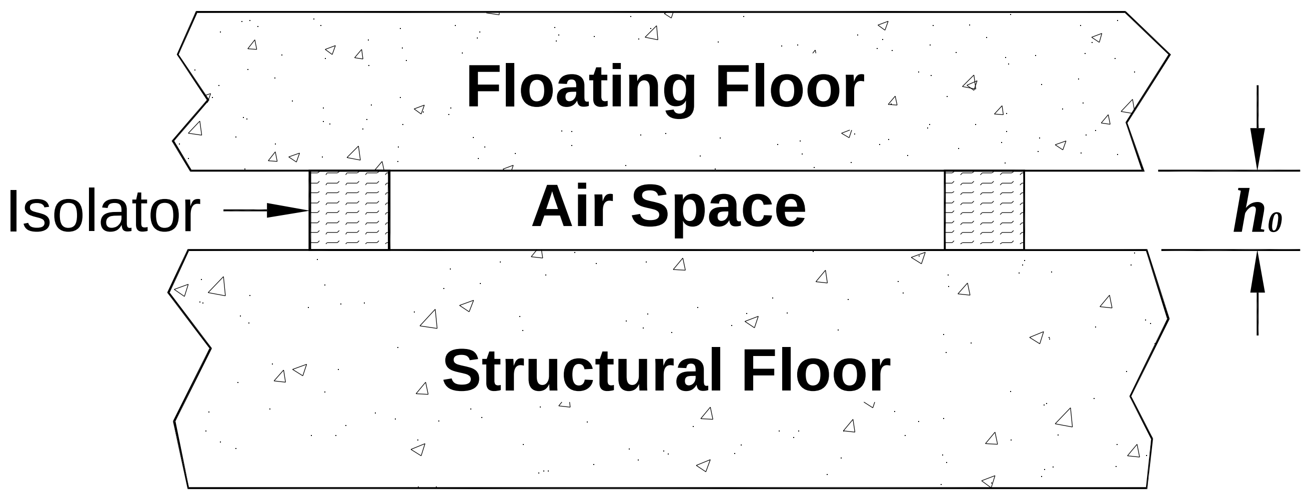


Figure 1; Section through a Typical Floating Floor

This paper will concentrate on the stiffness of the entrapped air in the air space between the two floors. Some basic assumptions will need to be made in order to start the investigation.

1. The floating floor is an acoustical floor, and thus is sealed so that the air is entrapped between the floating floor and the structural floor.
2. The isolators will be assumed to provide support for the dead weight load of the floor only, and have a stiffness that is much less than the stiffness of the entrapped air. For the purposes of this paper, the stiffness of the isolators will be ignored.
3. If the floating floor is rigid, such as a concrete slab, the entire floating floor will be evenly displaced under the excitation applied to the floor. If the floating floor is somewhat flexible such that only the area surrounding the excitation point is displaced, the

resistance to the movement of air radially outward away from the excitation point will be assumed to be high enough to maintain the spring like action of the entrapped air.

Further assumptions will be made and noted as required as the investigation proceeds. The expression for the stiffness of the entrapped air has been performed elsewhere by Vér[2] and Ungar[3]. The approximation of the stiffness of the entrapped air between the floating and structural floors will begin with the polytropic gas equation from thermodynamics.

$$pV^{\gamma} = Constant$$ **Equation 1**

Where:

p = the pressure of the entrapped air between the floors at any given time (psi). This will be the absolute pressure rather than the gage pressure.

V = the volume of the air space between the two floors at any time (in^3). This can be the total volume between the two floors, or the volume beneath the area of the floor supported by a single isolator in the array.

γ = the ratio of the specific heat of the air at a constant pressure to the specific heat of the air at a constant volume.

And;

$$\gamma = \frac{C_P}{C_V}$$ **Equation 2**

Where:

C_P = the specific heat of the entrapped air between the floors at a constant pressure.

C_V = the specific heat of the entrapped air between the floors at a constant volume.

---

[2] Vér, Istán L., *Acoustical and Vibration Performance of Floating Floors*; Bolt, Beranek, and Newman; BBN Project 135250, Report No. 1830; July 29, 1969

[3] Ungar, Eric E.; *Design of Floated Floors to Avoid Stiffness Effects of Entrapped Air*; Noise Control Engineering, July – August 1975, Vol. 5, No. 1; pp12 – 16

The initial state of the entrapped air between the floors may be related to its state at any other time by Equation 1 as follows.

$$p_0 V_0^{\gamma} = pV^{\lambda}$$ **Equation 3**

Where:

p_0= the initial pressure in the air space (psi). This will be assumed to be atmospheric pressure. Even though the floor is sealed, no seal that can be installed in a structure is going to be perfect, and over time the “dead load” pressure in the air space will equalize with the outside atmospheric pressure. For the purposes of this paper, $p_0 = 14.7\,psi$.

V_0= the initial volume of the air space (in3). This will take into account the static deflection of the isolators if they are nonadjustable.

The pressure at any given time in the air space from Equation 3 will be;

$$p = p_0 \left(\frac{V_0}{V} \right)^{\gamma}$$ **Equation 4**

When the floating floor is excited, the volume of the sir space will change with time as it is compressed and then allowed to expand. The dynamic pressure component may be determined by differentiating Equation 4 with respect to the volume of the air space.

$$\frac{dp}{dV} = -\gamma p_0 V_0^{\gamma} \left(\frac{1}{V^{\gamma+1}} \right)$$ **Equation 5**

Rearranging Equation 5, the dynamic pressure fluctuation will be;

$$dp = -\gamma p_0 V_0^{\gamma} \left(\frac{dV}{V^{\gamma+1}} \right)$$ **Equation 6**

If the isolators are properly specified and sized, it is reasonable to assume that for excitation frequencies down to as low a 1 Hz to 3 Hz the displacement of the floating floor will be small with respect to the static operating height of the air space. Thus the changes in the volume of the air space over time will be very small. Therefore, it may also be assumed that the volume of the air space when the floor is displaced during excitation is approximately equal to the initial volume of the air space, or $V \approx V_0$. The Equation 6 may be simplified and rewritten as;

$$dp = \left(-\frac{p_0 \gamma}{V_0} \right) dV$$

Equation 7

The following substitutions will be convenient.

$$V_0 = A_F h_0$$

Equation 8

$$dV = A_F dh$$

Equation 9

$$dp = \frac{dF_A}{A_F}$$

Equation 10

Where:

A_F = the area covered by the floating floor (in^2). This may also be taken as the area of the floor supported by a single isolator in the array.

h_0 = the initial operating height of the air space (in).

dh = the change in the height of the air space which is also the displacement of the floating floor (in).

h = the height of the air space at any given time (in).

dF_A = the dynamic component of the force exerted on the floor by the entrapped air in the air space (lbs).

F_A = the force exerted on the floor by the entrapped air in the air space (lbs).

Substituting Equations 8, 9, and 10 into Equation 7 will yield the following result.

$$dF_A = -\left(\frac{p_0\gamma}{h_0}\right)A_F\,dh \qquad \textbf{Equation 11}$$

It will be convenient to let the displacement of the floating floor to be expressed as follows.

$$dh = -x_F \qquad \textbf{Equation 12}$$

Where:

x_F = the displacement of the floating floor from the static condition (in).

Then;

$$dF_A = \left(\frac{p_0\gamma}{h_0}\right)A_F\,x_F \qquad \textbf{Equation 13}$$

Equation 13 follows the form of that for a linear spring such that;

$$F = Kx \qquad \textbf{Equation 14}$$

Where:

F = the force acting on the linear spring (lbs).

K = the spring rate, stiffness, of the linear spring (lb/in).

x = the displacement of the linear spring under the force F (in).

Using this analogy of a linear spring depicted in Equation 14 with Equation 13, the spring rate, or stiffness, of the entrapped air in the air space between the two floors will be;

$$K_A = \frac{p_0 A_F \gamma}{h_0} \qquad \textbf{Equation 15}$$

Where:

K_A = the spring rate, or stiffness, of the entire air space covered by the floating floor (lb/in).

It is not uncommon for a request to be made for an evaluation of a floor system without prior knowledge of the exact area to be covered by the floating floor. For cases like this it will be convenient to normalize the stiffness of the air space with respect to the area of the floating floor. The normalized form of Equation 15 will be;

$$k_A = \frac{p_0 \gamma}{h_0}$$ **Equation 16**

Where:

k_A = the spring rate, or stiffness, of the air space normalized with respect to the area of the floating floor, or the area supported by a single isolator in the array (lb/in^3) or (psi/in).

The value of γ will depend on the type of thermodynamic process which the entrapped air is undergoing, typically $1.0 \le \gamma \le 1.4$. For a reversible adiabatic process, $\gamma = 1.4$. If the process is isothermal, $\gamma = 1.0$. Under the adiabatic process the excitation frequency is such that the entrapped air is heated as it is compressed and cools as it expands, the pressure fluctuations are magnified by the increase in the temperature of the air under compression making the “air spring” appear to be stiffer. For an isothermal process, the compression and expansion happen slowly enough that the there is no appreciable change in the temperature of the entrapped air. The transition point between isothermal and adiabatic behavior is thought to be at an excitation frequency of less than 0.01 Hz[4]. Both Vér[2] and Ungar[3] indicate that if adequate heat transfer away from the entrapped air can occur, then up to around 50 Hz, the process may be considered to be adiabatic. Also, both Vér[2] and Ungar[3] suggest that filling the air space with a loose fibrous material, e.g. fiberglass, rock wool, or etc., will provide this additional heat transfer area, providing a buffer to slow the flow of air, and thus produce a

[4] Rothbart, Harold A. Editor-in-Chief; Mechanical Design and Systems Handbook, McGraw-Hill Book Company, 1964; Section 36, Schuder, Charles B.; *Pneumatic Components*, pg 36-12

situation where the compression and expansion of the floor under excitation will be isothermal. So;

$\gamma = \mathbf{1.0}$ For an air space that is filled with loose fibrous material.

And;

$\gamma = \mathbf{1.4}$ For an air space that is empty, or not filled with loose fibrous material.

To evaluate the effects of the air space on the natural frequency of an acoustical floating floor it will be necessary to define the natural frequency in terms of the normalized stiffness of the air space. Also, the floating floor will be assumed to be a single degree of freedom system without damping. The natural frequency of such a system has been shown by Ungar[3] to be;

$$f_N = \frac{1}{2\pi}\sqrt{\frac{g k_A}{w_F}}$$ **Equation 17**

Where:

f_N = the primary natural frequency of the floating floor system (Hz).

w_F = the weight of the floating floor normalized with respect to the area of the floating floor, or the area supported by a single isolator in the array (lb/in^2) or (psi).

g = the acceleration due to gravity (386.4 in /sec^2).

Using Equation 16, Equation 17 may be more conveniently expressed as;

$$f_N = \frac{1}{2\pi}\sqrt{\frac{g p_0 \gamma}{h_0 w_F}}$$ **Equation 18**

The results from Equation 18 are shown in Tables 1 and 2 and plotted in Figures 2 and 3.

Table 1; Natural Frequency of the Floating Floor Based on the Entrapped Air Stiffness vs. Floating Floor Load – No Loose Fibrous Material Fill in the Air Space.

Air Space Operating Height (in)	Floor Load (psf)						
	5	10	20	30	40	50	60
0.25	152.3	107.7	76.2	62.2	53.9	48.2	44.0
0.50	107.7	76.2	53.9	44.0	38.1	34.1	31.1
0.75	87.9	62.2	44.0	35.9	31.1	27.8	25.4
1.00	76.2	53.9	38.1	31.1	26.9	24.1	22.0
2.00	53.9	38.1	26.9	22.0	19.0	17.0	15.5
3.00	44.0	31.1	22.0	18.0	15.5	13.9	12.7
4.00	38.1	26.9	19.0	15.5	13.5	12.0	11.0
5.00	34.1	24.1	17.0	13.9	12.0	10.8	9.8
6.00	31.1	22.0	15.5	12.7	11.0	9.8	9.0

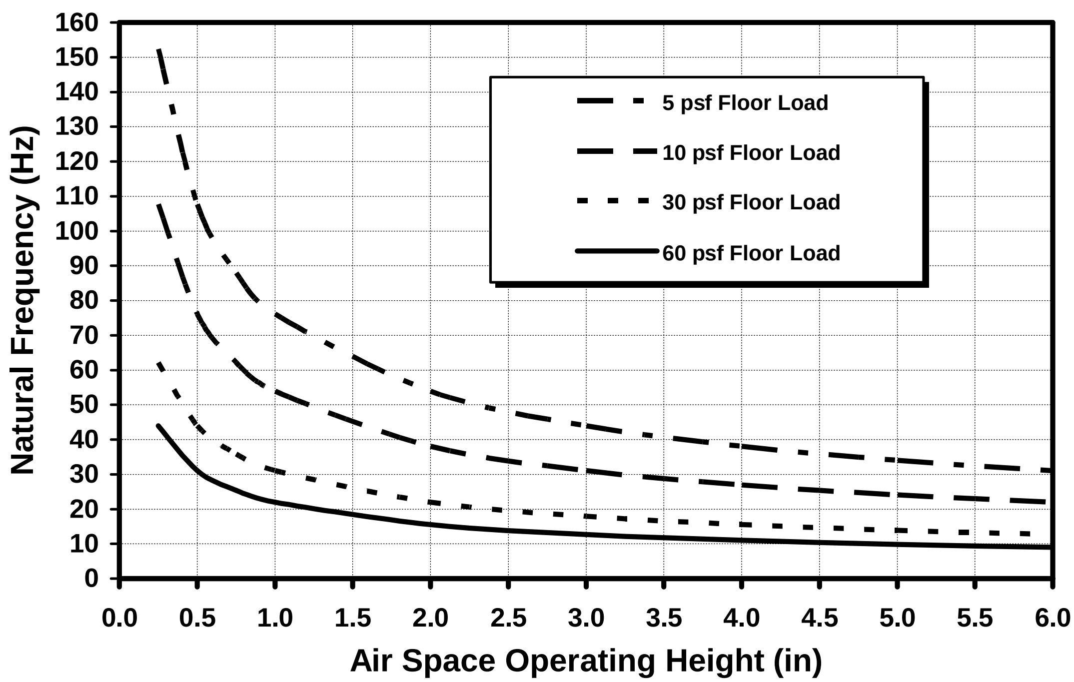


Figure 2; Plot of the Natural Frequency of the Floating Floor Based on the Entrapped Air Stiffness vs. Floating Floor Load – No Loose Fibrous Material Fill in the Air Space.

Table 2; Natural Frequency of the Floating Floor Based on the Entrapped Air Stiffness vs. Floating Floor Load – With Loose Fibrous Material Fill in the Air Space.

Air Space Operating Height (in)	Floor Load (psf)						
	5	10	20	30	40	50	60
0.25	128.7	91.0	64.4	52.6	45.5	40.7	37.2
0.50	91.0	64.4	45.5	37.2	32.2	28.8	26.3
0.75	74.3	52.6	37.2	30.3	26.3	23.5	21.5
1.00	64.4	45.5	32.2	26.3	22.8	20.4	18.6
2.00	45.5	32.2	22.8	18.6	16.1	14.4	13.1
3.00	37.2	26.3	18.6	15.2	13.1	11.8	10.7
4.00	32.2	22.8	16.1	13.1	11.4	10.2	9.3
5.00	28.8	20.4	14.4	11.8	10.2	9.1	8.3
6.00	26.3	18.6	13.1	10.7	9.3	8.3	7.6

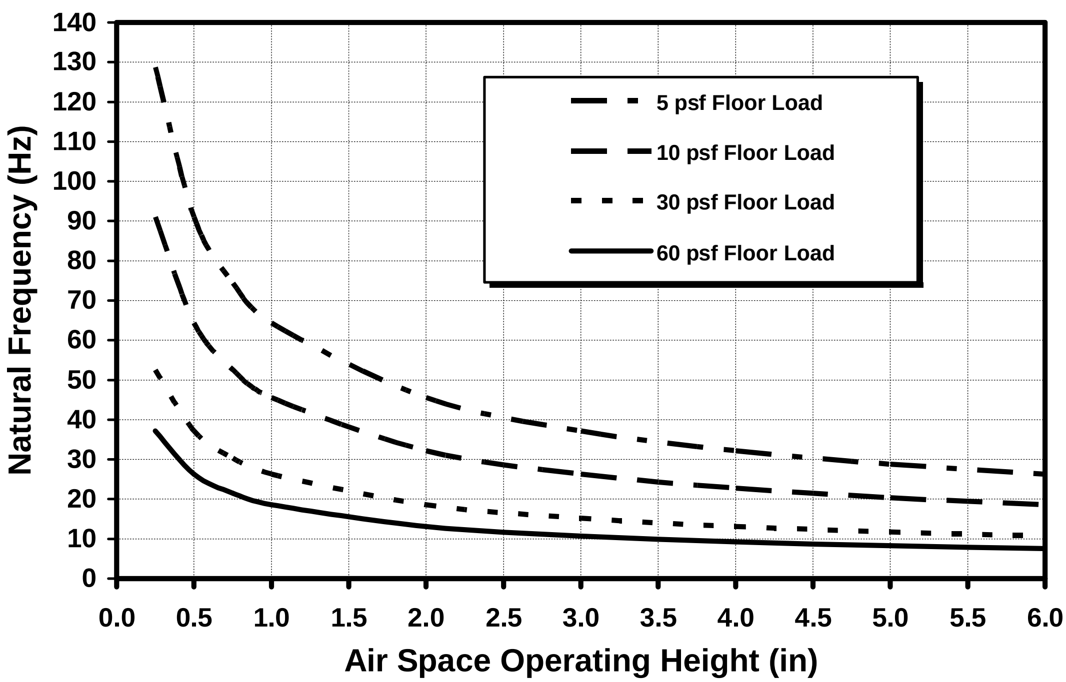


Figure 3; Plot of the Natural Frequency of the Floating Floor Based on the Entrapped Air Stiffness vs. Floating Floor Load – With Loose Fibrous Material Fill in the Air Space.

Discussion:

In each case, as one would expect, the natural frequency of the floating floor decreases with increasing air space operating height and increasing floor load. Regardless of the type of isolator used to support the floating floor, these results represent the minimum possible natural frequency for the floating floor system for each combination of air space operating height and floor load. From Table 2, with a commonly specified 2″ air space operating height and a loose fibrous fill material in the air space, the lowest possible natural frequency for the floating floor system will be ~13.1 Hz, and that is with a 60 psf floor load.

When the stiffness of the isolators is considered, it will add directly to the stiffness of the entrapped air. This is because the isolator and the entrapped air are each subjected to the total displacement of the floor, and thus behave as if they are springs acting in parallel. Where the dynamic stiffness of the isolators and the natural frequency of the floor supported by the isolators alone are known, the natural frequency of the floor system including the air stiffness may be computed using the following equation.

$$f_S = \sqrt{f_I^2 + f_A^2} \qquad \textbf{Equation 19}$$

Where:

f_S = the natural frequency of the floating floor system including the effects of both the isolator dynamic stiffness and the stiffness of the entrapped air (Hz).
f_A = the natural frequency of the floating floor if supported by the entrapped air alone (Hz). This natural frequency may be computed using Equation 18 above.
f_I = the natural frequency of the floating floor if supported by the isolators alone (Hz).

It is apparent that the stiffness of the entrapped air between the floors of an acoustical floating floor system has a significant impact on the primary natural, or resonance, frequency of the floor system. This must be taken into account when recommending floating floor systems for applications where substantial low frequency sound or vibration energy is present.

In conclusion, the use of a floating floor system that includes a loose fibrous material fill in the air space will substantially improve the performance of the floating floor system in the lower frequency ranges. Increasing the air space in conjunction with the proper isolator selection is a positive method for lowering the floor system natural frequency to meet the design objectives.

Finally the mass of the floating floor is critical in meeting low frequency performance goals. Increasing the mass of the floating floor will result in a lower natural frequency of the floating floor system as demonstrated by Equation 17 above.