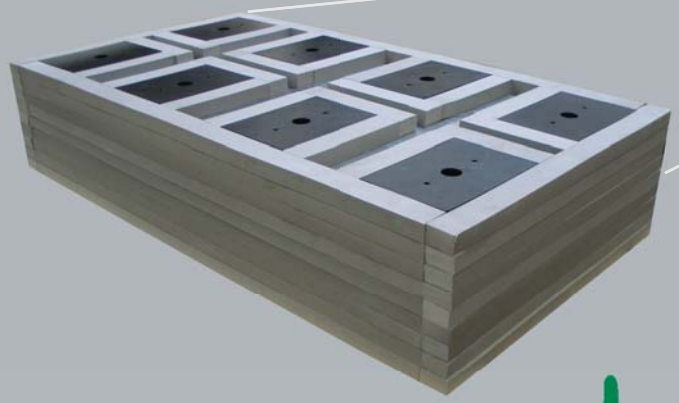
VIBRO/DYNAMICS®
a Socitec Group Company

MRM™ Shock Isolation Systems for

Forging Hammers



Forging Hammer Isolation

Vibro/Dynamics began producing isolation systems for forging hammers in 2002 after receiving numerous requests for an improved mounting system from hammer builders and forging producers. Vibration and shock isolation of forging hammers is very difficult due to their large masses and extreme shock forces. Vibro/Dynamics first developed the FS Series Coil Spring Isolators with viscous fluid dampers and then followed with the development of MRM™ Elastomeric Isolation Systems. Both types have proven to be very effective in isolating hammer and shock forces.

Coil spring and viscous damper units provide the greatest isolation performance, but have higher initial cost, more expensive foundations, and potential maintenance issues. The viscous dampers in the spring isolators are difficult to protect if a pit should flood; a situation usually requiring the replacement of the damper fluid. Some competitive damper designs have leaked due to the cracks developing in the damper tube walls, which requires the removal and repair of the spring isolators.

As a result, the MRM Systems has become an accepted standard for vibration and shock isolation around the world. They offer superior isolation performance over timber and pad systems without the larger inertia mass, flooding issues, and higher maintenance cost associated with coil spring isolator systems.
They are easy to install and maintain and have proven to be durable.

FSV20 and FSX20 Viscous Damped Spring Mounts

This document seeks to address the technical issues involved in the isolation of forging hammers. The technical understanding of the isolated hammer system can be best understood at three conditions:

1. When the ram is falling,
2. When the ram is performing work on the part,
3. When the ram rebounds.

When the ram is falling

Hammer capacity is generally rated by the amount of energy that can be delivered by the falling mass, which includes the ram and upper die. Most hammers are designed such that the falling weight starts with zero or near zero initial velocity and impacts the work piece at 6 to 7 m/s (18 to 23 ft/s). It is simple to calculate the hammer's capacity by knowing the maximum falling weight by Equation 1.

The falling mass is calculated by taking the falling weight, w, and dividing by one gravity, $g = 9.8\ m/s^2$ or $32.2\ ft/s^2$. The impact velocity, v_i, should be in units of m/s or ft/s. The units of energy capacity, E, are N·m = J for metric and ft·lb for imperial measure.

$$E = \frac{1}{2} \cdot \frac{w}{g} \cdot v_i^2 \qquad (1)$$

In the case of drop hammers where the falling mass is accelerated by gravity alone, the energy capacity of the hammer may be determined by multiplying the falling weight by the height of the drop, h, per Equation 2.

$$E = w \cdot h \qquad (2)$$

Some hammers accelerate the falling weight by using a piston powered by steam or pneumatic pressure, or by hydraulic accumulators. These hammers typically hit with higher blow rates. It is important that the isolation system be applied with sufficient damping such that there is no movement when the next blow occurs. If the system is traveling downwards when the next blow arrives, the blow will increase the amplitude of the downward motion more than the prior hit, possibly overstressing the isolation system and building over several blows to an unstable situation. For soft mounting systems and when the falling weight is accelerated by the piston, the hammer's recoil may unload the isolation system, possibly leading to instability. Usually, hammers have sufficient anvil weight so recoil is a minor issue compared to the shock caused by the ram doing work on the part.

When the ram is performing work on the part

The very short time in which the ram contacts the work piece and deforms the work piece is the most important time in the operation for the hammer user. There is a wide range of forging work that can be done in a hammer, so the magnitude of the blow force and the duration of the blow force can vary significantly. Hot open die forging work will impose a lower magnitude and longer duration force between the ram/part/anvil than a hot die forge blow. The finishing blows in die forging operations are the most severe. The analysis of the reaction of the anvil to the blow is actually simplified by the fact that the anvil is much more massive than the ram and the duration of the impact is very short. The ram travels downward until the anvil velocity is increased to equal the ram velocity, and then it rebounds.

Hammer builders understand that to develop maximum force on the part, the anvil must be much more massive than the ram. Figure 1 shows the theoretical hammer force relative to an extremely massive anvil that is 100 times as large as the ram. Note that once the anvil is more than about 10 times greater in mass, there is little change to the peak force attained.

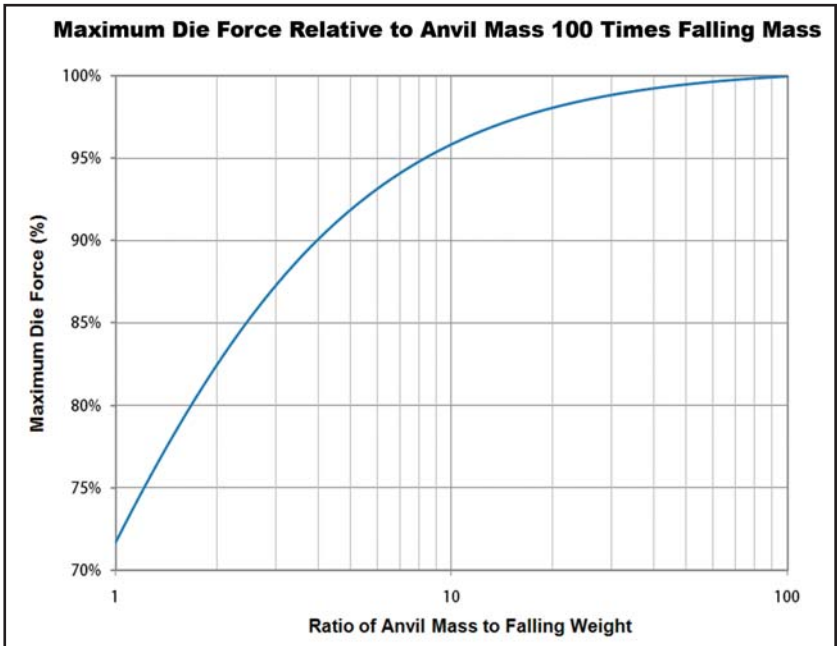


Figure 1

The anvil's inertia is used to generate the blow force. Softer isolation systems will slightly decrease the peak force of the blow. Both elastomer and spring type isolation systems reduce the available impact force to approximately 99.985% of the force compared with traditional timber support. Because only 0.015% is lost by employing a more efficient isolation system, the benefits to the hammer, foundation, personnel, and nearby equipment easily justify using an economical and reliable isolation system.

All hammer blows occur over a very short time compared to the oscillations of the anvil after the blow is struck. See Figure 2. The time for one oscillation of the anvil is the natural period of the hammer system. Traditional hammer support systems using oak timbers may be used as a benchmark for the performance for other isolation systems. Even with timber support, the natural period of the hammer system is much greater than the shock impulse duration of the ram striking the work. The difference results in a significant reduction in the force transferred from the anvil to the foundation. However, because the blow forces are extremely large, even small levels of vibration transmitted to the surroundings may be very disruptive and damaging. In general, the softer the support system, the greater the natural period and isolation effectiveness. The transmitted shock of the hammer will be reduced if the system natural period is at least six times greater that the shock force duration. Soft systems transmit less vibration to the surroundings than stiff systems.

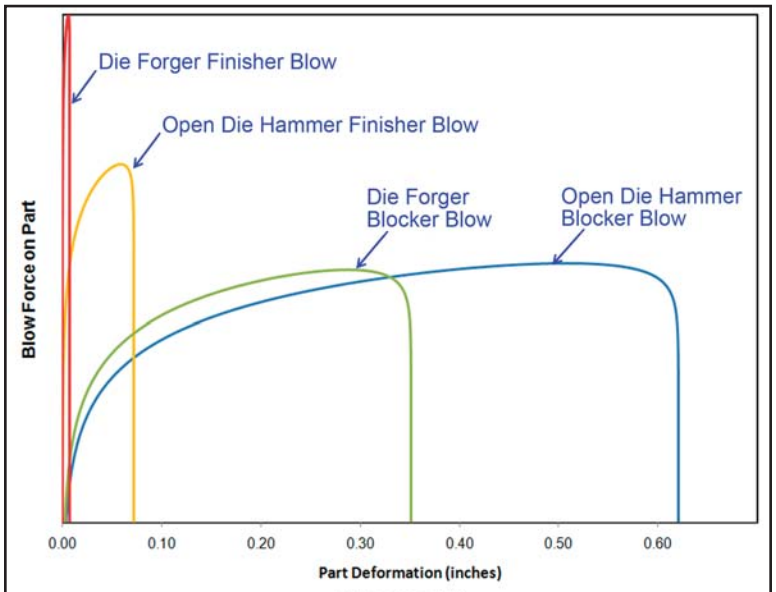


Figure 2

The collision between the ram and workpiece transfers the momentum of the ram into downward motion of the anvil and the upward rebound of the ram. Once the ram and anvil reach the same velocity the ability of the ram to do work is finished, and the maximum force on the workpiece is achieved. After this point in time, the ram rebounds upwards and the anvil continues to travel downwards.

When the ram rebounds

Once the work has been done on the workpiece and the ram is rebounding, the impact shock from the ram is transferred to the anvil and the isolation system controls the motion and transmitted forces. Because the shock impulse is of very short duration, the hammer system can be accurately modeled by using the conservation of momentum principle. Because some energy is lost in the impact of the ram upon the workpiece, the collision is termed inelastic, but the conservation of momentum laws still apply.

$$m_1 \cdot v_i + m_2 \cdot v_{2i} = m_1 \cdot v_f + m_2 \cdot v_{2f} \qquad (3)$$

Where:

m_1 = ram mass
m_2 = anvil mass
v_i = ram velocity immediately before impact
v_{2i} = anvil velocity immediately before impact
v_f = ram velocity immediately after impact
v_{2f} = anvil velocity immediately after impact

The ram will not rebound at the same velocity; this change can be captured in the Coefficient of Restitution, C_R, defined by Equation 4.

$$C_R = \frac{v_{2f} - v_f}{v_i - v_{2i}} \qquad (4)$$

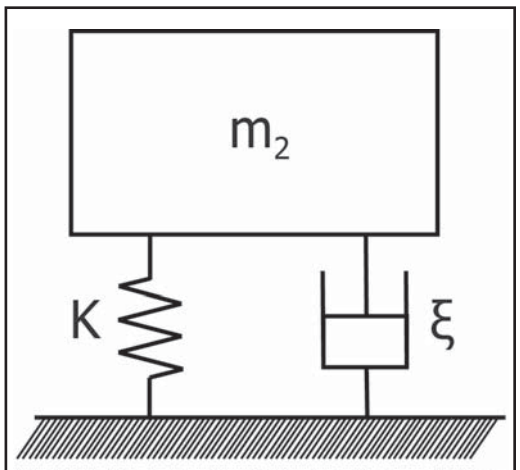
Open die forging operations that cause very large deformations in a hot work piece will have very low C_R values of 0.1-0.2. As the work piece cools with very little deformation taking place, as in the case of finishing blows in a closed die forging, C_R values may be as high as 0.5-0.6.

The hammer system can be modeled very effectively as a single degree of freedom system where the supporting isolation material is a simple spring and dashpot as shown in Figure 3. The dynamic stiffness, K , of the isolation system determines the amount of motion and the amount of force transferred to the foundation.

The damping component, ξ, of the system dissipates energy as heat as the system is brought back to the static state of equilibrium. The damping has little effect on the first downward peak displacement of the anvil, but over several cycles the anvil slows to the at rest state.

After the ram has struck the work piece and the momentum of the ram is transferred to the anvil, the anvil will oscillate about the equilibrium position upon the isolation system at a frequency, called the damped natural frequency of the system, given by Equation 5.

$$\Omega_d = \sqrt{\frac{K}{m_2} \cdot (1 - \xi^2)} \qquad (5)$$



Model for Single Degree of Freedom Hammer System
Figure 3

From this simple model, the equation describing the vertical motion of the anvil mass, m_2 can be solved as Equation 6.

$$x(t) = \frac{(\mathbf{1} + \boldsymbol{C_R}) \cdot v_i \cdot (\frac{m_1}{m_1 + m_2})}{\Omega_d} \cdot e^{-\xi \cdot \sqrt{\frac{K}{m_2}} \cdot t} \qquad (6)$$

Reviewing the variables within Equation 6;

- The motion of the hammer system is reduced when the anvil weight, m_2, is increased and,
- The motion is increased with a softer, lower natural frequency system, Ω_d.

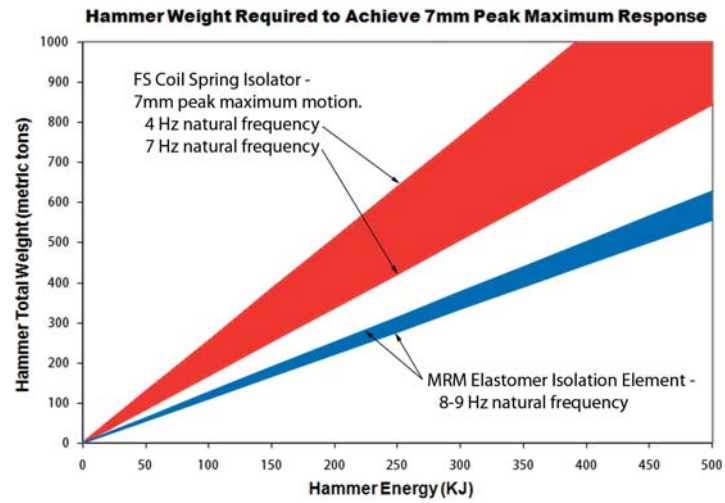


Figure 4

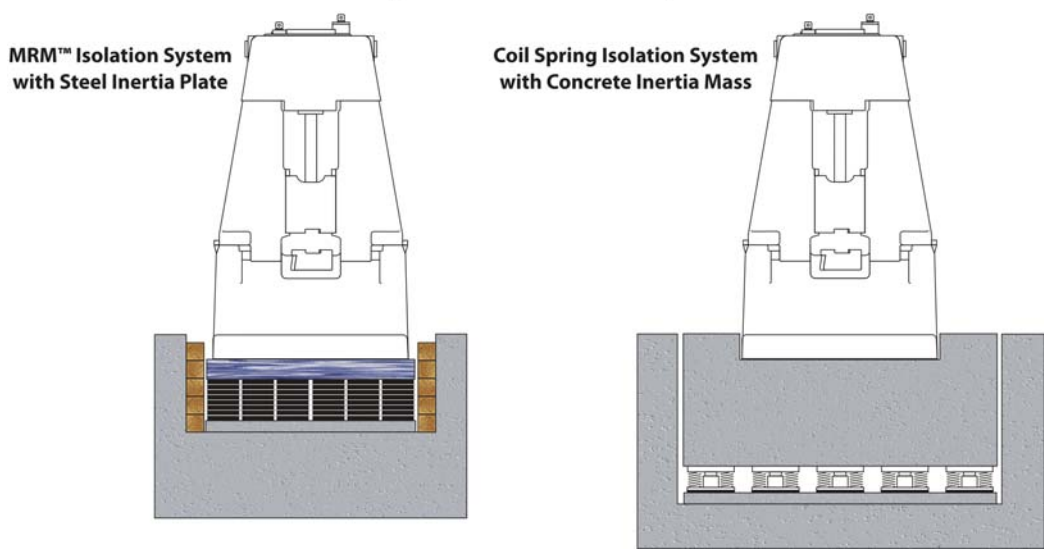
If a generally accepted limit of 7mm peak motion is applied, then it is clear that for coil spring and elastomeric systems there may be a need for the anvil to weigh more in order to maintain the natural frequency and isolation performance, as shown in Figure 4. Because of the cost to add a concrete or steel inertia mass, the MRM elastomer systems are more economical at the expense of a very small reduction in isolation effectiveness. A steel inertia mass is more economic since a steel plate is more dense and requires less space, thereby reducing the area and size of the foundation, see Figure 5. Field installations have proven the steel inertia masses to be more durable.

By Hooke's Law, the force transmitted to the foundation is the product of the isolation system dynamic stiffness, K, and the anvil motion x(t):

$$F(t) = K \cdot x(t) \qquad (7)$$

For coil spring isolators, the addition of a viscous damper mechanism adds a small amount of force to the force transmitted by the support springs. For elastomeric designs, the hysteresis damping of the material is included in the real dynamic stiffness.

Figure 5 - Inertia Mass Comparison



The forces generated in the die space are enormous. The exact magnitude and time duration are generally not known because measuring the force is not possible. However, experienced hammer operators can easily notice a significant reduction in body and arm fatigue of an isolated hammer compared to a traditionally supported hammer on timbers or thin pad material. The correct application of a well designed isolation system will result in a significant reduction of the ram's enormous impact shock. The MRM Systems transform the impact shock from a series of short duration, high magnitude impulses, as shown in Figure 2, to a series of longer duration, smaller magnitude impulses, as shown in Figure 6. Isolation of these impact shocks will decrease health problems, decrease building maintenance, decrease neighbor complaints, and decrease foundation costs.

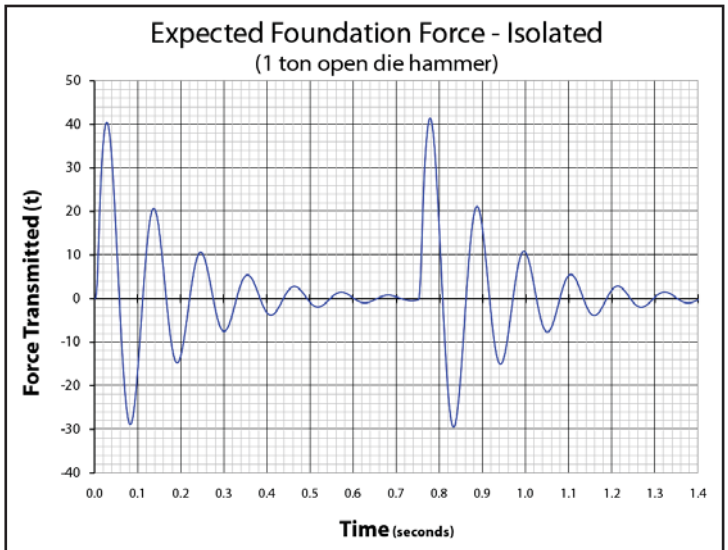


Figure 6

Summary

The MRM™ Elastomeric Isolation Systems have proven to be a very effective for forging hammers. When compared to traditional forge hammer installation methods, like timbers and rubber pads, the isolation performance of MRM Systems are clearly superior, yet they're faster and easier to install due to their unitized construction. MRM system isolation performance approaches that of coil spring systems and are economical and extremely durable. See Vibro/Dynamics Technical Bulletin M/L 710 for vibration isolation comparisons.

Since Vibro/Dynamics has the technology and know how to design and build both MRM Elastomer and FS Spring Mount Isolation Systems, we are in the best position to recommend an isolation system that best fits your needs.

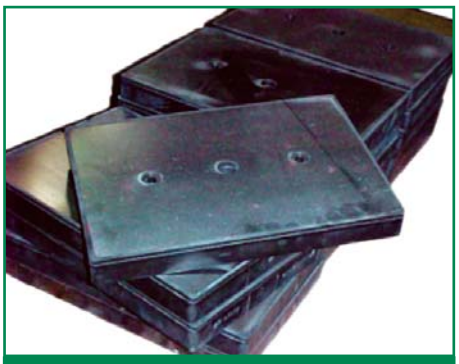
MRM™ Isolation Element Construction

MRM™ Systems are specially designed for die forgers and drop hammers. These revolutionary new products have the simplicity of a layered elastomer system, with shock isolation effectiveness similar to viscous spring isolators.

MRM Systems feature thick, soft, elastomer modules for greater vibration and shock control. Vertical dynamic natural frequencies as low as 8 Hz are achievable. Typical isolation efficiency is 60-80% reduction compared to traditional oak-timber systems

MRM Systems feature unitized construction. Each Element is constructed using alternating layers of custom elastomer modules and galvanized steel sheets that are securely fastened together. The elastomer modules are molded from proprietary compounds for superior shock isolation, durability, and creep resistance. Each Element is encased in a protective foam barrier for further protection against pit debris.

All MRM Elements are designed to be simply lowered into the foundation as complete units. No difficult and time-consuming layout and "in the pit" stacking of pads and plates is required!
The unique design features of the MRM Isolation System result in superior shock isolation, trouble-free installations and long lasting performance.



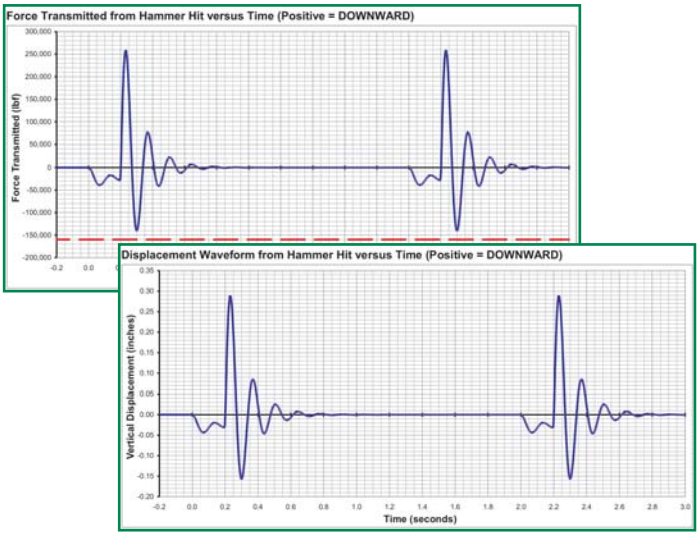
Modular Elastomers are made from proprietary compounds.

MRM4x9-12 shown with protective foam to seal against contamination from solid debris.

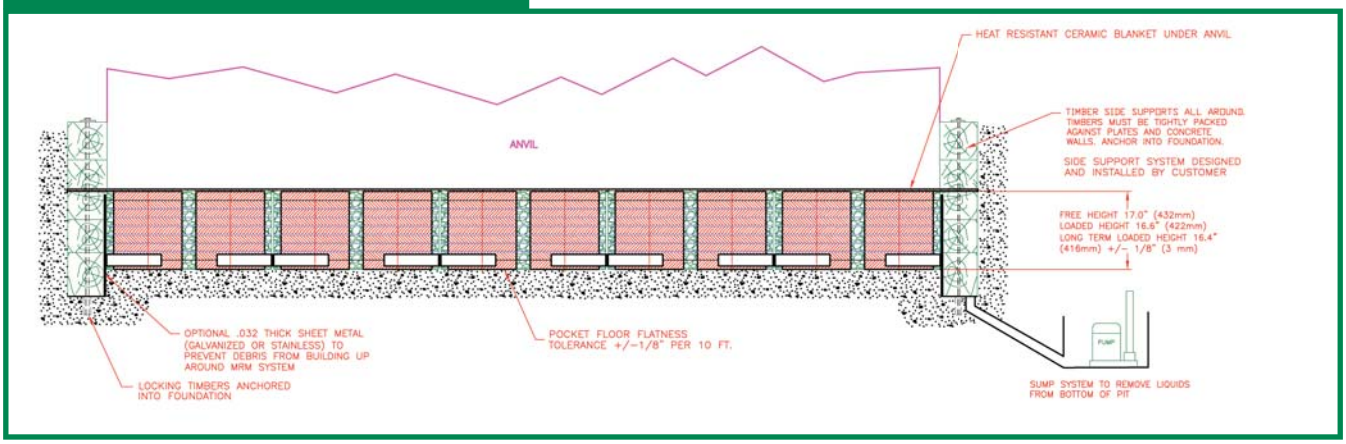
Application Engineering

Vibro/Dynamics Engineers carefully analyze every application using proprietary computer modeling software. Motion and force transmission charts are provided to assist the customer in their hammer installation and foundation design.

Foundation guidelines are also provided to help the forger design and maintain the hammer installation. If an inertia mass is required for reduced motion, Vibro/Dynamics will assist in determining its weight and size.

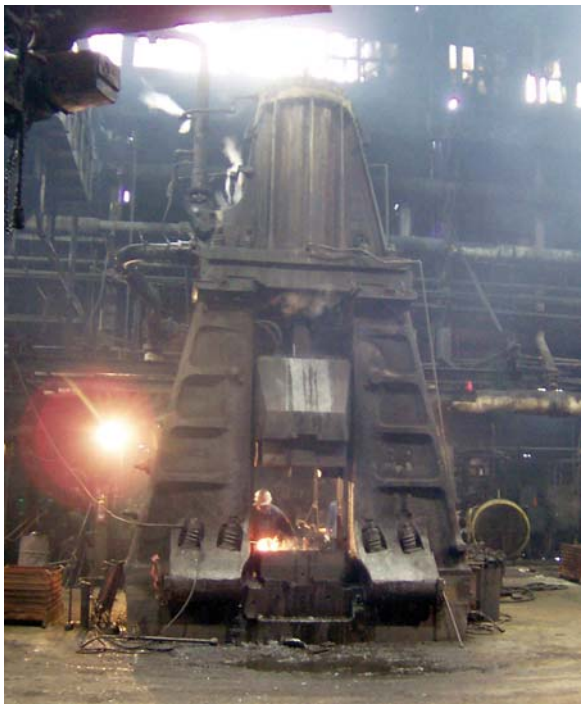


Typical Foundation Layout Drawing



Installation Photographs

50,000 lb. Erie Steam Hammer on 16) MRM6x8-2-15703.

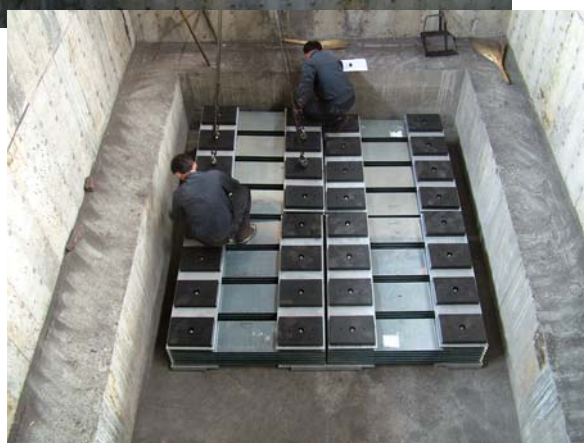


Erie 33,000 Steam Hammer on (6) MRM8x10-1-15711-G

16 Ton Die Forger on 14) MRM8x8-16366-G

3 Ton and 8 Ton Open Die Hammers

10 Ton Die Forger Foundation



CUSTOMER LIST

Customer	City/State	Country	Qty.	MRM™ Model Number	Hammer Information	Capacity ft/lbs	Capacity KJ
Consolidated Industries, Inc.	Chesire, CT	U.S.A.	6	MRM8 X 6-1-16692-G	Erie 12,000 lb. steam hammer	194,300	264
Cooper Industries	Monroe, NC	U.S.A.	2	MRM5 X 6-0-16980-G	Ceco Model E-4000	19,400	27
Council Tool Company, Inc.	Lake Waccama, NC	U.S.A.	2	MRM4 X 8-1-16410-G	Ceco 30 CD drop hammer	10,600	15
Dekalb Forge Company	Dekalb, IL	U.S.A.	6	MRM9 X 9-0-16614-G	Ceco 160 DHE	190,000	258
Dekalb Forge Company	Dekalb, IL	U.S.A.	8	MRM5 X 9-0-16955-G	Erie 10,000 lb.	151,000	205
Dekalb Forge Company	Dekalb, IL	U.S.A.	3	MRM8 X 9-0-16954-G	Erie 5,000 lb.	97,600	133
Dixie Industries Division	Chattanooga, TN	U.S.A.	2	MRM4 X 9-0-16986-G	Ceco 30 CD Drop Hammer	14,000	19
Dixie Industries Division	Chattanooga, TN	U.S.A.	2	MRM6 X 9-0-16984-G	Ceco 40 CD Drop Hammer	16,000	22
Dixie Industries Division	Chattanooga, TN	U.S.A.	2	MRM5 X 9-0-16985-G	Ceco 40 CD Drop Hammer	16,000	22
Kraft Tool Company	Shawnee, KS	U.S.A.	1	MRM4 X 8-1-15797-G	2000 CDE drop hammer	8,860	12
Kropp Forge	Cicero, IL	U.S.A.	16	MRM6X8-2-15562	Erie 50,000 lb. Steam Hammer	500,000	678
Kropp Forge	Cicero, IL	U.S.A.	10	MRM8 X 9-1-15703-G	Erie 40,000 lb. steam hammer	350,000	475
Ladish Forging	Cudahy, WI	U.S.A.	18	MRM8 X 9-0-16833-G	Erie 50,000 lb. hammer	700,000	950
Modern Drop Forge Company	Blue Island, IL	U.S.A.	2	MRM6 X 8-1-15818-G	Chambersburg 6000 Drop Hammer	30,000	41
Modern Drop Forge Company	Blue Island, IL	U.S.A.	4	MRM6 X 9-1-16054-G	Ceco 80 DHE die forger	98,000	133
Modern Forge Drop Company	Blue Island, IL	U.S.A.	2	MRM4 X 6-0-15940-G	Ceco #14 die forger	14,400	20
Modern Forge Drop Company	Blue Island, IL	U.S.A.	6	MRM5 X 8-0-17109-G	Ceco 50 DHE die forger	55,000	75
Modern Forge Drop Company	Piney Flats, TN	U.S.A.	1	MRM6 X 8-1-15769-G	Ceco #12 die forger	13,500	19
Modern Forge Drop Company	Piney Flats, TN	U.S.A.	2	MRM6 X 8-0-15770-G	Ceco #21 die forger	23,000	32
Sifco Forge Group	Cleveland, OH	U.S.A.	6	MRM8 X 10-1-15711-G	Erie 35,000 lb. steam hammer	383,500	520
Sifco Forge Group	Cleveland, OH	U.S.A.	10	MRM8 X 9-0-16737-G	Erie 35,000 lb. steam hammer	375,000	509
The Ajax Manufacturing Company	Cleveland, OH	U.S.A.	1	MRM4 X 8-0-15879	Ceco 10 CD Drop Hammer	4,370	6
The Ajax Manufacturing Company	Cleveland, OH	U.S.A.	1	MRM4 X 8-1-15842-G	Ceco #8 die forger	8,600	12
The Ajax Manufacturing Company	Cleveland, OH	U.S.A.	1	MRM4 X 6-0-16065	Ceco 15 CDE	5,500	8
The Ajax Manufacturing Company	Cleveland, OH	U.S.A.	2	MRM6 X 9-1-15947-G	Ceco #23 die forger	23,000	32
The Ajax Manufacturing Company	Cleveland, OH	U.S.A.	2	MRM4 X 6-0-16073	Ceco 30 CD drop hammer	15,490	21
The Ajax Manufacturing Company	Cleveland, OH	U.S.A.	1	MRM4 X 8-1-15842-G	Ceco #8 die forger	8,600	12
The Ajax Manufacturing Company	Cleveland, OH	U.S.A.	3	MRM6 X 9-0-16600-G	Ceco #38 Die Forger	38,000	52
The Ajax Manufacturing Company	Cleveland, OH	U.S.A.	2	MRM5 X 8-0-16566-G	Ceco 40 CD Drop Hammer	20,000	28
The Ajax Manufacturing Company	Cleveland, OH	U.S.A.	3	MRM5 X 8-0-16952-G	Ceco 60 CD Drop Hammer	30,000	41
Wyman-Gordon Forgings, Inc.	Cleveland, OH	U.S.A.	1	MRM4 X 8-1-15842-G	Ceco #8 die forger	8,600	12
Wyman-Gordon Forgings, Inc.	Cleveland, OH	U.S.A.	2	MRM4 X 8-0-16410-G	Ceco 3000 Drop Hammer	10,600	15
Anyang Duanya Forging Press Machinery	Anyang	P.R.China	4	MRM6 X 9-1-16228-G	C61-175 5 ton open die hammer	129,080	175
Anyang Duanya Forging Press Machinery	Anyang	P.R.China	4	MRM7 X 9-0-16537-G	C66-175 two arm open die hammer	129,080	175
Anyang Duanya Forging Press Machinery	Anyang	P.R.China	4	MRM5 X 9-0-16536-G	C61-120 single arm open die hammer	88,510	120
Anyang Duanya Forging Press Machinery	Anyang	P.R.China	1	MRM6 X 9-0-16535-G	C61-35 single arm open die hammer	25,820	35
Anyang Duanya Forging Press Machinery	Anyang	P.R.China	1	MRM4 X 9-121-16544-G	C41-560 single arm open die hammer	10,110	13.7
Anyang Duanya Forging Press Machinery	Anyang	P.R.China	1	MRM4 X 8-121-16543-G	C41-250 single arm open die hammer	4,210	5.7
Anyang Duanya Forging Press Machinery	Anyang	P.R.China	2	MRM6 X 9-0-16534-G	C61-70 single arm open die hammer	51,630	70
CNGC Inner Mongolia N0.1 Machinery		P.R.China	9	MRM8 X 9-0-16680-G	Russian 16 ton die forger	295,030	400
China Heavy Duty Truck Group Co.		P.R.China	14	MRM8 X 8-0-16366-G	China No. 1 Heavy Machinery 16t die forger	331,910	450
China Heavy Duty Truck Group Co.		P.R.China	14	MRM8 X 8-0-16366-G	China No. 1 Heavy Machinery 16t die forger	331,910	450
Dandong Aoshen Technical Development Co., Ltd.	Dandong	P.R.China	2	MRM8 X 9-0-16621-G	Shenyang Heavy Machinery 3 ton hammer	55,320	75
Dandong Aoshen Technical Development Co., Ltd.	Dandong	P.R.China	1	MRM4 X 9-121-16731-G	Hai'an Weihong Forging Machinery C41-750B	14,020	19
Fushun Qinggang Forging Co., Ltd.		P.R.China	4	MRM12 X 8-10-16058-G	Huaan SDY-8 open die hammer	193,250	262
Heilongjian Huann Electric-Hyd Co.	Heilongjian	P.R.China	1	MRM6 X 9-0-16297-G	Huaan SDY-1 open die hammer	26,190	35.5
Heilongjian Huann Electric-Hyd Co.	Heilongjian	P.R.China	2	MRM9 X 9-0-16279-G	Huaan SDY-3 open die hammer	77,450	105
Heilongjian Huaan Forging Mach.	Heilongjian	P.R.China	8	MRM6 X 9-0-16682-G	Huaan SDY-5 open die hammer	140,140	190
Heilongjian Huaan Forging Mach.	Heilongjian	P.R.China	2	MRM8 X 9-0-16822-G	Huaan SDY-3 open die hammer	112,110	152
Huaan		P.R.China	1	MRM7 X 5-0-16113-G	Huaan SDY-1 open die hammer	26,190	35.5
Liaoning 518 Internal-Combustion Engine Fittings		P.R.China	6	MRM8 X 9-1-15859-G	Yihui M10 die forger	184,400	250
Ningxia Orient Tantalum Industry Co., Ltd.	Ningxia	P.R.China	4	MRM4 X 9-1-15969-G	Huann MDY-3 die forger	66,390	90
Quanjiao Quanfa Machinery Co.,Ltd	Quanjiao	P.R.China	4	MRM4 X 10-1-16987-SG	Anyang Forging C86-75	55,320	75
The Ningbo Branch of Ordinance	Ningbo	P.R.China	2	MRM6 X 9-0-16534-G	C61-70 open die hammer	51,630	70
The Ningbo Branch of Ordinance	Ningbo	P.R.China	1	MRM4 X 9-121-16533-G	C41-750 pneumatic hammer	14,020	19
Herriamientas Stanley		Mexico	2	MRM4 X 6-0-16073	Ceco 30 CD drop hammer	15,490	21

COMPANY PROFILE

Since 1964, Vibro/Dynamics has been the leader and pioneer in the design and manufacture of vibration isolation and machinery installation systems for the metal forming, metal cutting, forging, can making, die casting, plastics, and woodworking industries.

Our Products and Services are designed to effectively reduce transmitted shock and vibration and to provide a way to precisely level, align, and properly support industrial machinery.

No other isolator manufacturer offers a broader product line and the most solutions. Whether it's a heavy blanker or forging hammer disturbing the neighbors, or an injection molder or die caster that likes to walk, Vibro/Dynamics has the best solution for you!

ISO 9001 CERTIFIED

Since 1997, Vibro/Dynamics has been unconditionally approved for ISO9001:2000 certification by ABS Quality Evaluations, Inc., Houston, Texas. We are very proud of our people and their effort in achieving this goal and maintaining this certification. We believe that this demonstrates our Company's commitment to quality and service.

OUR COMMITMENT

Vibro/Dynamics provides high-quality products, responsive service, and technologically innovative solutions for our customers.

The commitment, desire, and ability of our personnel to design, engineer, manufacture, and supply valuable solutions to meet our customer needs is the foundation of our success, growth, and long-lasting customer satisfaction.

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LIT-MRM 2016-09