



With its world headquarters located in Orchard Park, New York, USA, **ENIDINE Incorporated** is a world leader in the design and manufacture of standard and custom energy absorption and vibration isolation product solutions within the Industrial, Aerospace, Defense, Marine and Rail markets. Product ranges include shock absorbers, gas springs, rate controls, air springs, wire rope isolators, heavy industry buffers and emergency stops. With facilities strategically located throughout the world and in partnership with our vast global network of distributors, Enidine Incorporated continues to strengthen its presence within marketplace.

Founded in 1966, Enidine Incorporated now has close to 600 employees located throughout the globe in the United States, Germany, France, Japan, China and Korea. With a team of professionals in engineering, computer science, manufacturing, production and marketing our employees provide our customers the very best in service and application solutions.

“Enidine is widely recognized as the preferred source for energy absorption and vibration isolation products.”

From Original Equipment Manufacturers (OEM) to aftermarket applications, Enidine offers a unique combination of product selection, engineering excellence and technical support to meet even the toughest energy absorption application requirements.

Global Manufacturing and Sales Facilities offer our customers:

- **Highly Trained Distribution Network**
- **State-of-the Art Engineering Capabilities**
- **Custom Solution Development**
- **Customer Service Specialists**
- **Multiple Open Communication Channels**

If you are unsure whether one of our standard products meets your requirements, feel free to speak with one of our technical representatives at **+49 7621 98679-0**, or contact us via e-mail at **info@enidine.eu**.

Products/Engineering/Technical Support

Enidine continually strives to provide the widest selection of shock absorbers and rate control products in the global marketplace. Through constant evaluation and testing, we bring our customers the most cost effective products with more features, greater performance and improved ease of use.

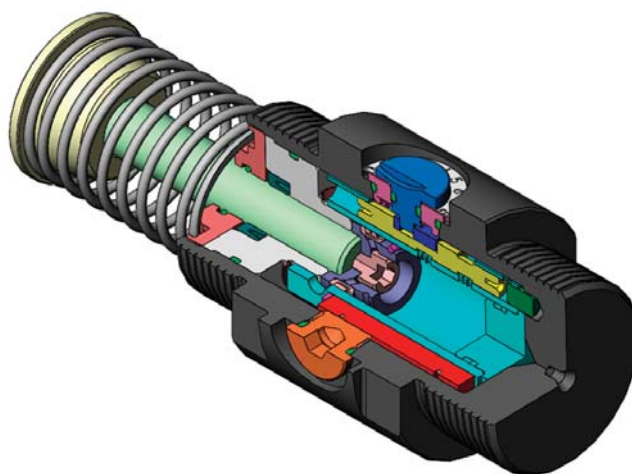
New Technologies and Enhancements

Research and Development

New Products and Services

Enidine engineers continue to monitor and influence trends in the motion control industry, allowing us to remain at the forefront of new energy absorption and vibration isolation product development.

Our experienced engineering team has designed custom solutions for a wide variety of challenging applications, including automated warehousing systems and shock absorbers for hostile industrial environments such as glass manufacturing, among others. These custom application solutions have proven to be critical to our customers' success. Let Enidine engineers do the same for you.



NEW
Technology



Custom designs are not an exception at Enidine, they are an integral part of our business. Should your requirements fit outside of our standard product range, Enidine engineers can assist in developing special finishes, components, hybrid technologies and new designs to ensure a "best-fit" product solution customized to your exact specifications.

A talented engineering staff works to design and maintain the most efficient energy absorption product lines available today, using the latest engineering tools:

- **3-D CAD Solid Modeling**
- **3-D Soluble Prototype Printing Capabilities**
- **Finite Element Analysis**
- **Complete Product Verification Testing Facility**

New product designs get to market fast because they can be fully developed in virtual environments before a prototype is ever built. This saves time and lets us optimize the best solution using real performance criteria.

Global Service and Support

Enidine offers its customers a global network of customer service staff technical sales personnel that are available to assist you with all of your application needs.

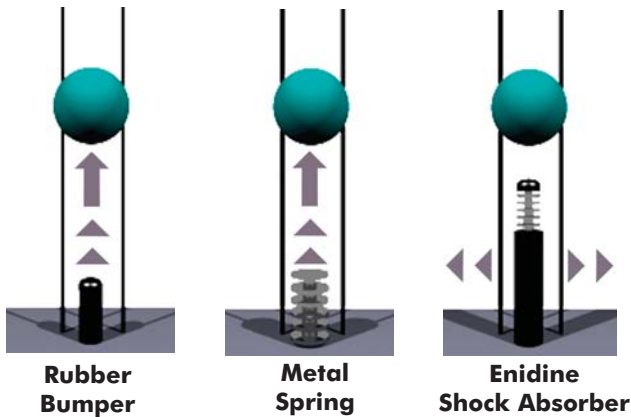
- Operating with lean manufacturing and cellular production, Enidine produces higher quality custom and standard products with greater efficiency and within shorter lead times.
- An authorized Global Distribution Network is trained regularly by ENIDINE staff on new products and services ensuring they are better able to serve you.
- Global operations in United States, Germany, France, China, Japan and Korea.
- A comprehensive, website full of application information, technical data, sizing examples and information to assist in selecting the product that's right for you.

Our website also features a searchable worldwide distributor lookup to help facilitate fast, localized service. Contact us today for assistance with all of your application needs.



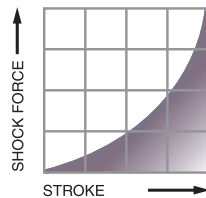
Our global customer service and technical sales departments are available to assist you find the solution that's right for your application needs. Call us at +49 7621 98679-0 or e-mail us at info@enidine.eu and let us get started today.

As companies strive to increase productivity by operating machinery at higher speeds, often the results are increased noise, damage to machinery/products, and excessive vibration. At the same time, safety and machine reliability are decreased. A variety of products are commonly used to solve these problems. However, they vary greatly in effectiveness and operation. Typical products used include rubber bumpers, springs, cylinder cushions and shock absorbers. The following illustrations compare how the most common products perform:

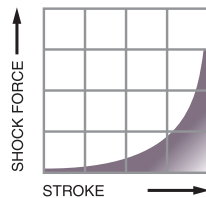


All moving objects possess kinetic energy. The amount of energy is dependent upon weight and velocity. A mechanical device that produces forces diametrically opposed to the direction of motion must be used to bring a moving object to rest.

Rubber bumpers and springs, although very inexpensive, have an undesirable recoil effect. Most of the energy absorbed by these at impact is actually stored. This stored energy is returned to the load, producing rebound and the potential for damage to the load or machinery. Rubber bumpers and springs initially provide low resisting force which increases with the stroke.



Cylinder cushions are limited in their range of operation. Most often they are not capable of absorbing energy generated by the system. by design, cushions have a relatively short stroke and operate at low pressures resulting in very low energy absorption. The remaining energy is transferred to the system, causing shock loading and vibration.



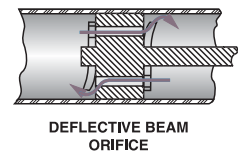
Shock absorbers provide controlled, predictable deceleration. These products work by converting kinetic energy to thermal energy. More specifically, motion applied to the piston of a hydraulic shock absorber pressurizes the fluid and forces it to flow through restricting orifices, causing the fluid to heat rapidly. The thermal energy is then transferred to the cylinder body and harmlessly dissipated to the atmosphere.

The advantages of using shock absorbers include:

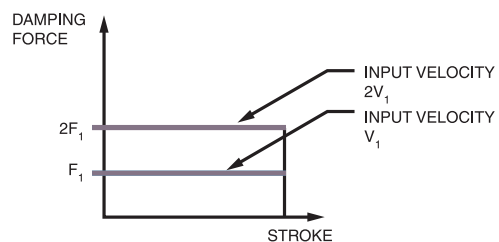
- 1. Longer Machine Life** – The use of shock absorbers significantly reduces shock and vibration to machinery. This eliminates machinery damage, reduces downtime and maintenance costs, while increasing machine life.
- 2. Higher Operating Speeds** – Machines can be operated at higher speeds because shock absorbers control or gently stop moving objects. Therefore, production rates can be increased.
- 3. Improved Production Quality** – Harmful side effects of motion, such as noise, vibration and damaging impacts, are moderated or eliminated so the quality of production is improved. Therefore, tolerances and fits are easier to maintain.
- 4. Safer Machinery Operation** – Shock absorbers protect machinery and equipment operators by offering predictable, reliable and controlled deceleration. They can also be designed to meet specified safety standards, when required.
- 5. Competitive Advantage** – Machines become more valuable because of increased productivity, longer life, lower maintenance costs and safer operation.

Automotive vs. Industrial Shock Absorbers

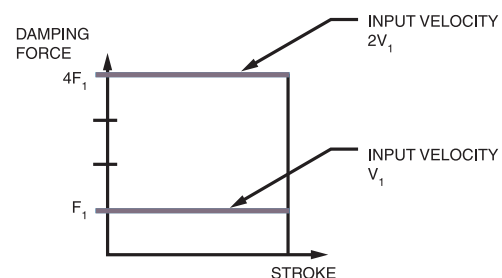
It is important to understand the differences that exist between the standard automotive-style shock absorber and the industrial shock absorber.



The automotive style employs the deflective beam and washer method of orificing. Industrial shock absorbers utilize single orifice, multi-orifice and metering pin configurations. The automotive type maintains a damping force which varies in direct proportion to the velocity of the piston, while the damping force in the industrial type varies in proportion to the square of the piston velocity. In addition, the damping force of the automotive type is independent of the stroke position while the damping force associated with the industrial type can be designed either dependent or independent of stroke position.



AUTOMOTIVE TYPE SHOCK ABSORBER



INDUSTRIAL TYPE SHOCK ABSORBER

Equally as important, automotive-style shock absorbers are designed to absorb only a specific amount of input energy. This means that, for any given geometric size of automotive shock absorber, it will have a limited amount of absorption capability compared to the industrial type.

This is explained by observing the structural design of the automotive type and the lower strength of materials commonly used. These materials can withstand the lower pressures commonly found in this type. The industrial shock absorber uses higher strength materials, enabling it to function at higher damping forces.

Adjustment Techniques

A properly adjusted shock absorber safely dissipates energy, reducing damaging shock loads and noise levels. For optimum adjustment setting see useable adjustment setting graphs. Watching and "listening" to a shock absorber as it functions aids in proper adjustment.



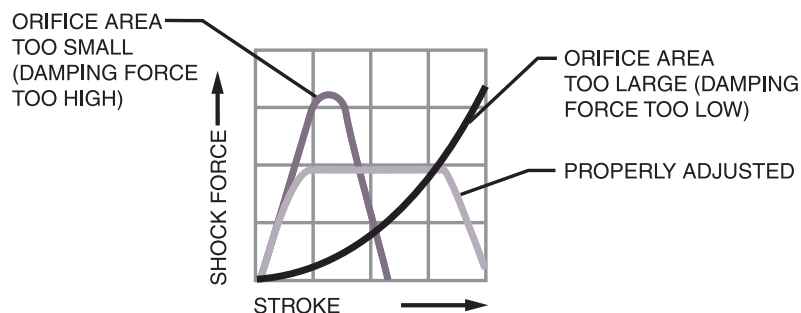
To correctly adjust a shock absorber, set the adjustment knob at zero (0) prior to system engagement. Cycle the mechanism and observe deceleration of the system.

If damping appears too soft (unit strokes with no visual deceleration and bangs at end of stroke), move indicator to next largest number. Adjustments must be made in gradual increments to avoid internal damage to the unit (e.g., adjust from 0 to 1, not 0 to 4).

Increase adjustment setting until smooth deceleration or control is achieved and negligible noise is heard when the system starts either to decelerate or comes to rest.

When abrupt deceleration occurs at the beginning of the stroke (banging at impact), the adjustment setting must be moved to a lower number to allow smooth deceleration.

If the shock absorber adjustment knob is set at the high end of the adjustment scale and abrupt deceleration occurs at the end of the stroke, a larger unit may be required.



Shock Absorber Performance When Weight or Impact Velocity Vary

When conditions change from the original calculated data or actual input, a shock absorber's performance can be greatly affected, causing failure or degradation of performance. Variations in input conditions after a shock absorber has been installed can cause internal damage, or at the very least, can result in unwanted damping performance. Variations in weight or impact velocity can be seen by examining the following energy curves:

Varying Impact Weight: Increasing the impact weight (impact velocity remains unchanged), without reorificing or readjustment will result in increased damping force at the end of the stroke. Figure 1 depicts this undesirable bottoming peak force. This force is then transferred to the mounting structure and impacting load.

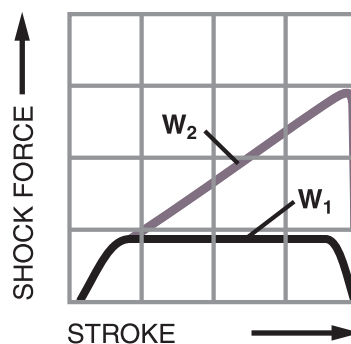


Figure 1

Varying Impact Velocity: Increasing impact velocity (weight remains the same) results in a radical change in the resultant shock force. Shock absorbers are velocity conscious products; therefore, the critical relationship to impact velocity must be carefully monitored. Figure 2 depicts the substantial change in shock force that occurs when the velocity is increased. Variations from original design data or errors in original data may cause damage to mounting structures and systems, or result in shock absorber failure if the shock force limits are exceeded.

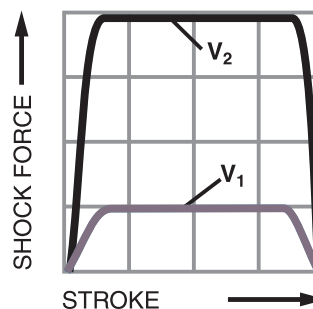


Figure 2

Shock Absorber Sizing Examples

Typical Shock Absorber Applications

Overview

SHOCK ABSORBER SIZING

Follow the next six steps to manually size Enidine shock absorbers:

STEP 1: Identify the following parameters. These must be known for all energy absorption calculations. Variations or additional information may be required in some cases.

- Weight of the load to be stopped (Kg).
- Velocity of the load upon impact with the shock absorber (m/s).
- External (propelling) forces acting on the load (N), if any.
- Cyclic frequency at which the shock absorber will operate.
- Orientation of the application's motion (i.e. horizontal, vertical up, vertical down, inclined, rotary horizontal, rotary vertical up, rotary vertical down).

NOTE: For rotary applications, it is necessary to determine both the radius of gyration (K) and the mass moment of inertia (I). both of these terms locate the mass of a rotating object with respect to the pivot point. It is also necessary to determine the angular velocity (ω) and the torque (T).

STEP 2: Calculate the kinetic energy of the moving object.

$$E_K = \frac{1}{2} \omega^2 \quad (\text{rotary}) \quad \text{or} \quad E_K = \frac{1}{2} MV^2 \quad (\text{linear})$$

Utilizing the Product Locators for Shock Absorbers located at the beginning of each product family section, select a model, either adjustable or non-adjustable, with a greater energy per cycle capacity than the value just calculated.

STEP 3: Calculate the work energy input from any external (propelling) forces acting on the load, using the stroke of the model selected in Step 2.

$$E_W = F_D \times S \quad (\text{linear}) \quad \text{or} \quad E_W = \frac{T}{R_S} \times S \quad (\text{rotary})$$

Caution: The propelling force must not exceed the maximum propelling force listed for the model chosen. If the propelling force is too high, select a larger model and recalculate the work energy.

STEP 4: Calculate the total energy per cycle $E_T = E_K + E_W$

The model selected must have at least this much energy capacity. If not, select a model with greater energy capacity and return to Step 3.

STEP 5: Calculate the energy that must be absorbed per hour. Even though the shock absorber can absorb the energy in a single impact, it may not be able to dissipate the heat generated if the cycle rate is too high.

$$E_T C = E_T \times C$$

The model selected must have an energy per hour capacity greater than this calculated figure. If it is not greater, there are two options:

- Choose another model that has more energy per hour capacity (because of larger diameter or stroke). Keep in mind that if the stroke changes, you must return to Step 3.
- Use an Air/Oil Tank. The increased surface area of the tank and piping will increase the energy per hour capacity by 20 percent.

STEP 6: If you have selected an HP, PM, SPM, TK, or PRO Series model, refer to the sizing graph(s) in the appropriate series section to determine the required damping constant. If the point cannot be found in the sizing graph, you must select a larger model or choose a different series. Note that if the stroke changes, you must return to Step 3.

If you have selected an adjustable model (OEM, HP or HDA series), refer to the Useable Adjustment Setting Range graph for the chosen model. The impact velocity must fall within the limits shown on the graph.

RATE CONTROL SIZING

Follow the next five steps to manually size Enidine rate controls:

STEP 1: Identify the following parameters.

These must be known for all rate control calculations. Variations or additional information may be required in some cases.

- Weight of the load to be controlled Kg
- Desired velocity of the load m/s
- External (propelling) force acting on the load N, if any.
- Cyclic frequency at which the rate control will operate.
- Orientation of the application's motion (i.e. horizontal, vertical up, vertical down, inclined, rotary horizontal, rotary vertical up, rotary vertical down.)
- Damping direction (i.e., tension [T], compression [C] or both [T and C].

G. Required stroke mm

NOTE: For rotary applications, please submit the application worksheet on page 108 to Enidine for sizing.

STEP 2: Calculate the propelling force at the rate control in each direction damping is required. (See sizing examples on page 6-12).

CAUTION: The propelling force in each direction must not exceed the maximum propelling force listed for the chosen model. If the propelling force is too high, select a larger model.

STEP 3: Calculate the total energy per cycle

$$E_T = E_W \text{ (tension)} + E_W \text{ (compression)}$$

$$E_W = F_D \times S$$

STEP 4: Calculate the total energy per hour

$$E_T C = E_T \times C$$

The model selected must have an energy per hour capacity greater than this calculated figure. If not, choose a model with a higher energy per hour capacity.

Compare the damping direction, stroke, propelling force, and total energy per hour to the values listed in the Rate Controls Engineering Data Charts (pages 109-114).

STEP 5: If you have selected a rate control, refer to the sizing graphs in the Rate Controls section to determine the required damping constant.

If you have selected an adjustable model (ADA), refer to the Useable Adjustment Setting Range graph for the chosen model. The desired velocity must fall within the limits shown on the graph.

Shock Absorber Sizing Examples

Typical Shock Absorber Applications

Overview

SYMBOLS

a = Acceleration (m/s²)
 A = Width (m)
 B = Thickness (m)
 C = Number of cycles per hour
 d = Cylinder bore diameter (mm)
 D = Distance (m)
 E_K = Kinetic energy (Nm)
 E_T = Total energy per cycle (Nm/c), E_K + E_W
 E_TC = Total energy to be absorbed per hour (Nm/hr)
 E_W = Work or drive energy (Nm)
 F_D = Propelling force (N)
 F_P = Shock force (N)
 H = Height (m)
 Hp = Motor rating (kw)
 I = Mass moment of inertia (kgm²)
 K = Radius of gyration (m)
 L = Length (m)
 P = Operating pressure (bar)
 R_S = Mounting distance from pivot point (m)
 S = Stroke of shock absorber (m)
 t = Time (s)
 T = Torque (Nm)
 V = Impact velocity (m/s)
 M = Mass (kg)

α = Angle of incline (degrees)
 θ = Start point from true vertical 0° (degrees)
 μ = Coefficient of friction
 Ø = Angle of rotation (degrees)
 ω = Angular velocity (rad/s)

USEFUL FORMULAS

1. To Determine Reaction Force

$$F_P = \frac{E_T}{S \times .85}$$

For PRO and PM Series only, use

$$F_P = \frac{E_T}{S \times .50}$$

2. To Determine Impact Velocity

A. If there is no acceleration (V is constant) (e.g., load being pushed by hydraulic cylinder or motor driven.)

$$V = \frac{D}{t}$$

B. If there is acceleration. (e.g., load being pushed by air cylinder)

$$V = \frac{2 \times D}{t}$$

3. To Determine Propelling Force Generated by Electric Motor

$$F_D = \frac{3000 \times \text{kw}}{V}$$

4. To Determine Propelling Force of Pneumatic or Hydraulic Cylinders

$$F_D = 0,0785 \times d^2 \times P$$

5. Free Fall Applications

A. Find Velocity for a Free Falling Weight:
 $V = \sqrt{19,6 \times H}$

B. Kinetic Energy of Free Falling Weight:
 $E_K = 9,8 \times M \times H$

6. Deceleration

A. To Determine the Approximate Stroke

$$a = \frac{F_P - F_D}{M}$$

B. To Determine the Approximate Stroke (Conventional Damping Only)

$$S = \frac{E_K}{a \times M \times 0,85 - 0,15 F_D}$$

*For PRO/PM and TK Models:

$$S = \frac{E_K}{a \times M \times 0,5 - 0,5 F_D}$$

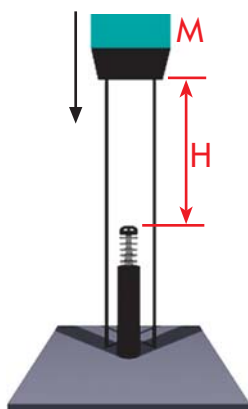
NOTE: Constants are printed in **bold**.

The following examples are shown using Metric formulas and units of measure.

Shock Absorbers

EXAMPLE 1:

Vertical Free Falling Weight



STEP 1: Application Data

(M) Mass = 1 550 kg
 (H) Height = 0,5 m
 (C) Cycles/Hr = 2

STEP 2: Calculate kinetic energy

$E_K = 9,8 \times M \times H$
 $E_K = 9,8 \times 1 550 \times 0,5$
 $E_K = 7 595 \text{ Nm}$

Assume Model OEM 4.0M x 6 is adequate (Page 31).

STEP 3: Calculate work energy

$E_W = 9,8 \times M \times S$
 $E_W = 9,8 \times 1 550 \times 0,15$
 $E_W = 2 278,5 \text{ Nm}$

STEP 4: Calculate total energy per cycle

$E_T = E_K + E_W$
 $E_T = 7 595 + 2 278,5$
 $E_T = 9 873,5 \text{ Nm/c}$

STEP 5: Calculate total energy per hour

$E_{T}C = E_T \times C$
 $E_{T}C = 9 873,5 \times 2$
 $E_{T}C = 19 747 \text{ Nm/hr}$

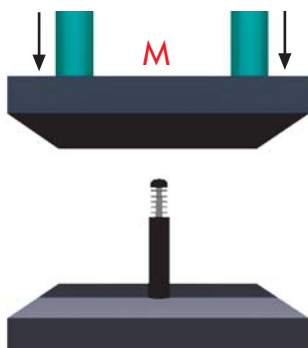
STEP 6: Calculate impact velocity and confirm selection

$V = \sqrt{19,6 \times H}$
 $V = \sqrt{19,6 \times 0,5}$
 $V = 3,1 \text{ m/s}$

Model OEM 4.0M x 6 is adequate for this application.

EXAMPLE 2:

Vertical Moving Load with Propelling Force Downward



STEP 1: Application Data

(M) Mass = 1 550 kg
 (V) Velocity = 2,0 m/s
 (d) Cylinder bore dia. = 100mm
 (P) Pressure = 5 bar
 (C) Cycles/Hr = 200

STEP 2: Calculate kinetic energy

$E_K = \frac{M}{2} \times V^2 = \frac{1 550}{2} \times 2^2$
 $E_K = 3 100 \text{ Nm}$

Assume Model OEM 4.0M x 4 is adequate (Page 31).

STEP 3: Calculate work energy

$F_D = [0,0785 \times d^2 \times P] + [9,8 \times M]$
 $F_D = [0,0785 \times 100^2 \times 5] + [9,8 \times 1 550]$
 $F_D = 19 117 \text{ N}$
 $E_W = F_D \times S$
 $E_W = 19 117 \times 0,1$
 $E_W = 1 911,7 \text{ Nm}$

STEP 4: Calculate total energy per cycle

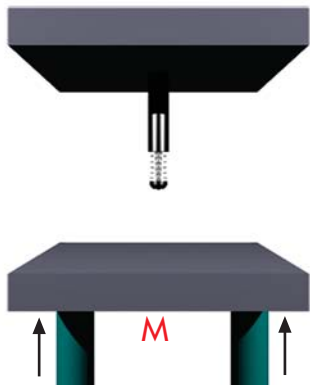
$E_T = E_K + E_W$
 $E_T = 3 100 + 1 911,7$
 $E_T = 5 011,7 \text{ Nm/c}$

STEP 5: Calculate total energy per hour

$E_{T}C = E_T \times C$
 $E_{T}C = 5 011,7 \times 200$
 $E_{T}C = 1 002 340 \text{ Nm/hr}$

Model OEM 4.0M x 4 is adequate.

EXAMPLE 3: Vertical Moving Load with Propelling Force Upward



STEP 1: Application Data

(M) Mass = 1 550 kg
(V) Velocity = 2 m/s
(d) 2 Cylinders bore dia. = 150mm
(P) Operating pressure = 5 bar
(C) Cycles/Hr = 200

STEP 2: Calculate kinetic energy

$$E_K = \frac{M}{2} \times V^2 = \frac{1\,550}{2} \times 2^2$$

$$E_K = 3\,100 \text{ Nm}$$

Assume Model OEM 3.0M x 5 is adequate (Page 31).

STEP 3: Calculate work energy

$$F_D = 2 \times [0,0785 \times d^2 \times P] - [9,8 \times M]$$

$$F_D = 2 \times [0,0785 \times 150^2 \times 5] - [9,8 \times 1\,550]$$

$$F_D = 2\,472,5 \text{ N}$$

$$E_W = F_D \times S$$

$$E_W = 2\,472,5 \times 0,125$$

$$E_W = 309 \text{ Nm}$$

STEP 4: Calculate total energy per cycle

$$E_T = E_K + E_W$$

$$E_T = 3\,100 + 309$$

$$E_T = 3\,409 \text{ Nm/c}$$

STEP 5: Calculate total energy per hour

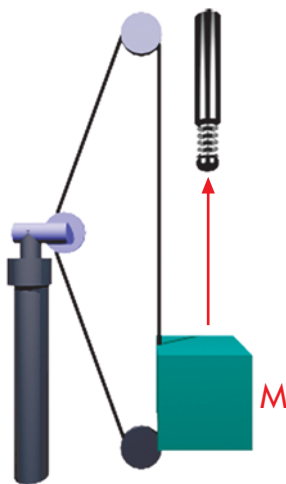
$$E_{TC} = E_T \times C$$

$$E_{TC} = 3\,409 \times 200$$

$$E_{TC} = 681\,800 \text{ Nm/hr}$$

Model OEM 3.0M x 5 is adequate.

EXAMPLE 4: Vertical Moving Load with Propelling Force from Motor



STEP 1: Application Data

(M) Mass = 90 kg
(V) Velocity = 1,5 m/s
(kW) Motor rating = 1 kW
(C) Cycles/Hr = 100

STEP 2: Calculate kinetic energy

$$E_K = \frac{M}{2} \times V^2 = \frac{90}{2} \times 1,5^2$$

$$E_K = 101 \text{ Nm}$$

CASE A: UP

STEP 3: Calculate work energy

$$F_D = \frac{3\,000 \times \text{kW}}{V} - 9,8 \times M$$

$$F_D = \frac{3\,000 \times 1}{1,5} - 882$$

$$F_D = 1\,118 \text{ N}$$

Assume Model OEM 1.25 x 2 is adequate (Page 26).

$$E_W = F_D \times S$$

$$E_W = 1\,118 \times 0,5$$

$$E_W = 56 \text{ Nm}$$

STEP 4: Calculate total energy per cycle

$$E_T = E_K + E_W$$

$$E_T = 101 + 56$$

$$E_T = 157 \text{ Nm/c}$$

STEP 5: Calculate total energy per hour

$$E_{TC} = E_T \times C$$

$$E_{TC} = 157 \times 100$$

$$E_{TC} = 15\,700 \text{ Nm/hr}$$

Model OEM 1.25 x 2 is adequate.

CASE B: DOWN

STEP 3: Calculate work energy

$$F_D = \frac{3\,000 \times \text{kW}}{V} + 9,8 \times M$$

$$F_D = \frac{3\,000 \times 1}{1,5} + 882$$

$$F_D = 2\,882 \text{ N}$$

Assume Model OEMXT 2.0M

x 2 is adequate (Page 30).

$$E_W = F_D \times S$$

$$E_W = 2\,882 \times 0,05$$

$$E_W = 144 \text{ Nm}$$

STEP 4: Calculate total energy per cycle

$$E_T = E_K + E_W$$

$$E_T = 101 + 144$$

$$E_T = 245 \text{ Nm/c}$$

STEP 5: Calculate total energy per hour

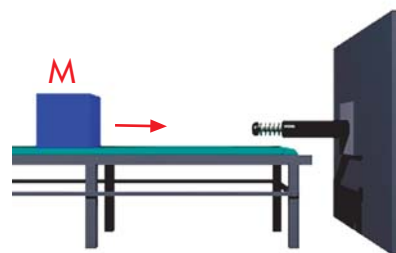
$$E_{TC} = E_T \times C$$

$$E_{TC} = 245 \times 100$$

$$E_{TC} = 24\,500 \text{ Nm/hr}$$

Model OEMXT 2.0M x 2 is adequate.

EXAMPLE 5: Horizontal Moving Load



STEP 1: Application Data

(M) Mass = 900 kg
(V) Velocity = 1,5 m/s
(C) Cycles/Hr = 200

STEP 2: Calculate kinetic energy

$$E_K = \frac{M}{2} \times V^2$$

$$E_K = \frac{900}{2} \times 1,5^2$$

$$E_K = 1\,012,5 \text{ Nm}$$

Assume Model OEMXT 2.0M x 2 is adequate (Page 30).

STEP 3: Calculate work energy: N/A

STEP 4: Calculate total energy per cycle

$$E_T = E_K = 1\,012,5 \text{ Nm/c}$$

STEP 5: Calculate total energy per hour

$$E_{TC} = E_T \times C$$

$$E_{TC} = 1\,012,5 \times 200$$

$$E_{TC} = 202\,500 \text{ Nm/hr}$$

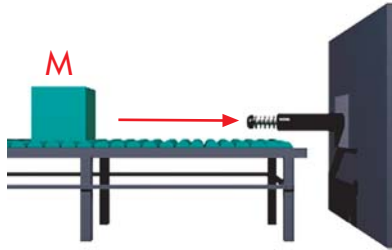
Model OEMXT 2.0M x 2 is adequate.

Shock Absorber Sizing Examples

Typical Shock Absorber Applications

Overview

EXAMPLE 6: Horizontal Moving Load with Propelling Force



STEP 1: Application Data
 (M) Mass = 900 kg
 (V) Velocity = 1,5 m/s
 (d) Cylinder bore dia. = 75mm
 (P) Operating pressure = 5 bar
 (C) Cycles/Hr = 200

STEP 2: Calculate kinetic energy

$$E_K = \frac{M}{2} \times V^2$$

$$E_K = \frac{900}{2} \times 1,5^2$$

$$E_K = 1\ 012,5\ \text{Nm}$$

Assume Model OEMXT 2.0M x 2 is adequate (Page 30).

STEP 3: Calculate work energy

$$F_D = 0,0785 \times d^2 \times P$$

$$F_D = 0,0785 \times 75^2 \times 5$$

$$F_D = 2\ 208,9\ \text{N}$$

$$E_W = F_D \times S$$

$$E_W = 2\ 208,9 \times 0,05$$

$$E_W = 110\ \text{Nm/c}$$

STEP 4: Calculate total energy per cycle

$$E_T = E_K + E_W$$

$$E_T = 1\ 012,5 + 110$$

$$E_T = 1\ 122,5\ \text{Nm/c}$$

STEP 5: Calculate total energy per hour

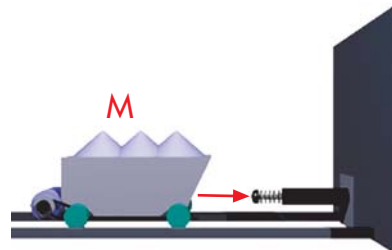
$$E_T C = E_T \times C$$

$$E_T C = 1\ 122,5 \times 200$$

$$E_T C = 224\ 500\ \text{Nm/hr}$$

Model OEMXT 2.0M x 2 is adequate.

EXAMPLE 7: Horizontal Moving Load, Motor Driven



STEP 1: Application Data

(M) Mass = 1 000 kg
 (V) Velocity = 1,5 m/s
 (kW) Motor rating = 1 kW
 (C) Cycles/Hr = 120

STEP 2: Calculate kinetic energy

$$E_K = \frac{M}{2} \times V^2$$

$$E_K = \frac{1\ 000}{2} \times 1,5^2$$

$$E_K = 1\ 125\ \text{Nm}$$

Assume Model OEMXT 2.0M x 2 is adequate (Page 30).

STEP 3: Calculate work energy

$$F_D = \frac{3\ 000 \times \text{kW}}{V}$$

$$F_D = \frac{3\ 000 \times 1}{1,5}$$

$$F_D = 2\ 000\ \text{N}$$

$$E_W = F_D \times S$$

$$E_W = 2\ 000 \times 0,05$$

$$E_W = 100\ \text{Nm}$$

STEP 4: Calculate total energy per cycle

$$E_T = E_K + E_W$$

$$E_T = 1\ 125 + 100$$

$$E_T = 1\ 225\ \text{Nm/c}$$

STEP 5: Calculate total energy per hour

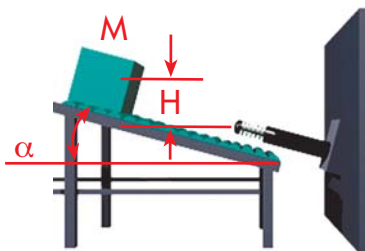
$$E_T C = E_T \times C$$

$$E_T C = 1\ 225 \times 120$$

$$E_T C = 147\ 000\ \text{Nm/hr}$$

Model OEMXT 2.0M x 2 is adequate.

EXAMPLE 8: Free Moving Load Down an Inclined Plane



STEP 1: Application Data

(M) Mass = 250 kg
 (H) Height = 0,2 m
 (α) Angle of incline = 30°
 (C) Cycles/Hr = 250

STEP 2: Calculate kinetic energy

$$E_K = 9,8 \times M \times H$$

$$E_K = 9,8 \times 250 \times 0,2$$

$$E_K = 490\ \text{Nm}$$

Assume Model OEMXT 1.5M x 3 is adequate (Page 27).

STEP 3: Calculate work energy

$$F_D = 9,8 \times M \times \sin \alpha$$

$$F_D = 9,8 \times 250 \times 0,5$$

$$F_D = 1\ 225\ \text{N}$$

$$E_W = F_D \times S$$

$$E_W = 1\ 225 \times 0,075$$

$$E_W = 91,9\ \text{Nm}$$

STEP 4: Calculate total energy per cycle

$$E_T = E_K + E_W$$

$$E_T = 490 + 91,9$$

$$E_T = 581,9\ \text{Nm/c}$$

STEP 5: Calculate total energy per hour

$$E_T C = E_T \times C$$

$$E_T C = 581,9 \times 250$$

$$E_T C = 145\ 475\ \text{Nm/hr}$$

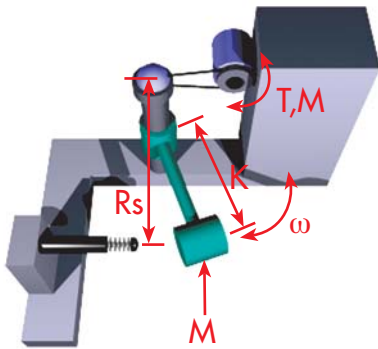
STEP 6: Calculate impact velocity and confirm selection

$$V = \sqrt{19,6 \times H}$$

$$V = \sqrt{19,6 \times 0,2} = 2,0\ \text{m/s}$$

Model OEMXT 1.5M x 3 is adequate.

EXAMPLE 9: Horizontal Rotating Mass



STEP 1: Application Data

(M) Mass = 90 kg
 (ω) Angular velocity = 1,5 rad/s
 (T) Torque = 120 Nm
 (K) Radius of gyration = 0,4 m
 (Rs) Mounting radius = 0,5 m
 (C) Cycles/Hr = 120

STEP 2: Calculate kinetic energy

$$I = M \times K^2$$

$$I = 90 \times 0,4^2$$

$$I = 14,4 \text{ kgm}^2$$

$$E_K = \frac{I \times \omega^2}{2}$$

$$E_K = \frac{14,4 \times 1,5^2}{2}$$

$$E_K = 16,2 \text{ Nm}$$

Assume Model STH 0.5M is adequate (Page 40).

STEP 3: Calculate work energy

$$F_D = \frac{T}{R_S}$$

$$F_D = \frac{120}{0,5}$$

$$F_D = 240 \text{ N}$$

$$E_W = F_D \times S$$

$$E_W = 240 \times 0,013$$

$$E_W = 3 \text{ Nm}$$

STEP 4: Calculate total energy per cycle

$$E_T = E_K + E_W$$

$$E_T = 16,2 + 3$$

$$E_T = 19,2 \text{ Nm/c}$$

STEP 5: Calculate total energy per hour

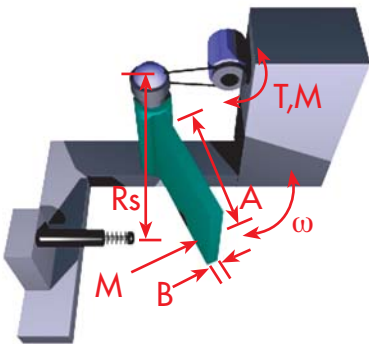
$$E_{TC} = E_T \times C$$

$$E_{TC} = 19,2 \times 120$$

$$E_{TC} = 2304 \text{ Nm/hr}$$

Model STH 0.5M is adequate.

EXAMPLE 10: Horizontal Rotating Door



STEP 1: Application Data

(M) Mass = 25 kg
 (ω) Angular velocity = 2,5 rad/s
 (T) Torque = 10 Nm
 (Rs) Mounting radius = 0,5 m
 (A) Width = 1,0 m
 (B) Thickness = 0,1 m
 (C) Cycles/Hr = 250

STEP 2: Calculate kinetic energy

$$K = 0,289 \times \sqrt{4 \times A^2 + B^2}$$

$$K = 0,289 \times \sqrt{4 \times 1,0^2 + 0,1^2}$$

$$K = 0,58 \text{ m}$$

$$I = M \times K^2$$

$$I = 25 \times 0,58^2$$

$$I = 8,4 \text{ kgm}^2$$

$$E_K = \frac{I \times \omega^2}{2}$$

$$E_K = \frac{8,4 \times 2,5^2}{2}$$

$$E_K = 26,3 \text{ Nm}$$

Assume Model OEM .5M is adequate (Page 19).

STEP 3: Calculate work energy

$$F_D = \frac{T}{R_S}$$

$$F_D = \frac{10}{0,5}$$

$$F_D = 20 \text{ N}$$

$$E_W = F_D \times S$$

$$E_W = 20 \times 0,025$$

$$E_W = 0,5 \text{ Nm}$$

STEP 4: Calculate total energy per cycle

$$E_T = E_K + E_W$$

$$E_T = 26,3 + 0,5$$

$$E_T = 26,8 \text{ Nm/c}$$

STEP 5: Calculate total energy per hour

$$E_{TC} = E_T \times C$$

$$E_{TC} = 26,8 \times 250$$

$$E_{TC} = 6700 \text{ Nm/hr}$$

STEP 6: Calculate impact velocity and confirm selection

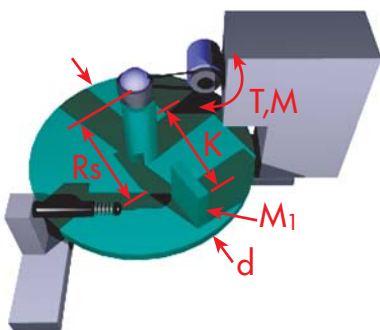
$$V = R_S \times \omega$$

$$V = 0,5 \times 2,5$$

$$V = 1,25 \text{ m/s}$$

Model OEM 0.5M is adequate.

EXAMPLE 11: Horizontal Moving Load, Rotary Table Motor Driven with Additional Load Installed



STEP 1: Application Data

(M) Mass = 200 kg
 (M1) Installed load = 50 kg
 Rotational speed = 10 RPM
 (T) Torque = 250 Nm
 Rotary table dia. = 0,5 m
 (KLoad) Radius of gyration = 0,2 m
 (Rs) Mounting radius = 0,225 m
 (C) Cycles/Hr = 1

Step 2: Calculate kinetic energy

To convert RPM to rad/s,
 multiply by **0,1047**

$$\omega = \text{RPM} \times 0,1047$$

$$\omega = 10 \times 0,1047$$

$$\omega = 1,047 \text{ rad/s}$$

$$I = M \times K$$

In this case, the mass moment of inertia of the table and the mass moment of inertia of the load on the table must be calculated.

$$K_{\text{Table}} = \text{Table Radius} \times 0,707$$

$$K_{\text{Table}} = 0,25 \times 0,707 = 0,176 \text{ m}$$

$$I_{\text{Table}} = M \times K_{\text{Table}}^2$$

$$I_{\text{Table}} = 200 \times 0,176^2$$

$$I_{\text{Table}} = 6,2 \text{ kgm}^2$$

$$I_{\text{Load}} = M_1 \times K_{\text{Load}}^2$$

$$I_{\text{Load}} = 50 \times (0,20)^2 = 2 \text{ kgm}^2$$

$$E_K = \frac{(I_{\text{Table}} + I_{\text{Load}}) \times \omega^2}{2}$$

$$E_K = \frac{(6,2 + 2) \times 1,047^2}{2}$$

$$E_K = 4,5 \text{ Nm}$$

Assume model PM 50M-3 is adequate (Page 46).

STEP 3: Calculate work energy

$$F_D = \frac{T}{R_S} = \frac{250}{0,225} = 1111,1 \text{ N}$$

$$E_W = F_D \times S = 1111,1 \times 0,022$$

$$E_W = 24,4 \text{ Nm}$$

STEP 4: Calculate total energy per cycle

$$E_T = E_K + E_W$$

$$E_T = 4,5 + 24,4$$

$$E_T = 28,9 \text{ Nm/c}$$

STEP 5: Calculate total energy per hour: not applicable, C=1

STEP 6: Calculate impact velocity and confirm selection

$$V = R_S \times \omega$$

$$V = 0,225 \times 1,047$$

$$V = 0,24 \text{ m/s}$$

From PM Sizing Graph.
 Model PM 50M-3 is adequate.

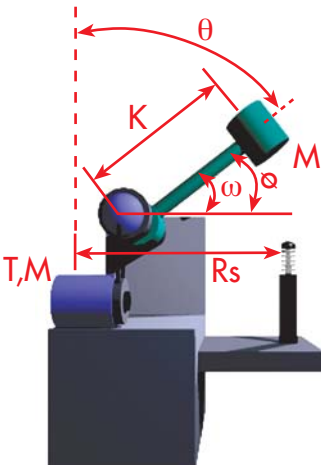
Shock Absorber Sizing Examples

Typical Shock Absorber Applications

Overview

EXAMPLE 12:

Vertical Motor Driven Rotating Arm with Attached Load CASE A-Load Aided by Gravity



STEP 1: Application Data

(M) Mass = 50 kg
 (ω) Angular velocity = 2 rad/s
 (T) Torque = 350 Nm
 (θ) Angle of rotation = 30°
 (K_{Load}) Radius of gyration = 0,6 m
 (R_S) Mounting radius = 0,4 m
 (C) Cycles/Hr = 1

STEP 2: Calculate kinetic energy

$$I = M \times K^2 = 50 \times 0,6^2$$

$$I = 18 \text{ kgm}^2$$

$$E_K = \frac{I \times \omega^2}{2}$$

$$E_K = \frac{18 \times 2^2}{2}$$

$$E_K = 36 \text{ Nm}$$

Assume Model OEM 1.0 is adequate (Page 21).

CASE A

STEP 3: Calculate work energy

$$F_D = \frac{T + (9,8 \times M \times K \times \sin \theta)}{R_S}$$

$$F_D = \frac{350 + (9,8 \times 50 \times 0,6 \times 0,5)}{0,4}$$

$$F_D = 1\,242,5 \text{ N}$$

$$E_W = F_D \times S$$

$$E_W = 1\,242,5 \times 0,025$$

$$E_W = 31,1 \text{ Nm}$$

STEP 4: Calculate total energy per cycle

$$E_T = E_K + E_W$$

$$E_T = 36 + 31,1$$

$$E_T = 67,1 \text{ Nm/c}$$

STEP 5: Calculate total energy per hour: not applicable, C=1

STEP 6: Calculate impact velocity and confirm selection.

$$V = R_S \times \omega$$

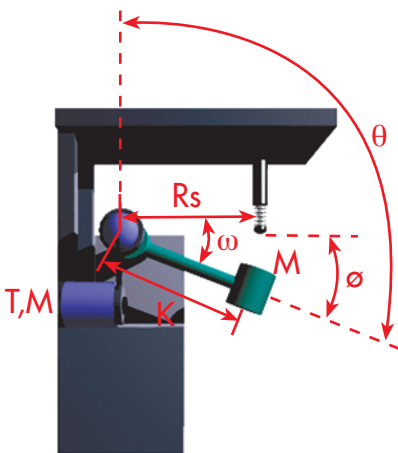
$$V = 0,4 \times 2$$

$$V = 0,8 \text{ m/s}$$

Model LROEM 1.0 is adequate.
 Needed for higher calculated propelling force.

EXAMPLE 13:

Vertical Motor Driven Rotating Arm with Attached Load CASE B-Load Opposing Gravity



STEP 1: Application Data

(M) Mass = 50 kg
 (ω) Angular velocity = 2 rad/s
 (T) Torque = 350 Nm
 (θ) Angle of rotation = 30°
 (K_{Load}) Radius of gyration = 0,6 m
 (R_S) Mounting radius = 0,4 m
 (C) Cycles/Hr = 1

STEP 2: Calculate kinetic energy

$$I = M \times K^2 = 50 \times 0,6^2$$

$$I = 18 \text{ kgm}^2$$

$$E_K = \frac{I \times \omega^2}{2}$$

$$E_K = \frac{18 \times 2^2}{2}$$

$$E_K = 36 \text{ Nm}$$

Assume Model OEM 1.0M is adequate (Page 21).

CASE B

STEP 3: Calculate work energy

$$F_D = \frac{T - (9,8 \times M \times K \times \sin \theta)}{R_S}$$

$$F_D = \frac{350 - (9,8 \times 50 \times 0,6 \times 0,5)}{0,4}$$

$$F_D = 507,5 \text{ N}$$

$$E_W = F_D \times S$$

$$E_W = 507,5 \times 0,025$$

$$E_W = 12,7 \text{ Nm}$$

STEP 4: Calculate total energy per cycle

$$E_T = E_K + E_W$$

$$E_T = 36 + 12,7$$

$$E_T = 48,7 \text{ Nm/c}$$

STEP 5: Calculate total energy per hour: not applicable, C=1

STEP 6: Calculate impact velocity and confirm selection

$$V = R_S \times \omega$$

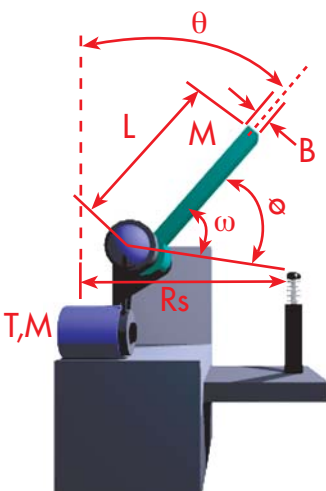
$$V = 0,4 \times 2$$

$$V = 0,8 \text{ m/s}$$

Model OEM 1.0M is adequate.

EXAMPLE 14:

Vertical Rotating Beam



STEP 1: Application Data

(M) Mass = 245 kg
 (ω) Angular velocity = 3,5 rad/s
 (T) Torque = 30 Nm
 (θ) Starting point from true vertical = 20°
 (Ø) Angle of rotation = 50°
 (R_S) Mounting radius = 0,5 m
 (B) Thickness = 0,06 m
 (L) Length = 0,6 m
 (C) Cycles/Hr = 1

STEP 2: Calculate kinetic energy

$$K = 0,289 \times \sqrt{4 \times L^2 + B^2}$$

$$K = 0,289 \times \sqrt{4 \times 0,6^2 + 0,06^2}$$

$$K = 0,35 \text{ m}$$

$$I = M \times K^2 = 245 \times 0,35^2$$

$$I = 30 \text{ kgm}^2$$

$$E_K = \frac{I \times \omega^2}{2} = \frac{30 \times 3,5^2}{2} = 184 \text{ Nm}$$

Assume Model OEM 1.5M x 2 is adequate (Page 27).

STEP 3:

$$F_D = \frac{T + [9,8 \times M \times K \times \sin (\theta + \theta)]}{R_S}$$

$$F_D = \frac{30 + [9,8 \times 245 \times 0,35 \times \sin (20^\circ + 50^\circ)]}{0,5}$$

$$F_D = 1\,640 \text{ N}$$

$$E_W = F_D \times S$$

$$E_W = 1\,640 \times 0,05$$

$$E_W = 82 \text{ Nm}$$

STEP 4: Calculate total energy per cycle

$$E_T = E_K + E_W$$

$$E_T = 184 + 82$$

$$E_T = 266 \text{ Nm/c}$$

STEP 5: Calculate total energy per hour: not applicable, C=1

STEP 6: Calculate impact velocity and confirm selection

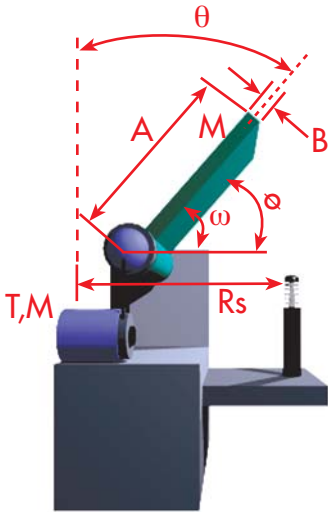
$$V = R_S \times \omega$$

$$V = 0,5 \times 3,5$$

$$V = 1,75 \text{ m/s}$$

Model OEM 1.5M x 2 is adequate.

EXAMPLE 15: Vertical Rotating Lid



STEP 1: Application Data

(M) Mass = 910 kg
 (ω) Angular velocity = 2 rad/s
 (kW) Motor rating = 0,20 kW
 (θ) Starting point from true vertical = 30°
 (ϕ) Angle of rotation = 60°
 (R_S) Mounting radius = 0,8 m
 (A) Width = 1,5 m
 (B) Thickness = 0,03 m
 (C) Cycle/Hr = 1

STEP 2: Calculate kinetic energy

$K = 0,289 \times \sqrt{4 \times A^2 + B^2}$
 $K = 0,289 \times \sqrt{4 \times 1,50^2 + 0,03^2}$
 $K = 0,87 \text{ m}$

$$I = M \times K^2 = 910 \times 0,87^2$$

$$I = 688,8 \text{ kgm}^2$$

$$E_K = \frac{I \times \omega^2}{2} = \frac{688,8 \times 2^2}{2}$$

$$E_K = 1\,377,6 \text{ Nm}$$

Assume Model OEM 3.0M x 2 is adequate (Page 21).

STEP 3: Calculate work energy

$$T = \frac{3\,000 \times \text{kW}}{\omega}$$

$$T = \frac{3\,000 \times 0,20}{2} = 300 \text{ Nm}$$

$$F_D = \frac{T + (9,8 \times M \times K \times \sin(\theta + \phi))}{R_S}$$

$$F_D = \frac{300 + (9,8 \times 910 \times 0,87 \times \sin(60^\circ + 30^\circ))}{0,8}$$

$$F_D = 10\,073 \text{ N}$$

$$E_W = F_D \times S$$

$$E_W = 10\,073 \text{ N} \times 0,05$$

$$E_W = 503,7 \text{ Nm}$$

STEP 4: Calculate total energy per cycle

$$E_T = E_K + E_W$$

$$E_T = 1\,377,6 + 503,7$$

$$E_T = 1\,881,3 \text{ Nm/c}$$

STEP 5: Calculate total energy per hour: not applicable, C=1

STEP 6: Calculate impact velocity and confirm selection

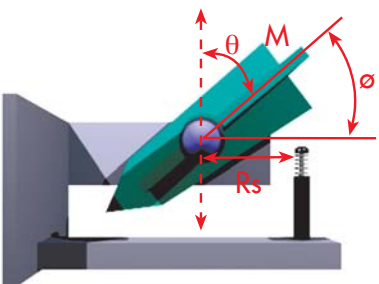
$$V = R_S \times \omega$$

$$V = 0,8 \times 2$$

$$V = 1,6 \text{ m/s}$$

Model OEM 3.0M x 2 is adequate.

EXAMPLE 16: Vertical Rotation with Known Inertia Aided by Gravity



STEP 1: Application Data

(M) Mass = 100 kg
 (I) Known Inertia = 100 kgm²
 (C/G) Center-of-Gravity = 305 mm
 (θ) Starting point from true vertical = 60°
 (ϕ) Angle of rotation at impact = 30°
 (R_S) Mounting radius = 254 mm
 (C) Cycles/Hr = 1

STEP 2: Calculate kinetic energy

$$H = C/G \times [\cos(\theta) - \cos(\theta + \phi)]$$

$$H = 0,305 \times [\cos(60^\circ) - \cos(30^\circ + 60^\circ)]$$

$$E_K = 9,8 \times M \times H$$

$$E_K = 9,8 \times 100 \times 0,5$$

$$E_K = 149,5 \text{ Nm}$$

STEP 3: Calculate work energy

$$F_D = (9,8 \times M \times C/G \times \sin(\theta + \phi)) / R_S$$

$$F_D = (9,8 \times 100 \times 0,305 \times \sin(60^\circ + 30^\circ)) / 0,254$$

$$F_D = 1176,8 \text{ N}$$

$$E_W = F_D \times S = 1176,8 \times 0,025$$

$$E_W = 29,4 \text{ Nm}$$

STEP 4: Calculate total energy per cycle

$$E_T = E_K + E_W = 149,5 + 29,4$$

$$E_T = 178,9 \text{ Nm/c}$$

STEP 5: Calculate total energy per hour: not applicable, C = 1

$$E_T C = E_T \times C$$

$$E_T C = 178,9 \times 1$$

$$E_T C = 178,9 \text{ Nm/hr}$$

STEP 6: Calculate impact velocity and confirm selection

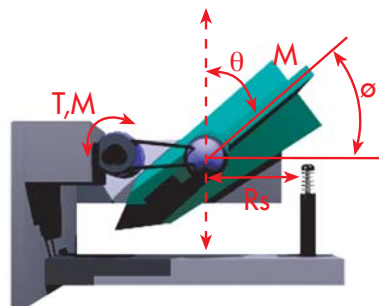
$$\omega = \sqrt{(2 \times E_K) / I}$$

$$\omega = \sqrt{(2 \times 149,5) / 100} = 1,7 \text{ rad/s}$$

$$V = R_S \times \omega = 0,254 \times 1,7 = 0,44 \text{ m/s}$$

Model OEM 1.15M x 1 is adequate (Page 24).

EXAMPLE 17: Vertical Rotation with Known Inertia Aided by Gravity (w/Torque)



STEP 1: Application Data

(M) Mass = 100 kg
 (ω) Angular Velocity = 2 rad/s
 (T) Torque = 310 Nm
 (I) Known Inertia = 100 kgm²
 (C/G) Center-of-Gravity = 305 mm
 (θ) Starting point from true vertical = 60°
 (ϕ) Angle of rotation at impact = 30°
 (R_S) Mounting radius = 254 mm
 (C) Cycles/Hr = 100

STEP 2: Calculate kinetic energy

$$E_K = (I \times \omega^2) / 2$$

$$E_K = (100 \times 2^2) / 2$$

$$E_K = 200 \text{ Nm}$$

STEP 3: Calculate work energy

$$F_D = [T + (9,8 \times M \times C/G \times \sin(\theta + \phi))] / R_S$$

$$F_D = [310 + (9,8 \times 100 \times 0,305 \times \sin(60^\circ + 30^\circ))] / 0,254$$

$$F_D = 2\,397,2 \text{ N}$$

$$E_W = F_D \times S = 2\,397 \times 0,025$$

$$E_W = 59,9 \text{ Nm}$$

STEP 4: Calculate total energy per cycle

$$E_T = E_K + E_W = 200 + 59,9$$

$$E_T = 259,9 \text{ Nm/c}$$

STEP 5: Calculate total energy per hour: not applicable, C = 1

$$E_T C = E_T \times C$$

$$E_T C = 259,9 \times 100$$

$$E_T C = 25\,990 \text{ Nm/hr}$$

STEP 6: Calculate impact velocity and confirm selection

$$V = R_S \times \omega = 0,254 \times 2$$

$$= 0,51 \text{ m/s}$$

Model OEMXT 1.5M x 1 is adequate (Page 27).

Shock Absorber Sizing Examples

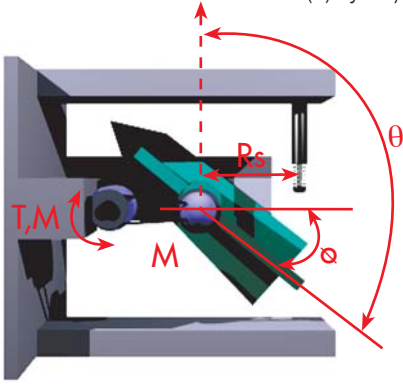
Typical Shock Absorber Applications

Overview

EXAMPLE 18:
Vertical Rotation with Known Inertia Opposing Gravity (w/Torque)

STEP 1: Application Data

- (M) Mass = 100 kg
- (ω) Angular Velocity = 2 rad/s
- (T) Torque = 310 Nm
- (I) Known Inertia = 100 kgm²
- (C/G) Center-of-Gravity = 305 mm
- (θ) Starting point from true vertical = 120°
- (\emptyset) Angle of rotation at impact = 30°
- (R_S) Mounting radius = 254 mm
- (C) Cycles/Hr = 100



STEP 2: Calculate kinetic energy

$$E_K = (I \times \omega^2) / 2$$

$$E_K = (100 \times 2^2) / 2$$

$$E_K = 200 \text{ Nm}$$

STEP 3: Calculate work energy

$$F_D = [T - (9,8 \times M \times C/G \times \sin(\theta - \emptyset))] / R_S$$

$$F_D = [310 - (9,8 \times 100 \times 0,305 \times \sin(120^\circ - 30^\circ))] / 0,254$$

$$F_D = 43,7 \text{ N}$$

$$E_W = F_D \times S = 43,7 \times 0,025 = 1,1 \text{ Nm}$$

STEP 4: Calculate total energy per cycle

$$E_T = E_K + E_W = 200 + 1,1$$

$$E_T = 201,1 \text{ Nm/c}$$

STEP 5: Calculate total energy per hour: not applicable, C=1

$$E_T C = E_T \times C$$

$$E_T C = 201,1 \times 100$$

$$E_T C = 20\ 110 \text{ Nm/hr}$$

STEP 6: Calculate impact velocity and confirm selection

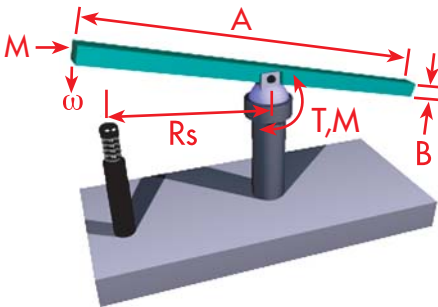
$$V = R_S \times \omega = 0,254 \times 2 = 0,51 \text{ m/s}$$

Model OEMXT 1.5M x 1 is adequate (Page 27).

EXAMPLE 19:
Vertical Rotation Pinned at Center (w/Torque)

STEP 1: Application Data

- (M) Mass = 100 kg
- (ω) Angular velocity = 2 rad./s
- (T) Torque = 310 Nm
- (A) Length = 1,016 mm
- (R_S) Mounting radius = 254 mm
- (B) Thickness = 50,8 mm
- (C) Cycles/Hr = 100



STEP 2: Calculate kinetic energy

$$K = 0,289 \times \sqrt{A^2 + B^2}$$

$$K = 0,289 \times \sqrt{1,016^2 + 0,0508^2}$$

$$K = 0,29 \text{ m}$$

$$I = M \times K^2$$

$$I = 100 \times 0,29^2 = 8,6 \text{ kgm}^2$$

$$E_K = (I \times \omega^2) / 2$$

$$E_K = (8,6 \times 2^2) / 2$$

$$E_K = 17,2 \text{ Nm}$$

Assume Model OEM 1.0 is adequate (Page 21).

STEP 3: Calculate work energy

$$F_D = T / R_S$$

$$F_D = 310 / 0,254$$

$$F_D = 1\ 220,5 \text{ N}$$

$$E_W = F_D \times S = 1\ 220,5 \times 0,025$$

$$E_W = 30,5 \text{ Nm}$$

STEP 4: Calculate total energy per cycle

$$E_T = E_K + E_W = 17,2 + 30,5$$

$$E_T = 47,7 \text{ Nm/c}$$

STEP 5: Calculate total energy per hour

$$E_T C = E_T \times C$$

$$E_T C = 47,7 \times 100$$

$$E_T C = 4\ 770 \text{ Nm/hr}$$

STEP 6: Calculate impact velocity and confirm selection

$$V = R_S \times \omega = 0,254 \times 2 = 0,51 \text{ m/s}$$

Model OEM 1.0 is adequate.

Shock Absorber Sizing Examples

Typical Shock Absorber and Crane Applications

Overview

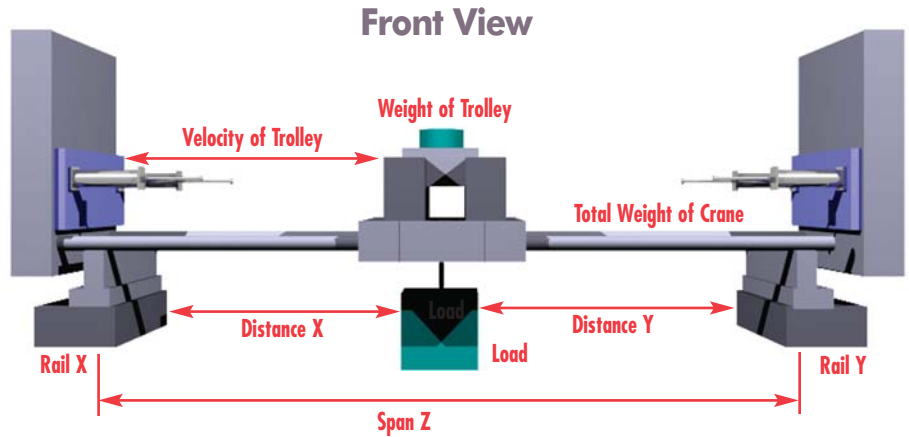
Crane A		Per Buffer
Propelling Force Crane	kN	
Propelling Force Trolley	kN	
Weight of Crane	t	
Weight of Trolley	t	
Distance X_{min}	m	
Distance X_{max}	m	
Distance Y_{min}	m	
Distance Y_{max}	m	
Crane Velocity	m/s	
Trolley Velocity	m/s	

Crane B		Per Buffer
Propelling Force Crane	kN	
Propelling Force Trolley	kN	
Weight of Crane	t	
Weight of Trolley	t	
Distance X_{min}	m	
Distance X_{max}	m	
Distance Y_{min}	m	
Distance Y_{max}	m	
Crane Velocity	m/s	
Trolley Velocity	m/s	

Crane C		Per Buffer
Propelling Force Crane	kN	
Propelling Force Trolley	kN	
Weight of Crane	t	
Weight of Trolley	t	
Distance X_{min}	m	
Distance X_{max}	m	
Distance Y_{min}	m	
Distance Y_{max}	m	
Crane Velocity	m/s	
Trolley Velocity	m/s	

Please note:
 Unless instructed otherwise, Enidine will always calculate with:

- 100% velocity v , and
- 100% propelling force F_D



Plan Views

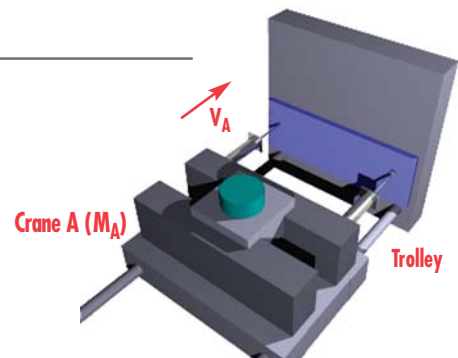
Application 1 Crane A against Solid Stop

Velocity:

$$V_r = V_A$$

Impact mass per buffer:

$$M_D = \frac{M}{2}$$



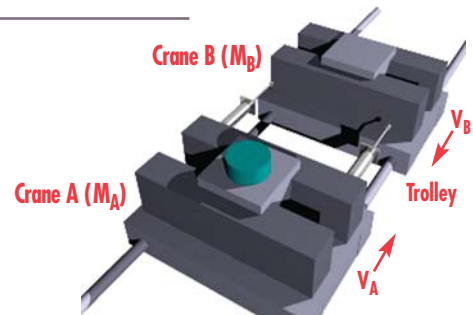
Application 2 Crane A against Crane B

Velocity:

$$V_r = V_A + V_B$$

Impact mass per buffer:

$$M_D = \frac{M_A \cdot M_B}{M_A + M_B} \div 2$$



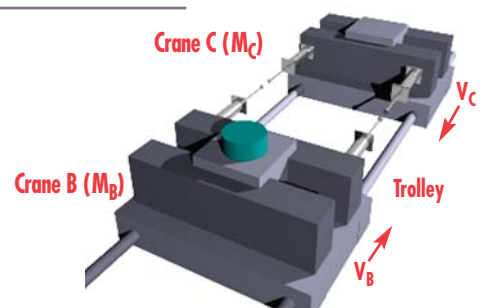
Application 3 Crane B against Crane C

Velocity:

$$V_r = \frac{V_B + V_C}{2}$$

Impact mass per buffer:

$$M_D = \frac{M_B \cdot M_C}{M_B + M_C}$$



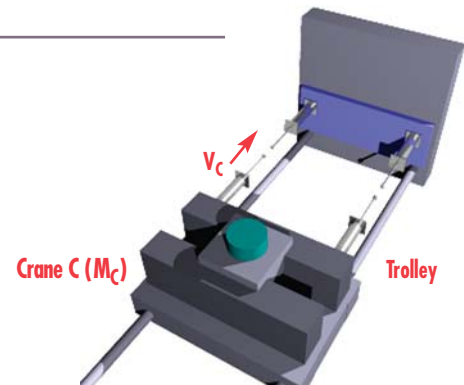
Application 4 Crane C against Solid Stop with Buffer

Velocity:

$$V_r = \frac{V_C}{2}$$

Impact mass per buffer:

$$M_D = M_C$$



Shock Absorber Sizing Examples

Typical Shock Absorber and Crane Applications

Overview

Please note that this example is not based on any particular standard. The slung load can swing freely, and is therefore not taken into account in the calculation.

<p>Total Weight of Crane: 380 t</p> <p>Weight of Trolley: 45 t</p> <p>Span: z = 100 m</p> <p>Trolley Impact Distance: x = 90 m</p> <p>Crane Velocity: $V_{Crane} = 90 \text{ m/min} = 1,5 \text{ m/s}$</p> <p>Required Stroke: 600 mm</p> <p>Trolley Velocity: $V_{Trolley} = 240 \text{ m/min} = 4,0 \text{ m/s}$</p> <p>Required Stroke: 1 000 mm</p>	<p>Calculation Example for Harbor Cranes as Application 1</p> <p>Given Values</p>
<p>Bridge Mass per Rail = $\frac{\text{crane mass}_{total} - \text{trolley mass}}{2}$</p> <p>Bridge Mass per Rail = $\frac{380 \text{ t} - 45 \text{ t}}{2} = 167,5 \text{ t}$</p> <p>$M_{Dmax} = \text{Bridge Mass per Rail} + \text{Trolley Mass in Impact Position}$</p> <p>$M_{Dmax} = 167,5 \text{ t} + \frac{(45 \text{ t} \cdot 90 \text{ m})}{100 \text{ m}}$</p> <p>$M_{Dmax} = 208 \text{ t}$</p>	<p>Determination of the Maximum Impact Mass M_{Dmax} per Buffer</p>
<p>$E_K = \frac{M_{Dmax}}{2} \cdot V_r^2$</p> <p>$E_K = \frac{208 \text{ t}}{2} \cdot (1,5 \text{ m/s})^2$</p> <p>$E_K = 234 \text{ kN}$</p> <p>Selecting for required 600mm stroke: HD 5.0 x 24, maximum shock force ca. 460 kN = $F_s = \frac{E_K}{s \cdot \eta}$</p>	<p>$V_r = V_A$ Application 1</p> <p>$E_K = \text{Kinetic Energy}$</p> <p>$\eta = \text{Efficiency}$</p> <p>Determine Size of Shock Absorber for Crane</p>
<p>$M_D = \text{Trolley Mass per Shock Absorber}$</p> <p>$M_D = \frac{45 \text{ t}}{2}$</p> <p>$M_D = 22,5 \text{ t}$</p> <p>$E_K = \frac{W_D}{2} \cdot V_r^2$</p> <p>$E_K = \frac{22,5 \text{ t}}{2} \cdot (4 \text{ m/s})^2$</p> <p>$E_K = 180 \text{ kNm}$</p> <p>Selecting for required 1 000 mm stroke: HD 4.0 x 40, maximum shock force ca. 212 kN = $F_s = \frac{E_K}{s \cdot \eta}$</p>	<p>$V_r = V_A$ Application 1</p> <p>Determine Size of Shock Absorber for Trolley</p>

Shock Absorber and Rate Controls Quick Selection Guide

Typical Selections

Technical Data

Use this **Enidine Product Quick Selection Guide** to quickly locate potential shock absorber models most suited for your requirements. Models are organized in order of smallest to largest energy capacity per cycle within their respective product families.

Enidine Adjustable Shock Absorbers

Enidine Non-Adjustable Shock Absorbers

Catalog No. Model	(S) Stroke mm	E _T Max. Nm/c	E _T C Max. Nm/hr	Damping Type	Page No.
OEM 0.1M (B)	7,0	5,5	12 400	D	21
OEM .15M (B)	10,0	5,5	19 000	D	21
OEM .25M (B)	10,0	5,5	20 000	D	21
(LR)OEM .25M (B)	10,0	5,5	20 000	D	21
OEM .35M (B)	12,0	17,0	34 000	D	21
(LR)OEM .35M (B)	12,0	17,0	34 000	D	21
OEM .5M (B)	12,0	28,0	32 000	D	21
(LR)OEM .5M (B)	12,0	28,0	32 000	D	21
OEM 1.0M (B)	25,0	74,0	70 000	C	21
(LR)OEM 1.0M (B)	25,0	74,0	70 000	C	21
OEM 1.15M X 1	25,0	195,0	75 700	C	24
(LR)OEM 1.15M X 1	25,0	195,0	75 700	C	24
OEM 1.15M X 2	50,0	385,0	98 962	C	24
(LR)OEM 1.15M X 2	50,0	385,0	98 962	C	24
OEM 1.25M x 1	25,0	195,0	91 000	C	24
(LR)OEM 1.25M x 1	25,0	195,0	91 000	C	24
OEM 1.25M x 2	50,0	385,0	111 400	C	24
(LR)OEM 1.25M x 2	50,0	385,0	111 400	C	24
(LR)OEMXT ¾ x 1	25,0	425,0	126 000	C	27
OEMXT ¾ x 1	25,0	425,0	126 000	C	27
(LR)OEMXT 1.5M x 1	25,0	425,0	126 000	C	27
OEMXT 1.5M x 1	25,0	425,0	126 000	C	27
(LR)OEMXT ¾ x 2	50,0	850,0	167 000	C	27
OEMXT ¾ x 2	50,0	850,0	167 000	C	27
(LR)OEMXT 1.5M x 2	50,0	850,0	167 000	C	27
OEMXT 1.5M x 2	50,0	850,0	167 000	C	27
OEMXT ¾ x 3	75,0	1 300,0	201 000	C	27
OEMXT 1.5M x 3	75,0	1 300,0	201 000	C	27
(LR)OEMXT 1 1/8 x 2	50,0	2 300,0	271 000	C	29
OEMXT 1 1/8 x 2	50,0	2 300,0	271 000	C	29
(LR)OEMXT 2.0M x 2	50,0	2 300,0	271 000	C	29
OEMXT 2.0M x 2	50,0	2 300,0	271 000	C	29
OEM 3.0M x 2	50,0	2 300,0	372 000	C	31
OEMXT 1 1/8 x 4	100,0	4 500,0	362 000	C	29
OEMXT 2.0M x 4	100,0	4 500,0	362 000	C	29
OEM 4.0M x 2	50,0	3 800,0	1 503 000	C	31
OEM 3.0M x 3.5	90,0	4 000,0	652 000	C	31
OEMXT 1 1/8 x 6	150,0	6 780,0	421 000	C	29
OEMXT 2.0M x 6	150,0	6 780,0	421 000	C	29
OEM 3.0M x 5	125,0	5 700,0	933 000	C	31
OEM 3.0M x 6.5	165,0	7 300,0	1 215 000	C	31
OEM 4.0M x 4	100,0	7 700,0	1 808 000	C	31
OEM 4.0M x 6	150,0	11 500,0	2 012 000	C	31
OEM 4.0M x 8	200,0	15 400,0	2 407 000	C	31
OEM 4.0M x 10	250,0	19 200,0	2 712 000	C	31

Catalog No. Model	(S) Stroke mm	E _T Max. Nm/c	E _T C Max. Nm/hr	Damping Type	Page No.
TK 6M	4,0	1,0	3 600	D	38
TK 8M	4,0	6,0	4 800	D	38
TK 21M	6,4	2,2	4 100	D	39
PMX 8MF/MC (B)	6,4	3,0	5 650	SC	46
TK 10M (B)	6,4	6,0	13 000	D	39
PMX 10MF (B)	7,0	6,0	12 400	SC	46
PM 15MF (B)	10,4	10,0	28 200	SC	46
PRO 15MF (B)	10,4	10,0	28 200	P	61
STH .25M	6,0	11,0	4 420	D	40
SPM 25MF/MC (B)	12,7	20,0	34 000	SC	46
PM 25MF/MC (B)	16,0	26,0	34 000	SC	46
PRO 25MF/MC (B)	16,0	26,0	34 000	P	61
SPM 50MC (B)	12,7	28,0	45 200	SC	46
PM 50MC (B)	22,0	54,0	53 700	SC	46
PRO 50MC (B)	22,0	54,0	53 700	P	61
STH .5M	12,5	65,0	44 200	D	40
PM 100MF/MC (B)	25,0	90,0	70 000	SC	46
PRO 100MF/MC (B)	25,0	90,0	70 000	P	61
PRO 110MF/MC (B)	40,0	190,0	75 700	P	63
PM 120MF (B)	25,0	160,0	75 700	SC	49
PM 125MF (B)	25,0	160,0	87 400	SC	49
PRO 120MF	25,0	160,0	75 700	P	63
PRO 125MF	25,0	160,0	87 400	P	63
PMXT 1525MF	25,0	367,0	126 000	SC	53
STH .75M	19,0	245,0	88 400	D	40
PM 220MF (B)	50,0	310,0	90 300	SC	49
PM 225MF (B)	50,0	310,0	111 000	SC	49
PRO 220MF	50,0	310,0	90 300	P	63
PRO 225MF	50,0	310,0	111 000	P	63
PMXT 1550MF	50,0	735,0	167 000	SC	53
STH 1.0M	25,0	500,0	147 000	D	40
PMXT 1575MF	75,0	1 130,0	201 000	SC	53
STH 1.0M x 2	50,0	1 000,0	235 000	D	40
PMXT 2050MF	50,0	1 865,0	271 000	SC	53
STH 1.5M x 1	25,0	1 150,0	250 000	D	40
PMXT 2100MF	100,0	3 729,0	362 000	SC	53
STH 1.5M x 2	50,0	2 300,0	360 000	D	40
PMXT 2150MF	150,0	5 650,0	421 000	SC	53

Key for Damping Type:
D – Dashpot
C – Conventional

P – Progressive
SC – Self-compensating

Key for Damping Type:
D – Dashpot
C – Conventional

P – Progressive
SC – Self-compensating

Shock Absorber and Rate Controls Quick Selection Guide

Typical Selections

Technical Data

Use this **Enidine Product Quick Selection Guide** to quickly locate potential shock absorber models most suited for your requirements. Models are organized in order of smallest to largest energy capacity per cycle within their respective product families.

Enidine Heavy Duty Shock Absorbers

Catalog No. Model	(S) Stroke mm	E _T Min./Max. Nm/c		Damping Type	Page No.
HD 1.5 x (Stroke)	50-600	3 000	20 800	C, P, SC	73-74
HD 2.0 x (Stroke)	250-1 400	24 000	76 500	C, P, SC	75-76
HD 3.0 x (Stroke)	50-1 400	9 350	130 900	C, P, SC	77-78
HDA 3.0 x (Stroke)	50-300	4 500	27 200	C	77-78
HD 3.5 x (Stroke)	50-1 200	12 750	204 000	C, P, SC	79-80
HD 4.0 x (Stroke)	50-1 200	15 100	271 600	C, P, SC	81-82
HDA 4.0 x (Stroke)	50-250	13 500	67 500	C	81-82
HD 5.0 x (Stroke)	100-1 200	46 700	467 000	C, P, SC	83-84
HDA 5.0 x (Stroke)	100-300	37 000	112 000	C	83-84
HD 6.0 x (Stroke)	100-1 200	76 500	805 000	C, P, SC	85-86
HDA 6.0 x (Stroke)	100-300	61 000	183 000	C	85-86

Key for Damping Type:
D – Dashpot
C – Conventional

P – Progressive
SC – Self-compensating

Enidine Heavy Industry Shock Absorbers

Catalog No. Model	(S) Stroke mm	E _T Min./Max. Nm/c		Damping Type	Page No.
HI 50 x (Stroke)	50-100	3 050	6 200	C, P, SC	91
HI 80 x (Stroke)	50-100	6 700	13 500	C, P, SC	91
HI 100 x (Stroke)	50-800	10 000	132 000	C, P, SC	91
HI 120 x (Stroke)	100-1000	32 000	260 000	C, P, SC	91
HI 130 x (Stroke)	250-800	100 000	270 000	C, P, SC	92
HI 150 x (Stroke)	115-1000	62 000	510 000	C, P, SC	92

Key for Damping Type:
D – Dashpot
C – Conventional

P – Progressive
SC – Self-compensating

Jarret Shock Absorbers

Catalog No. Model	(S) Stroke mm	Min./Max. Energy Capacity kJ		Damping Type	Page No.
BC1N	12-80	0,1	14	—	95
BC5	105-180	25	150	—	97
XLR	150-800	6	150	—	99
BCLR	400-1300	100	1 000	—	101

Key for Damping Type:
D – Dashpot
C – Conventional

P – Progressive
SC – Self-compensating

Enidine Adjustable Rate Controls

Catalog No. Model	(S) Stroke mm	F _D Max. Propelling Force		E _T C Max. Nm/hr	Page No.
		Tension N	Compression N		
ADA 505M	50,0	2 000	2 000	73 450	109
ADA 510M	100,0	2 000	1 670	96 050	109
ADA 515M	150,0	2 000	1 335	118 650	109
ADA 520M	200,0	2 000	900	141 250	109
ADA 525M	250,0	2 000	550	163 850	109
ADA 705M	50,0	11 000	11 000	129 000	110
ADA 710M	100,0	11 000	11 000	168 000	110
ADA 715M	150,0	11 000	11 000	206 000	110
ADA 720M	200,0	11 000	11 000	247 000	110
ADA 725M	250,0	11 000	11 000	286 000	110
ADA 730M	300,0	11 000	11 000	326 000	110
ADA 735M	350,0	11 000	11 000	366 000	110
ADA 740M	400,0	11 000	11 000	405 000	111
ADA 745M	450,0	11 000	8 800	444 000	111
ADA 750M	500,0	11 000	7 500	484 000	111
ADA 755M	550,0	11 000	6 200	524 000	111
ADA 760M	600,0	11 000	5 300	563 000	111
ADA 765M	650,0	11 000	4 500	603 000	111
ADA 770M	700,0	11 000	4 000	642 000	111
ADA 775M	750,0	11 000	3 500	681 000	111
ADA 780M	800,0	11 000	3 100	721 000	111

Enidine Non-Adjustable Rate Controls

Catalog No. Model	(S) Stroke mm	F _D Max. Propelling Force		E _T C Max. Nm/C	Page No.
		Tension N	Compression N		
DA 50M x 50	50,0	11 121	11 121	565	113
DA 50M x 100	100,0	11 121	11 121	1120	113
DA 50M x 150	150,0	11 121	11 121	1695	113
DA 50M x 200	200,0	11 121	11 121	2260	113
DA 75M x 50	50,0	22 250	22 250	1120	113
DA 75M x 100	100,0	22 250	22 250	2240	113
DA 75M x 150	150,0	22 250	22 250	3360	114
DA 75M x 200	200,0	22 250	22 250	4480	114
DA 75M x 250	250,0	22 250	22 250	5600	114
TB 100M x 100	100,0	44 482	44 482	4480	114
TB 100M x 150	150,0	44 482	44 482	6779	114

Key for Damping Type:
D – Dashpot
C – Conventional

P – Progressive
SC – Self-compensating