OLEO INTERNATIONAL

LEADING THE WORLD IN ENERGY ABSORPTION

RAIL
PRODUCTS AND SERVICES

RAIL

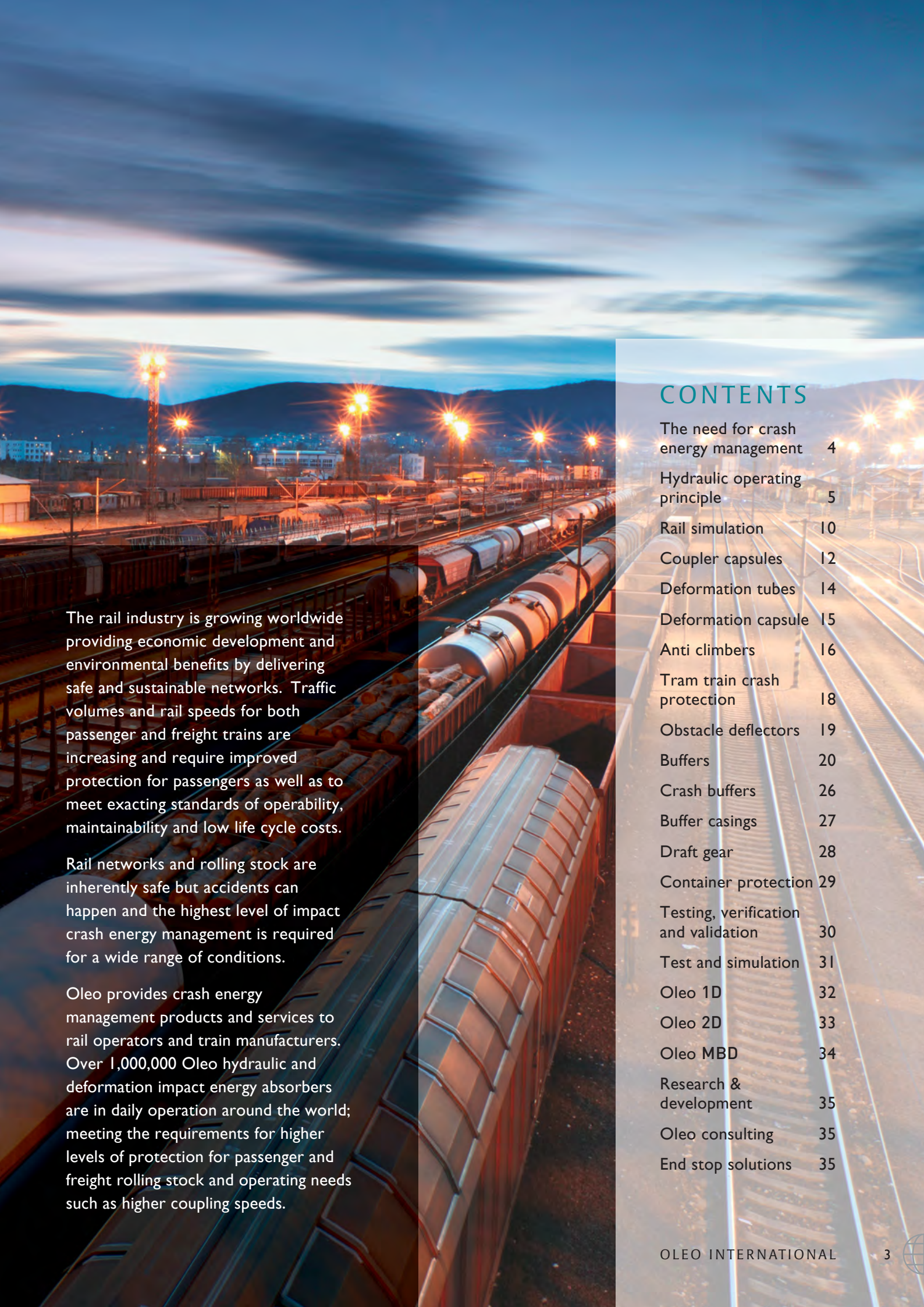
OLEO INTERNATIONAL

Oleo is a leading expert in energy absorption technology, supplying solutions to the rail, industrial and elevator sectors.

Our ongoing investment in research and development ensures that we are continually updating our designs and introducing new products and services to our portfolio.

We are able to supply an energy absorption solution to suit any requirement; we provide solutions – not just products.

Our products are sold through our offices in the United Kingdom, China, India, Germany and the USA and through a wide range of worldwide distributors.



The rail industry is growing worldwide providing economic development and environmental benefits by delivering safe and sustainable networks. Traffic volumes and rail speeds for both passenger and freight trains are increasing and require improved protection for passengers as well as to meet exacting standards of operability, maintainability and low life cycle costs.

Rail networks and rolling stock are inherently safe but accidents can happen and the highest level of impact crash energy management is required for a wide range of conditions.

Oleo provides crash energy management products and services to rail operators and train manufacturers. Over 1,000,000 Oleo hydraulic and deformation impact energy absorbers are in daily operation around the world; meeting the requirements for higher levels of protection for passenger and freight rolling stock and operating needs such as higher coupling speeds.

CONTENTS

THE NEED FOR CRASH ENERGY MANAGEMENT

Rail projects often require unique trains due to variations in infrastructure, environment, regulations and operating practices. Neither time nor cost permit prototype trains to conduct operating trials and crash testing. At the same time crash energy management systems are increasingly complex; incorporating anti climbers, buffers, couplers and crush elements.

Oleo provide sophisticated simulation of collisions to evaluate the crash energy management system across the train as well as energy absorption devices that are correlated by over thirty years of full size testing. The services and products provided to the rail industry include:

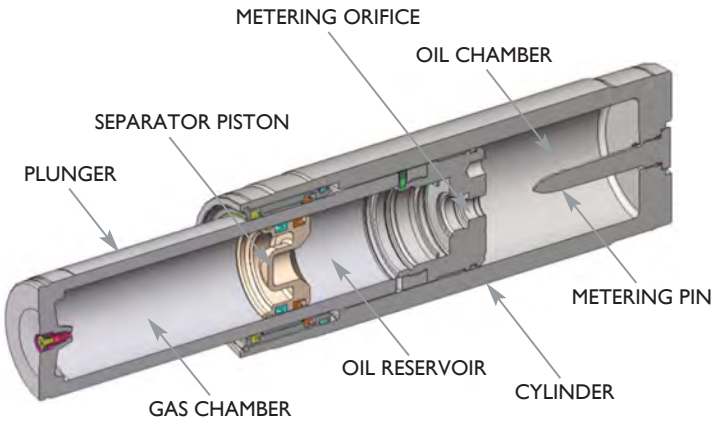
- 1 dimensional simulation of train collisions using proprietary software.
- 3 dimensional multi body dynamics simulation of train collisions incorporating proprietary algorithms.
- Anti climbers.
- Coupler energy absorption modules.
- Side buffers.
- Crash buffers.
- Terminal end stops.
- Draft gear.
- Container & trailer cushioning.

HYDRAULIC OPERATING PRINCIPLE

The aircraft industry provided the first application for the Oleo gas hydraulic energy absorber principle in landing gear.

Over the last sixty years Oleo has developed and refined this to meet the specific needs of the rail industry. The units are made from precision parts, protected and sealed against contamination to reduce the need for maintenance even under arduous operating conditions to provide:

- Controlled impact energy dissipation that improves passenger safety and minimises costly damage to rolling stock.
- Virtually all of the impact energy is dissipated over the closure stroke avoiding damaging re-coil forces.
- Uniform deceleration level in order to maintain minimum impact forces.
- Accurate, predictable and consistently repeatable performance characteristics.
- Long maintenance free service under normal operating conditions.



The illustration shows the robust construction of the Oleo hydraulic unit. Under impact the plunger is forced into the cylinder displacing oil through the orifice, moving the separator piston and compressing the gas. The compressed gas acts on the oil through the separator piston to give recoil force to re-extend the unit after impact. The energy absorbed and dissipated is dependent on the closure velocity.

When the plunger is forced into the cylinder rapidly, the oil displaced by the plunger has to pass through the orifice at very high velocity. This raises the pressure in the oil chamber to a level which optimises the closure force of the unit.

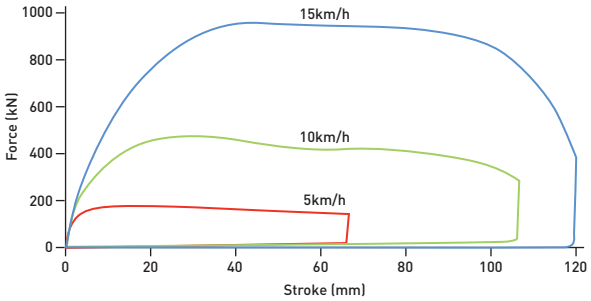
This optimisation process ensures that the impact energy is absorbed evenly throughout the plunger travel maintaining a level impact force. This very useful feature is accomplished by Oleo's innovative metering designs which progressively alter the flow area as the unit closes. The actual metering designs are precisely calculated to provide the best possible protection to rolling stock at specified impact speeds.

The Oleo hydraulic unit therefore possesses the unique feature that its characteristics change according to operational needs. The majority of the impact energy is absorbed within the unit and the already low recoil force is damped by the reverse flow of oil, leaving very little energy and recoil force to be returned to the impacting vehicle.

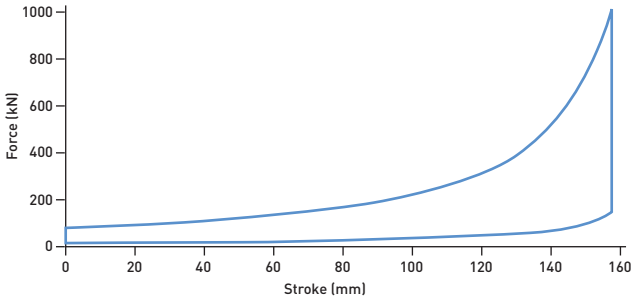
The graph below illustrates the energy absorption characteristics as speeds increase.

This shows the impact of two identical rail vehicles and illustrates how the whole stroke is used to absorb energy as speeds increase.

DYNAMIC CHARACTERISTICS



STATIC CHARACTERISTICS



When the plunger is moved slowly, oil passes through the orifice at a low velocity with little pressure drop, so that the resistance to closure is low and controlled mainly by the compression of the gas. This gives a "soft" or static characteristic to cushion low speed impacts gently.

HYDRAULIC OPERATING PRINCIPLE

The Oleo hydraulic energy absorber provides ultimate protection controlling the deceleration of rolling stock, whatever the speed of impact, keeping end forces down to a minimum and absorbing energy by conversion into heat. Recoil forces are also kept to a minimum and further damped by the reverse flow of the oil.

The key advantages are:

- Long maintenance free service – for the lowest life cycle costs.
- Highest efficiency – more than 95% of the impact energy is dissipated into heat.
- Uniform energy absorption over the full stroke.
- Controlled and predictable impact forces.
- Hydraulic cushioning provided is fully reversible.
- Low recoil forces.
- Specialist plated working surfaces for smooth and wear resistant action.

CRASH ENERGY ABSORPTION METHODS

Recoverable energy absorption methods commonly used in the rail industry are:

a) Oleo gas hydraulic buffers (with all the advantages outlined above).

b) Fluid elastomer

This generally consists of a pot of polymer based fluid, a plunger consisting of a rod and a larger diameter head which is pushed into the fluid when the buffer is stroked. The fluid material is very viscous and operates at high pressure at which the material is compressible. The slow closure characteristic is a function of the change of fluid volume when the plunger is pushed in the pot. The dynamic characteristic is a function of the fluid having to flow past the head when the plunger rapidly enters the pot.

Fluid elastomer buffers slow closure characteristic tend to be rather stiff and dynamically they only utilise their full stroke at higher impact velocities. Even when the fluid elastomer fully strokes they are not as efficient as hydraulic buffers. At lower speed impacts, which occur more frequently, they do not use their full stroke and therefore their efficiency is reduced further. Fluid elastomer energy absorption characteristics are velocity sensitive and dependent on the positioning of its long chain molecules and this, combined with material properties that vary from batch to batch, make their performance unpredictable and not suitable for numerical simulation.

c) Ring springs (or friction springs)

These consist of a series of concentric inner and outer rings designed in such a way that the inner rings compress and the outer rings expand when a tensile load is applied. The strain energy stored in the rings form the basic underlying spring characteristic. The friction generated when the inner and outer rings 'ride' over each other provide the spring with its energy absorbing characteristics.

Ring springs have a linear force displacement characteristic and dissipate approximately 66% of the energy stored, the remaining 33% is returned to the impacting masses as kinetic energy. Their dynamic characteristics are very similar to the static characteristic. For any given stroke ring springs generally have less than half the capacity of hydraulic buffers.

d) Solid elastomer

A solid elastomeric spring consists of a series of thermal plastic 'donuts' separated by metallic shims. When compressed energy is stored within the material as strain energy. The energy is dissipated within the material during both the compression and extension of the material due to the internal friction rising from the long cross linked polymers within the material. Solid elastomer performance is similar to rubber buffers but with significantly better endurance and improved energy capacity.

Solid elastomer buffers absorb approximately 50% of the stored energy, the remaining 50% is returned to the impacting masses as kinetic energy. The force displacement characteristic of a solid elastomer buffer is less than linear. Compared to hydraulic buffers the solid elastomer buffers have poor energy absorption and dissipation performance. For any given stroke solid elastomer buffers have less than half the capacity of hydraulic buffers.

e) Rubber

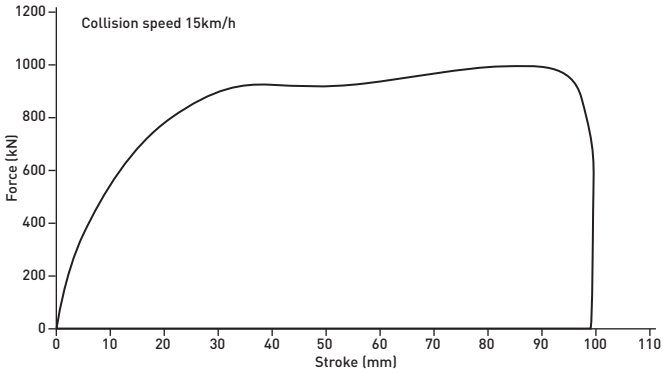
Rubber buffers come in many arrangements, but generally consist of a series of plates with rings of rubber bonded to the surface. When compressed energy is stored within the material as strain energy. The energy is dissipated within the material during both the compression and extension of the material due to the internal friction.

Rubber buffers have similar poor energy absorption and dissipation performance as solid elastomer but with the additional disadvantage that they do not have the same life expectancy of the solid elastomer buffers.

All of the above are used in buffers, couplers and anti climbers. They all absorb impact energy with different degrees of efficiency and they all return different amounts of the absorbed energy during recoil.

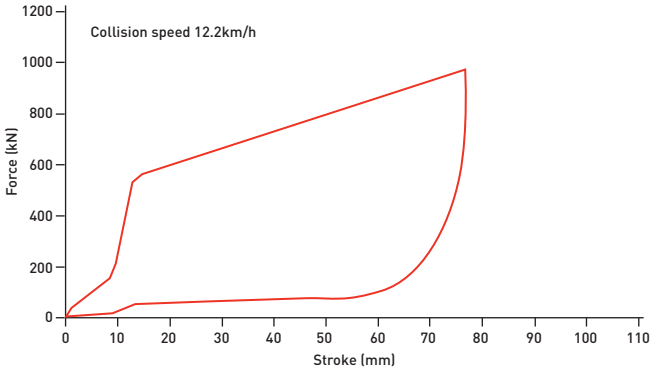
The graph below shows the characteristics of the various energy absorbers at the maximum impact speed while keeping the end force below 1000kN to avoid the onset of structural damage to the rail vehicle.

GAS-HYDRAULIC – FORCE v STROKE



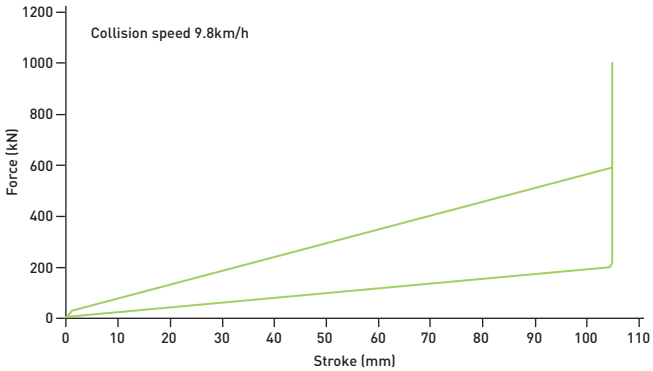
Oleo **Gas-Hydraulic** side buffer
Collision velocity of 15.0km/h
Energy stored (We) = 84.4kJ
Energy absorbed (Wa) = 84.3kJ
Maximum stroke = 98mm
Efficiency (We / Wa) = 99.9%

FLUID ELASTOMER – FORCE v STROKE



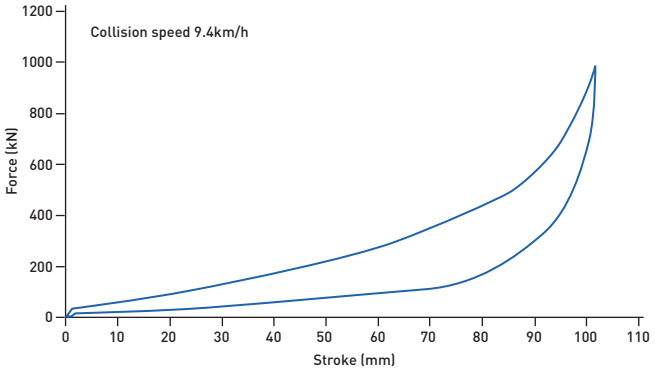
Typical **Fluid-Elastomer** side buffer
Collision velocity of 12.2km/h
Energy stored (We) = 52.9kJ
Energy absorbed (Wa) = 42.8kJ
Maximum stroke = 75mm
Efficiency (We / Wa) = 81%

RING SPRING – FORCE v STROKE



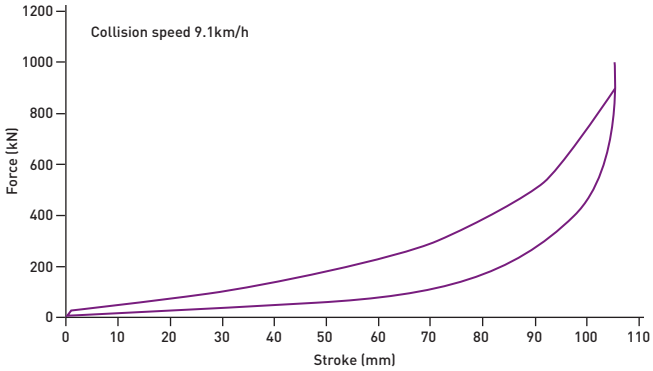
590kN Ring Spring side buffer
Collision velocity of 9.8km/h
Energy stored (We) = 32.0kJ
Energy absorbed (Wa) = 21.1kJ
Maximum stroke = 105mm
Efficiency (We / Wa) = 66%

ELASTOMER – FORCE v STROKE



Simulation of **Solid Elastomer** side buffer
Collision velocity of 9.4km/h
Energy stored (We) = 29.0kJ
Energy absorbed (Wa) = 15.6kJ
Maximum stroke = 100mm
Efficiency (We / Wa) = 54%

RUBBER – FORCE v STROKE



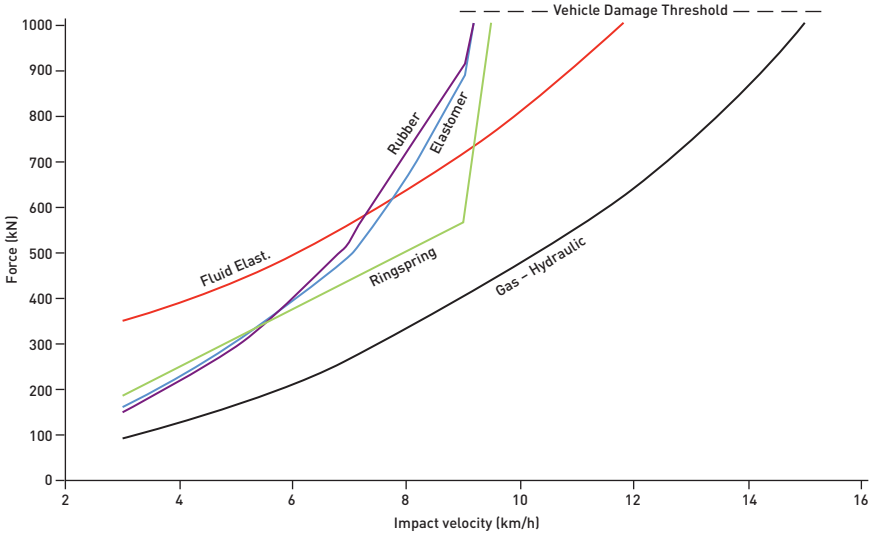
Category A Rubber side buffer
Collision velocity of 9.1km/h
Energy stored (We) = 27.0kJ
Energy absorbed (Wa) = 13.9kJ
Maximum stroke = 105mm
Efficiency (We / Wa) = 51%

HYDRAULIC OPERATING PRINCIPLE

COMPARING THE RELATIVE PERFORMANCE

The gas hydraulic unit has the lowest max force because it stores the most impact energy. It absorbs the most energy and returns the least. This characteristic is very important when considering consequences under crash scenarios. Oleo gas hydraulic units will absorb energy along the whole stroke, reducing deceleration and damaging recoil, thereby reducing longitudinal forces and delaying the point of structural deformation.

IMPACT VELOCITY v BUFFER FORCE



The diagram above shows typical impact forces against impact velocity for the various types of buffer. You will see that the Oleo gas hydraulic buffer gives the lowest force over the velocity range.

Applied impact case used for analysis above.

NON RECOVERABLE TECHNOLOGY

In addition to the various recoverable technologies there are a number of non-recoverable technologies which can be used in conjunction with recoverable units in case of an over speed or crash condition.

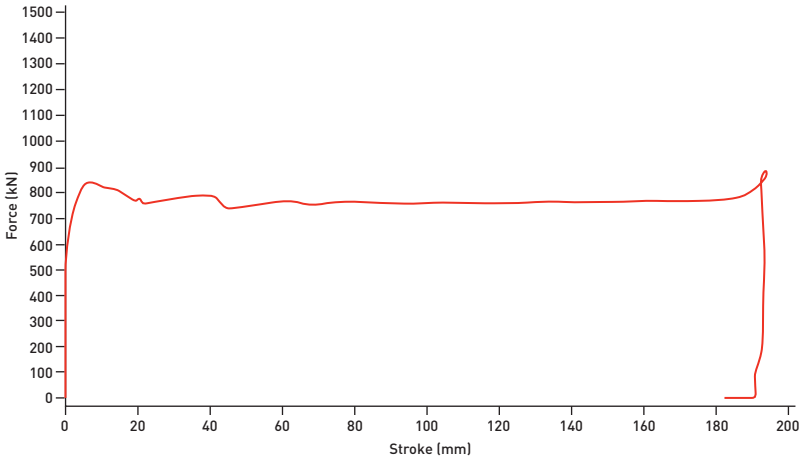
Unrecoverable energy absorption methods commonly used in the rail industry are:

a) Deforming tubes
b) Crush boxes
c) Peeling technology
d) Splitting technology

Oleo's preferred solution is deforming tubes since they yield regular near constant force displacement characteristics and do not require a separate shear out to prevent premature activation. They can also be used in conjunction with Oleo hydraulic capsules and are designed to withstand considerable vertical loads without changing their force deflection characteristics, which makes them suitable for use in the prevention of overriding.

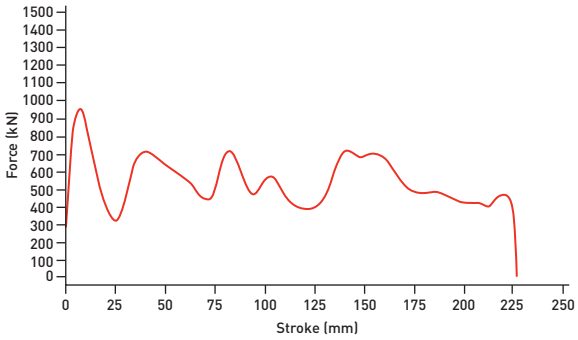
Deforming tubes: The basic principle of operation is to dissipate energy through the extrusion of cylindrical tubes. The tubes can be extruded either though external dies to reduce the tubes diameter or through internal dies to increase the diameter of the tube. The force required to deform the tube will depend on the wall thickness and the material of the tube. A typical dynamic force displacement diagram is given below.

REPRESENTATIVE DYNAMIC CHARACTERISTIC FOR DEFORMING TUBE



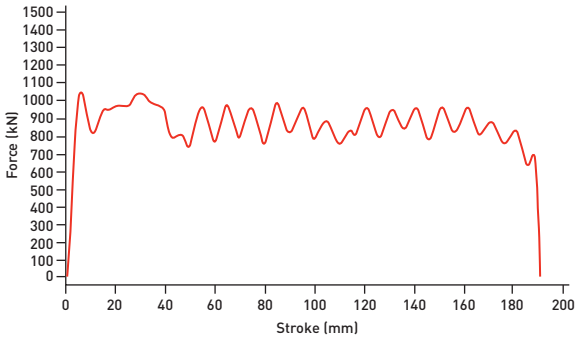
Crush box: The basic principle of a crush box is to dissipate energy through the buckling of a 'box' like structure usually constructed from sheet metal. The main advantage of this type of energy absorber is that it can deform a significant proportion of its original length allowing large deflections. The main disadvantage is that the dynamic force displacement characteristic is highly irregular and the deformation changes significantly if subject to vertical loads.

DYNAMIC CHARACTERISTICS – CRUSH BOX



Peeling technology: The basic principle of operation is to remove metal by peeling or machining the outer surface of a metal tube. The main advantage of this type of device is that, like deforming tubes, it can be designed to take significant vertical loads without affecting its force deflection characteristics. The main disadvantage of this type of device is the need to have a shear out device to prevent premature triggering and the irregular nature of the dynamic force displacement characteristics.

DYNAMIC CHARACTERISTICS – PEELING



Splitting technology: Splitting technology comes in several different forms; the general principle is to absorb energy by splitting a tube lengthwise and plastically deforming the material. The main types either rely on ductile tearing of the material or splitting the material with a wedge. The main advantage of these devices is that they can be designed to give relatively large deflection for a given installation length. The main disadvantage is that they often need a significant force to initiate the tearing or require a shear out device to prevent premature triggering, when used in conjunction with a wedge. They also tend to have an irregular force displacement characteristic and require a space for the material to expand into once the splitting begins.

RAIL SIMULATION

Rail safety awareness and regulations are increasing for the protection of passengers and rolling stock. Rail crash tests are not usually feasible and Oleo offer the unique combination of crash energy management simulations correlated with impact energy absorption devices. This helps to achieve real improvements and assist in the process to conform to exacting standards such as EN15227.

Oleo simulation capability has been developed over the last twenty years and the results used by rail operators, train builders and coupler manufacturers worldwide.

OLEO 1D

A one dimensional simulation programme that accommodates the combined effects of impact energy absorption characteristics of couplers, buffers and anti climbers with approximate crush behaviours of vehicles ends.

OLEO 2D AND MULTI BODY DYNAMICS SIMULATION

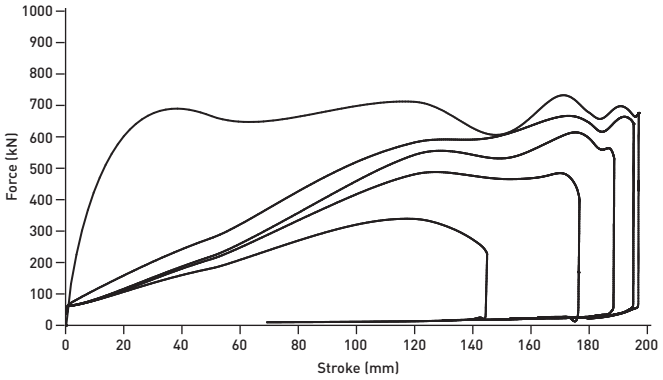
Oleo Multi Body Dynamics (MBD) Simulation Service includes a two dimensional model of the rail vehicle including bogie and suspension characteristics, coupler and anti climber characteristics.

Vertical misalignments can be simulated and subsequent horizontal and vertical forces at the coupler interfaces; anti climber reaction forces and wheel to rail displacement can be predicted.

Below is an example of a five carriage metro train travelling at 15km/h and impacting with a stationary five carriage metro train. The inputs for this include the carriage and passenger mass, stiffness, brake coefficients as well as the characteristics of the energy absorption devices incorporated in the couplers and anti climbers.

This graph shows the force characteristics at each interface of both trains. For each interface data such as peak force, maximum stroke and energy dissipated is provided.

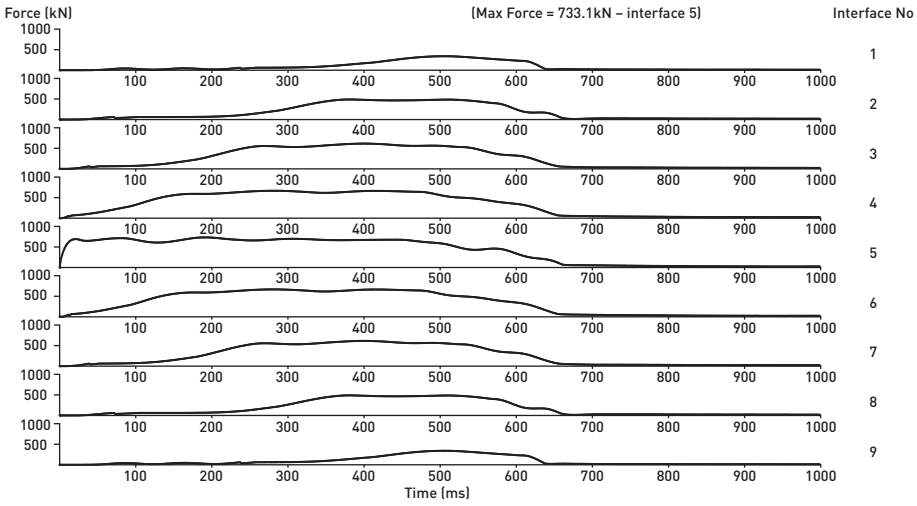
FORCE-STROKE DIAGRAMS



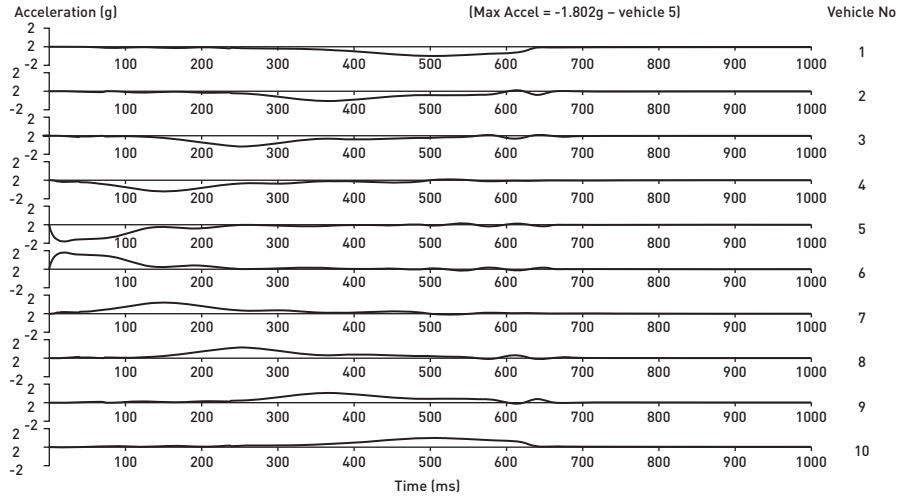
This shows that in this case all impact energy is fully absorbed and that the maximum force of 730kN is below the damage threshold for all carriages on both trains.

This graphs below the force and acceleration time data for both metro trains.

FORCE-TIME DIAGRAMS



ACCELERATION-TIME DIAGRAMS



(Accelerations are calculated from forces exerted on the vehicles in accordance with Newton's II Law and may not correspond with accelerometer readings)

COUPLER CAPSULES

Passenger rail vehicles are coupled together using automatic, semi-automatic and permanent couplers. Oleo has supplied hydraulic energy absorbers and deformation tubes to all the major coupler manufacturers for over twenty years and has over 70,000 coupler units in service worldwide.

Oleo energy absorption modules can be integrated into any coupler and have been incorporated by all major coupler manufacturers. The modular approach provides rail operators, train builders and coupler manufacturers with cost effective units that can be standardised.

Oleo energy absorption modules incorporate the highest element of recoverable energy absorption to meet rail industry requirements for higher coupling speeds, lower life cycle costs and low repair and maintenance costs at the same time offering the highest level of total energy absorption and dissipation to meet increasing standards of passenger safety.

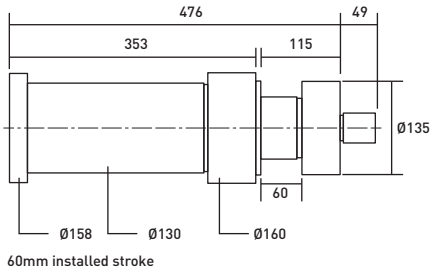
Oleo has developed a range of over 300 gas hydraulic capsules and can offer customised performance characteristics and physical dimensions to meet the requirements of rail operators, train builders and coupler manufactures. Oleo offers the widest range of the key parameters:

- Start forces ranging from 50kN to 400kN
- End force ratings ranging from 200kN to 3000kN
- Stroke ranging from 35mm to 400mm

The units are proven in a wide range of applications giving long service life. The proprietary sealing technology gives unsurpassed levels of protection against gas and oil leaks. Oleo gas hydraulic capsule range includes specially developed units that are rated down to -60 deg C.

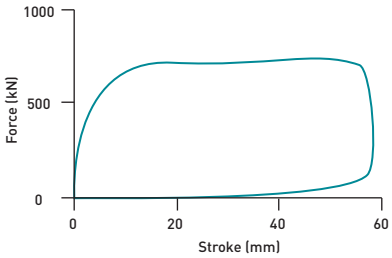
COUPLER CAPSULE EXAMPLES

Capsule type: **Gas Hydraulic**
Stroke: **50mm**
Dynamic capacity: **81kJ**

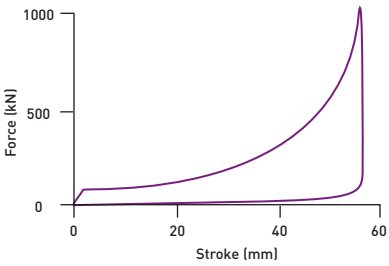


60mm installed stroke

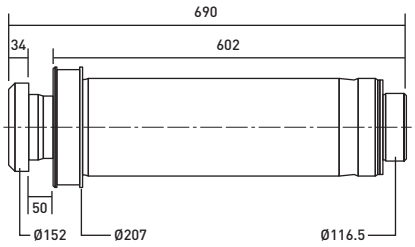
DYNAMIC DIAGRAM



STATIC DIAGRAM

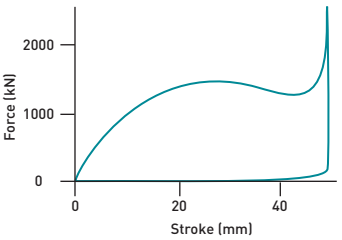


Capsule type: **Gas Hydraulic**
Stroke: **50mm**
Dynamic capacity: **90kJ**

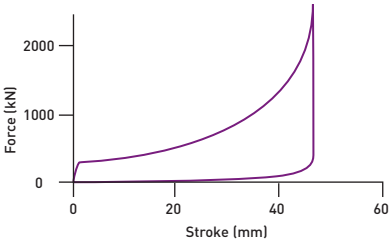


50mm installed stroke

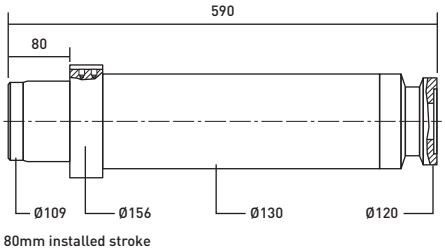
DYNAMIC DIAGRAM



STATIC DIAGRAM

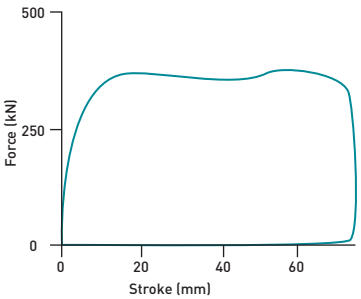


Capsule type: **Gas Hydraulic**
Stroke: **80mm**
Dynamic capacity: **43kJ**

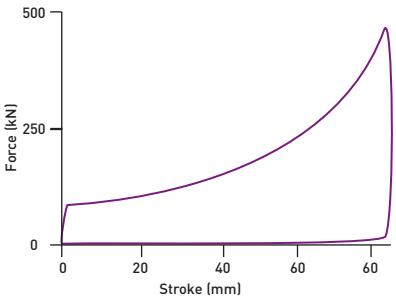


80mm installed stroke

DYNAMIC DIAGRAM



STATIC DIAGRAM



DEFORMATION TUBES

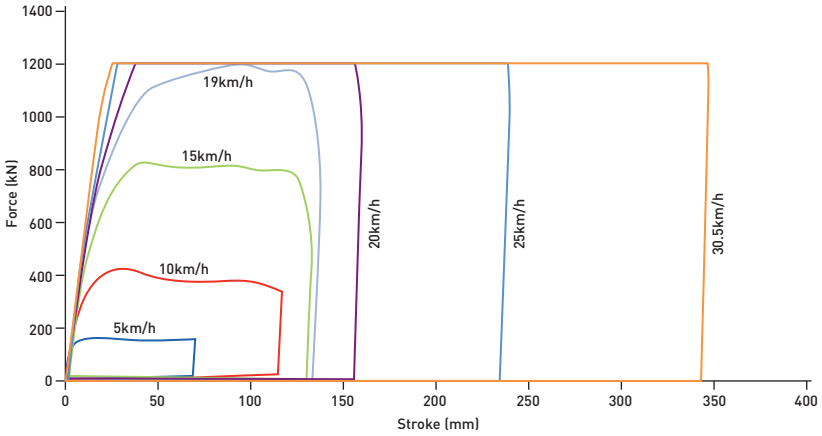
These devices are very efficient at absorbing energy by controlled deformation. However, by their nature these are “single use” and are most commonly used with a recoverable energy absorber.

The combination of a deformation tube and recoverable energy absorption is a very effective way of enabling rolling stock to have good crash protection and low operating costs by avoiding repair costs arising from minor collisions and coupling activities.

Gas hydraulic capsules are velocity sensitive and as speeds rise allow both devices to work together to utilise the full stroke, this maximises the energy absorption of their combined stroke. This very useful feature is illustrated by comparing the crash performance of two 50 tonne rail vehicles fitted with a 1200kN 200mm stroke deformation tube and either an EFG or an Oleo gas hydraulic unit.

The graph below shows the gas hydraulic and deformation tube:

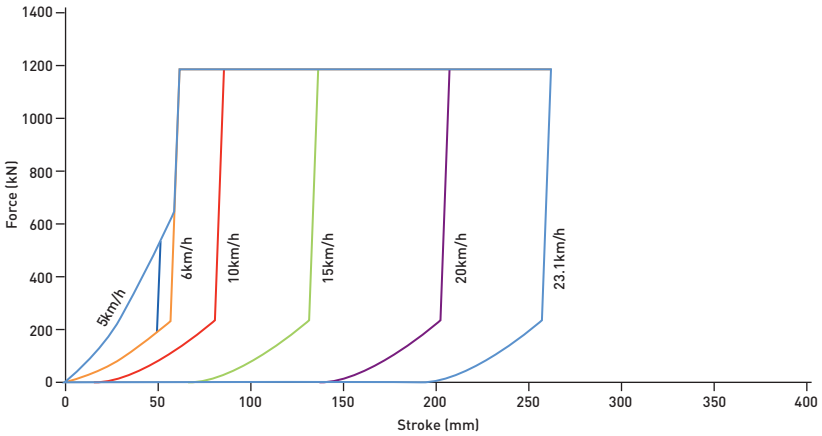
GAS HYDRAULIC AND DEFORMATION TUBE



This combination allows fully recoverable gas hydraulic only energy absorption up to 19km/h and as collision speeds increase the Oleo gas hydraulic and deformation devices work together to more absorb energy across the combined stroke. This allows the structure of the rail vehicle to be protected at crash speeds up to 30km/h.

The graph below shows an EFG and a deformation tube:

EFG3 AND DEFORMATION TUBE



The EFG works first in isolation and absorbs very little energy over its stroke regardless of impact speed. Consequently the deformation tube starts to stroke at 6km/h but can protect the structure of the rail vehicle up to 23km/h.

DEFORMATION CAPSULE

Oleo has developed a range of deformation tubes as summarised below:

Start Force: **50kN to 250kN**

Stroke: **50mm to 400mm**

These can be fully customised to meet customer requirements and meet demanding specifications such as high bending forces that may be required for train rescue scenarios.

Bending strength is important to ensure integrity during impact and also to permit lifting of vehicles at coupler positions in order to return trains to the track following derailments.

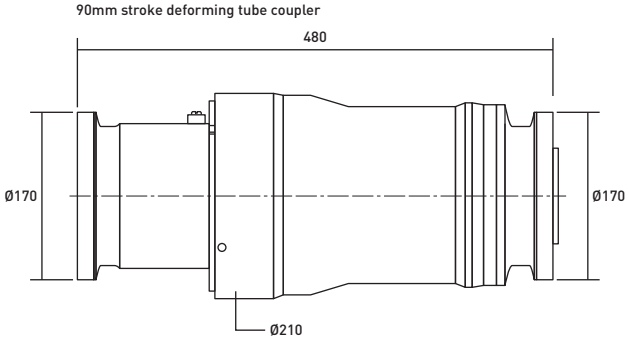
Simple replacement can be made by releasing the capsules between muff clamps.

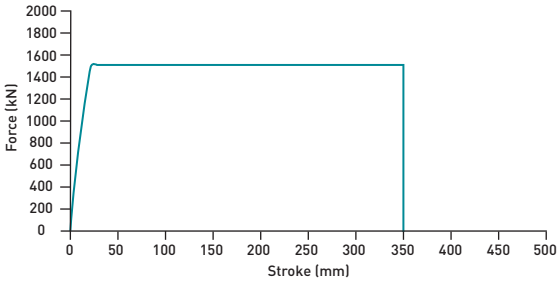
DEFORMATION CAPSULE EXAMPLE

Capsule type: **Deformation capsule**

Stroke: **200mm**

Dynamic Capacity: **150kJ**





ANTI CLIMBERS

In train collisions there are two distinct objectives to improve passenger safety:

- elimination of vehicle over-riding or climb over.
- prevention of uncontrolled structural collapse.

Both are achieved by managing the impact energy absorption and dissipation. Rail vehicles are now designed with controllable deformation characteristics and higher energy absorption characteristics in couplers as well as anti climbing features.

Without anti climbers one vehicle will over ride another in a serious accident. Oleo anti climbers contribute to the 'crash worthiness' of rail vehicles in two ways:

- By absorbing impact energy as collision forces rise following coupler overload. This can be by incorporating a gas hydraulic unit and/or a deforming tube in one or more stages.
- By locking vehicles together during the early part of the collision; controlling vertical movement and helping to direct forces longitudinally.

The anti climber contact faces lock together prior to any vehicle structural deformation and minimise the tendency of vehicles to climb or override.

Oleo were involved in the development of anti climbers working in conjunction with British Rail Research in the 1990's when it was established that end on collisions of railway vehicles presented the greatest hazards to passengers and that most fatalities happened at speeds of less than 60km/h, where successful prevention of over riding and energy management are possible. Extensive full size vehicle impacts were undertaken and the results can be seen in a film entitled "Oleo Crash Energy Management".

The Oleo deformation tube has been specifically designed to limit vertical movement even in offset impacts, and promotes a controlled longitudinal stroke. Oleo anti climbers have benefited from extensive dynamic testing as static compression tests do not realistically reflect the performance characteristics during a collision. Oleo recommends that the strength of the engaged anti climbers should be significantly more than 50% of the specified weight of a fully laden vehicle.

These units are customised to meet the geometry and specific parameters of a train and Oleo has implemented many successful projects.

Oleo anti climbers are available as standard designs or to a specific requirement.

Crash test in association with British Rail Research

Image © Bomardier

Anti climber type: **Gas Hydraulic and Deformation**
Crush Force: **700kN**
Stroke: **600mm**

Reversible:
Stroke 105-5mm
Capacity is greater than 75kJ
Max buffer force is less than 800kN

Non reversible:
Total stroke is greater than 300mm
Capacity is greater than 240kJ
Buffer force average is less than 800kN

Projection 383mm with buffer heads of 350 x 380mm

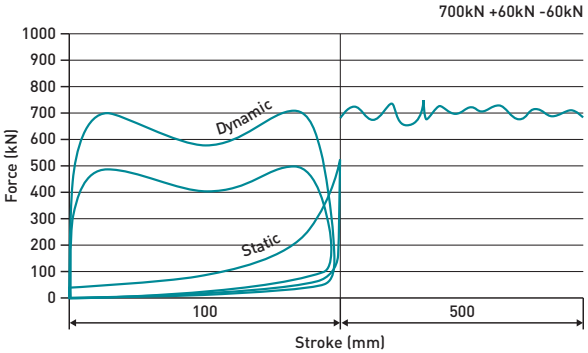
Anti climber type: **Gas Hydraulic and Deformation**
Crush force: **800kN**
Stroke: **300mm**

Reversible:
Stroke 105-5mm
Capacity is greater than 70kJ
Max buffer force is less than 700kN

Non reversible:
Total stroke is greater than 600mm
Capacity is greater than 420kJ
Buffer force is less than 760kN

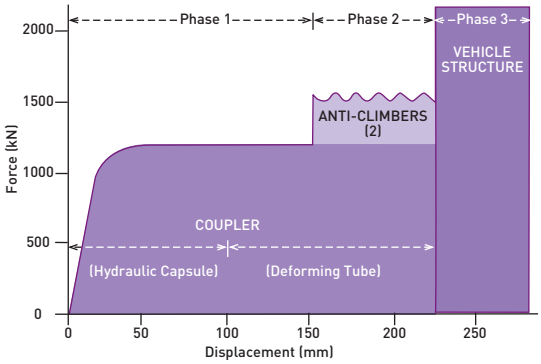
Projection 682mm with buffer head of 350 x 380mm

FORCE STROKE DIAGRAM

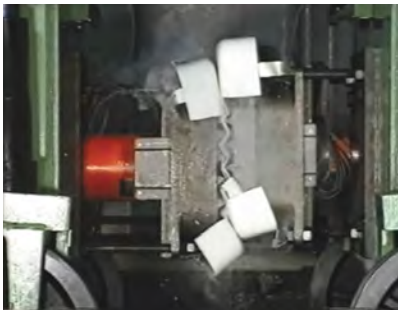


Anti climber type: **Anti climber with one shot honeycomb elements**
Crush Force: **150kN**
Stroke: **75mm**

TYPICAL ENERGY DIAGRAM



Anti climber validation test including anti climber cover



TRAM TRAIN CRASH PROTECTION

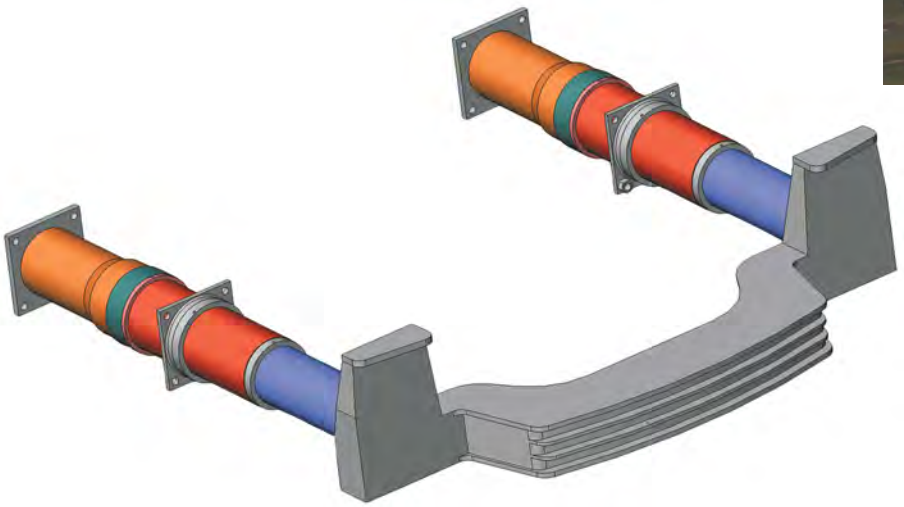
Oleo can provide crash protection for any rail vehicle including tram train protection. Crash protection is produced to the customers design or Oleo can assist with the design and planning.

An example of tram train crash protection is work undertaken for the Avanto LRV.

Oleo produced a design in cooperation with Siemens for two 3 stage parallel telescopic struts to carry a beam with anti climbing profile and buffing plates.

Compatible interfaces were established on the beam to ensure suitable operation on both mainline and inner city track traffic.

- Fully recoverable up to 8km/h
- Over 25km/h with deformation stages



OBSTACLE DEFLECTORS

Mass transit systems operate in environments where the path of the vehicle can be impeded with "foreign" objects/obstacles. This situation can result in life threatening impact and/or derailment.

Obstacle deflectors are devised primarily to limit the impact force by deflecting or creating a "glancing" impact. Having potentially deflected the obstacle the force of the impact must still be limited to prevent damage to the vehicle. The deflector must be strong enough so as to do its job without itself being damaged.

The deflector must not be completely rigid, it is afforded a degree of movement (movement is necessary to absorb energy and limit forces) and is hinged to the vehicle structure to allow only angular motion. The angular motion is resisted by an articulating jointed strut with one end fixed to the vehicle and the other end to the deflector.

Oleo can provide obstacle deflectors to a clients own specification or assist in developing the specification and design.

Oleo have worked on obstacle deflectors for various clients an example of which is below:

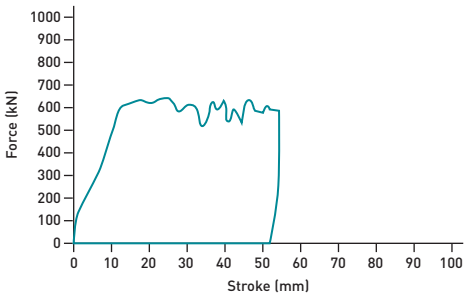
TWO OLEO PARALLEL DEFORMING STRUTS CARRY A DEFLECTOR SHIELD

Non reversible:

Stroke:	**greater than 215mm**
Start peak force:	**greater than 200 kN**
Max. buffer force:	**less than 200 kN**
Capacity:	**greater than 40 kJ**

FORCE STROKE DIAGRAMS (TEST RESULTS)

DYNAMIC DIAGRAM



STATIC DIAGRAM

BUFFERS

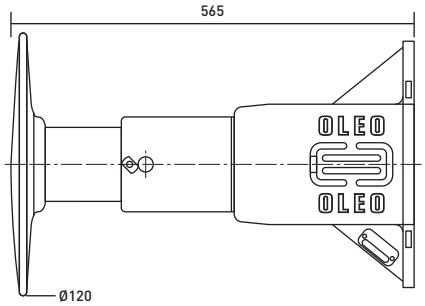
There are several alternative Oleo buffer units, each offering excellent vehicle protection and superior performance over a range of impact velocities for both passenger and freight applications.

Oleo takes a flexible approach and supplies a range of high capacity hydraulic capsules either complete with a casing or separately for installation into a customer's own casing.

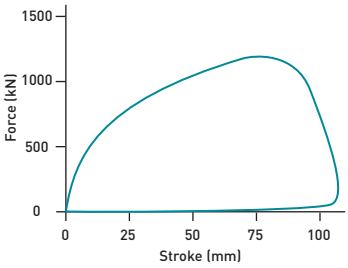
Oleo buffers are available as standard designs or to a specific requirement. Oleo buffers include, but are not limited to, the following:

TRADITIONAL INTEGRAL RAILWAY SIDE BUFFER – (NO CASING REQUIRED)

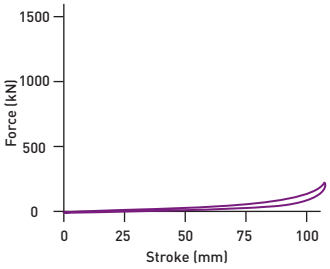
Buffer type: **Type 4**
Capacity: **70kJ @ 1000kN force**
Ultimate capacity: **117kJ**



DYNAMIC DIAGRAM



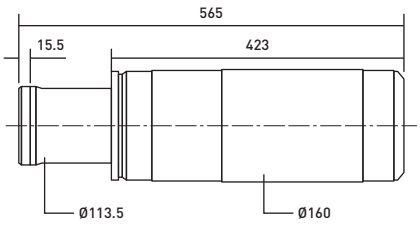
STATIC DIAGRAM



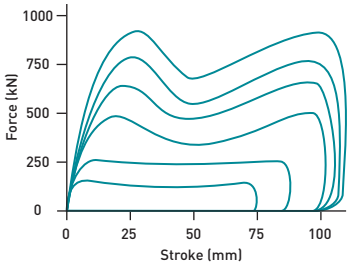
CONFORMING TO DYNAMIC CAPACITY WITHIN EN 15551 AND UIC 526 CAT C 70KJ MIN @ 1000KN FORCE 105MM INSTALLED STROKE.

The 105mm stroke buffer was designed to meet the requirements of UIC 526 Cat C dynamic characteristics. The units operate mainly as side buffers on freight vehicles with 105mm stroke.

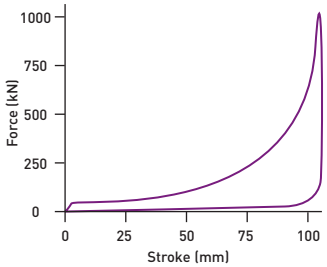
Capsule type: **Type 5-105**
Dynamic capacity: **80kJ @1000kN force**
Ultimate capacity: **200kJ**



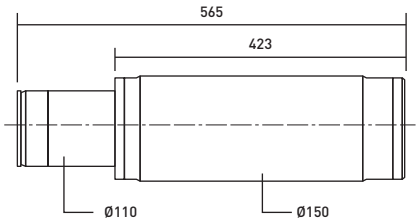
DYNAMIC DIAGRAM



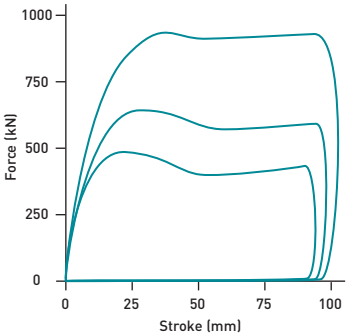
STATIC DIAGRAM



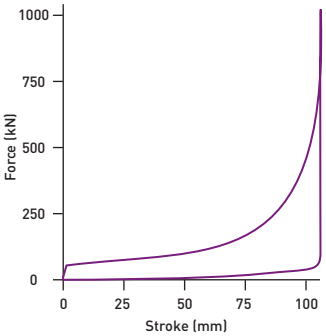
Buffer type: **Uni plus 105**
Dynamic capacity: **80kJ @1000kN force**
Ultimate capacity: **160kJ**



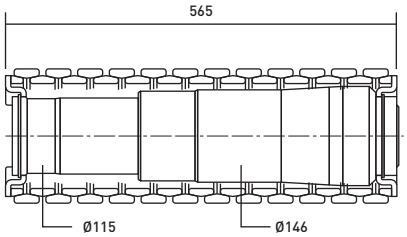
DYNAMIC DIAGRAM



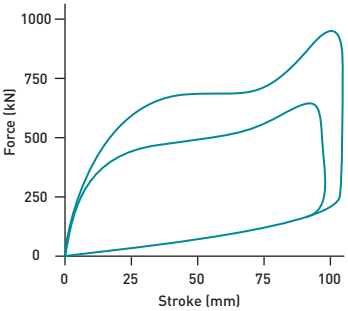
STATIC DIAGRAM



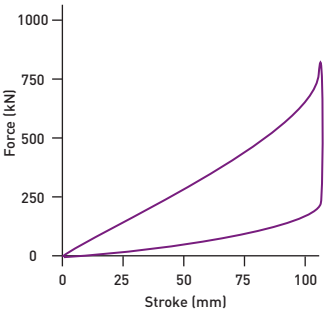
Buffer type: **Type 3RCC (combination)**
Dynamic capacity: **70kJ @1000kN force**
Ultimate capacity: **117kJ**



DYNAMIC DIAGRAM



STATIC DIAGRAM

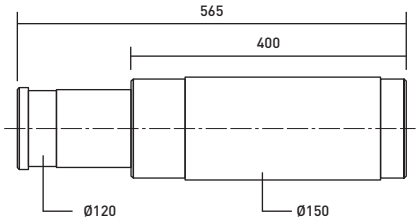


These buffers fit forged steel casings and European cast steel casings.

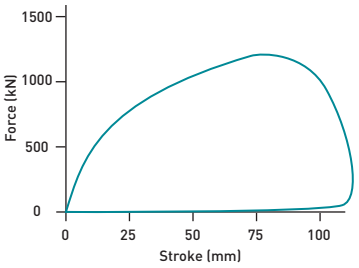
BUFFERS

ALTERNATIVE UIC BUFFER

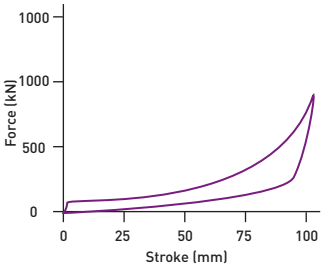
Buffer type: **Type 4EC-80**
Dynamic capacity: **75kJ @ 1000kN force**
Ultimate capacity: **140kJ**



DYNAMIC DIAGRAM



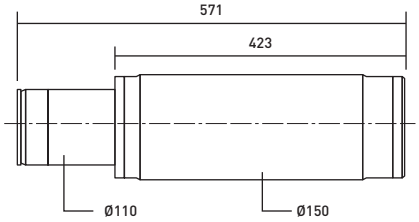
STATIC DIAGRAM



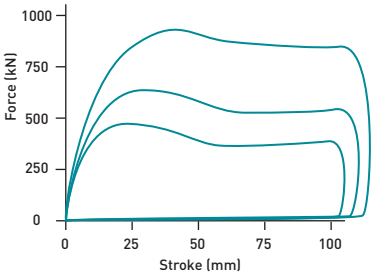
CONFORMING TO UIC 528 – 110MM INSTALLED STROKE FOR COACHING STOCK

The 110mm stoke buffer was designed to meet the requirements of UIC 528.

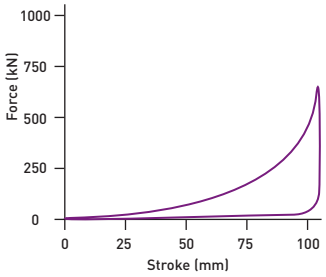
Buffer type: **Type 5-110**
Dynamic capacity: **84kJ @ 1000kN force**
Ultimate capacity: **200kJ**



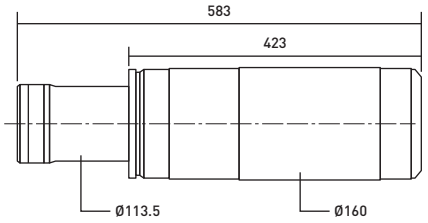
DYNAMIC DIAGRAM



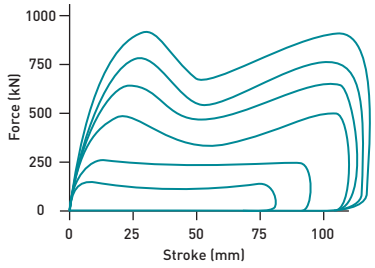
STATIC DIAGRAM



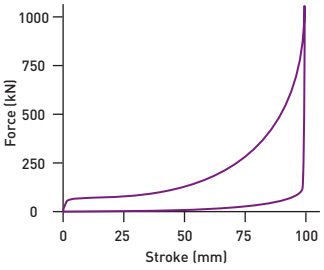
Buffer type: **Uni plus – 110**
Dynamic capacity: **84kJ @ 1000kN force**
Ultimate capacity: **160kJ**



DYNAMIC DIAGRAM



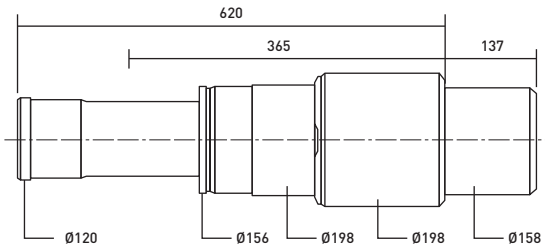
STATIC DIAGRAM



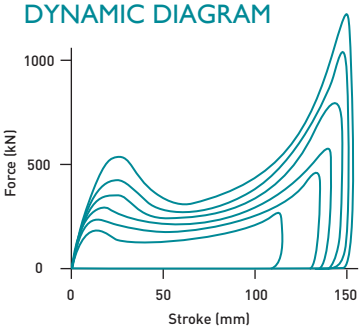
CONFORMING TO UIC 526-3 CAT L – 150MM INSTALLED STROKE

The 150mm stoke buffer was designed to meet the requirements of UIC 526-3 Cat L, which emphasises the need to protect light, fragile loads and also requires the buffer to protect heavy loads when necessary. Alternative performance characteristics are available.

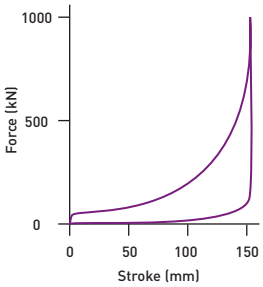
Buffer type: **Type 5-150**
Dynamic capacity: **80kJ @625kN**
Ultimate capacity: **288kJ**



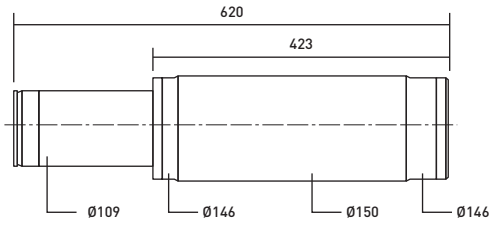
DYNAMIC DIAGRAM



STATIC DIAGRAM

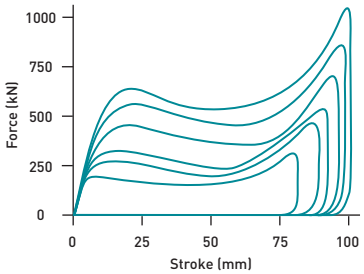


Buffer type: **Uni plus – 150**
Dynamic capacity: **80kJ @625kN force**
Ultimate capacity: **198kJ**

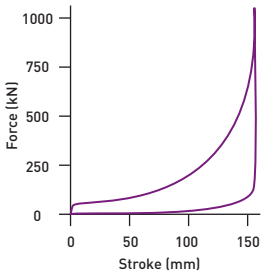


(Fits directly on the buffer beam – no boring required)

DYNAMIC DIAGRAM



STATIC DIAGRAM



BUFFERS

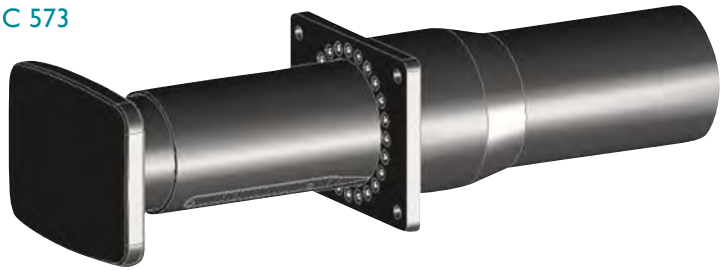
HYBRID MULTI STAGE BUFFERS

In some applications, in order to meet crash worthiness standards, very long stroke buffers are required to meet high levels of impact energy absorption and dissipation.

This can be achieved by combining the attractive features of gas hydraulic units with deformation devices. The gas hydraulic element offers fully reversible energy absorption for slower impacts while the deformation device enables the hybrid buffer to fully stroke and maximise its potential for impact energy absorption.

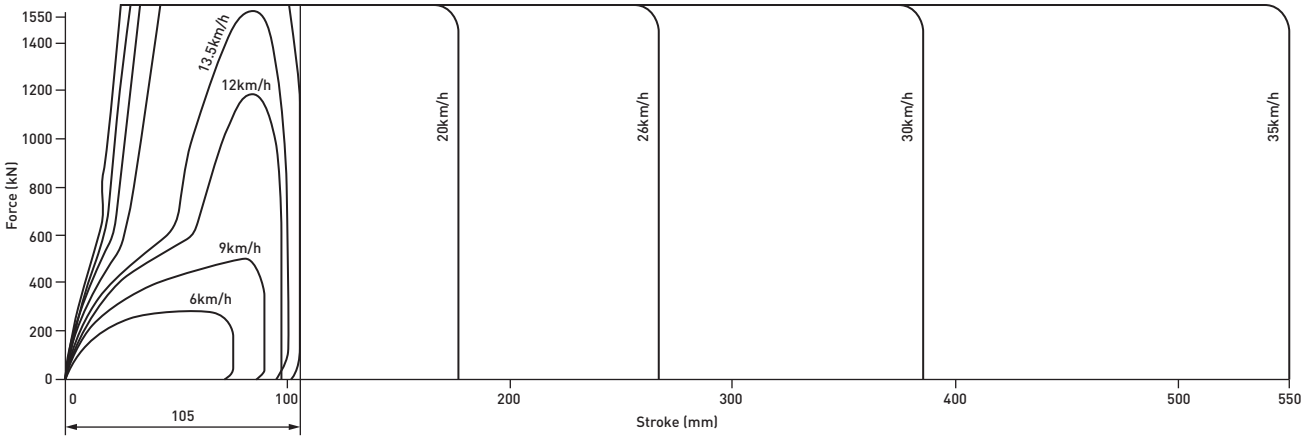
Oleo has developed patented technology for such two stage devices.

TWO STAGE BUFFER IN ACCORDANCE WITH UIC 573



Projection:	**620mm**
Buffer head:	**300mm x 450mm**
Reversible	
Stroke:	**105-5mm**
Capacity:	**greater than 120kJ**
Max. buffer force:	**less than 1550kN**
Non reversible	
Total stroke:	**greater than 550mm**
Capacity:	**greater than 900kJ**
Buffer force:	**less than 1700kN**

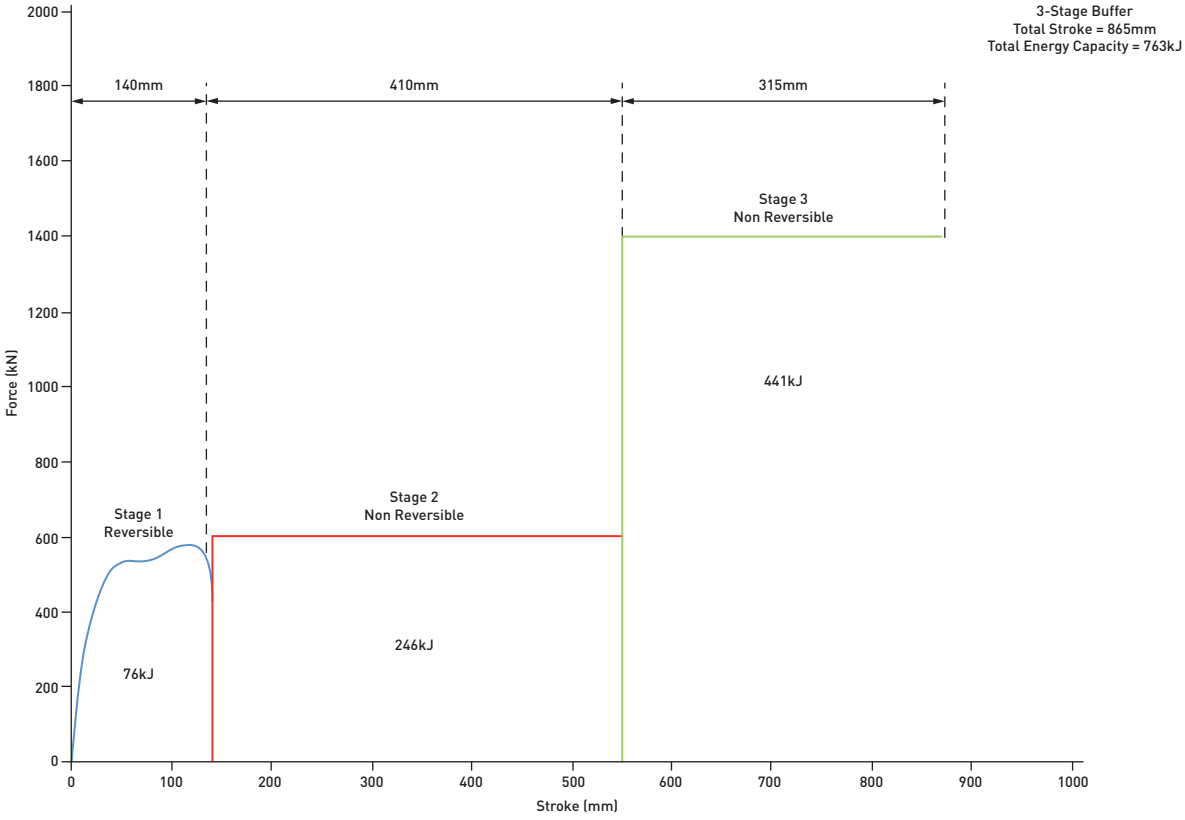
FORCE STROKE DIAGRAM



This technology can be used in applications that require extra stages of deformation set at different force thresholds such as the illustrative example given below:

- A reversible gas hydraulic phase – the whole unit recovering up to an impact velocity of 15km/h.
- A non reversible phase set at a relatively low threshold – no damage to the vehicle or the absorption system itself up to a higher impact velocity of 20km/h.
- A second non reversible phase set at a higher force threshold – no damage to the vehicle but the absorption system "may" need total replacement above an impact velocity of 25km/h.
- Vehicle damage would occur beyond the 25km/h impact velocity.

EXAMPLE OF A "3-STAGE BUFFER"



CRASH BUFFERS

IP250C & IP400C CRASH BUFFER TO UIC 573

Overall length 620mm buffer head 350mm x 450mm

- The buffers fully comply with UIC 573 annex F 250kJ and 400kJ requirements
- The reversible element Oleo capsule type 40 fully complies with UIC 526 Cat.C requirements

The Cat.C reversible first stage of this crash buffer provides more capacity than any Cat.C insert and postpones accidental events.

Reversible

Gas hydraulic capsule

Stroke:	**less than 105-5mm**
Capacity:	**greater than 120kJ**
Max. buffer force:	**IP250C is less than 1500kN**
Max. buffer force:	**IP400C is less than 1800kN**

Non reversible

Deformation Stage

Stroke:	**greater than 170mm**
Capacity:	**greater than 120kJ**
Average buffer force:	**IP250C – 1500kN**
Average buffer force:	**IP400C – 1800kN**
Total stroke:	**greater than 275mm**
Total capacity:	**IP250C is greater than 250kJ**
Total capacity:	**IP400C is greater than 450kJ**

Image © Siemens AG

BUFFER CASINGS

Oleo buffers can be fitted into any type of casing. Some of the most commonly used types are illustrated below, these have been approved by various railway authorities for use on their networks. The casings used by Oleo are made from either forged or cast steel, according to the client's requirements.

Oleo casings are available as standard designs or to a specific requirement. Casings include but are not limited to the following:

Buffer stroke and projection:

STANDARD UIC FREIGHT VEHICLE AND LOCOMOTIVE BUFFERS

Stroke: **105mm**

Projection: **620mm**

STANDARD UIC PASSENGER COACH BUFFERS

Stroke: **110mm**

Projection: **650mm**

LONG STROKE BUFFER FOR FREIGHT PROTECTION

Stroke: **150mm**

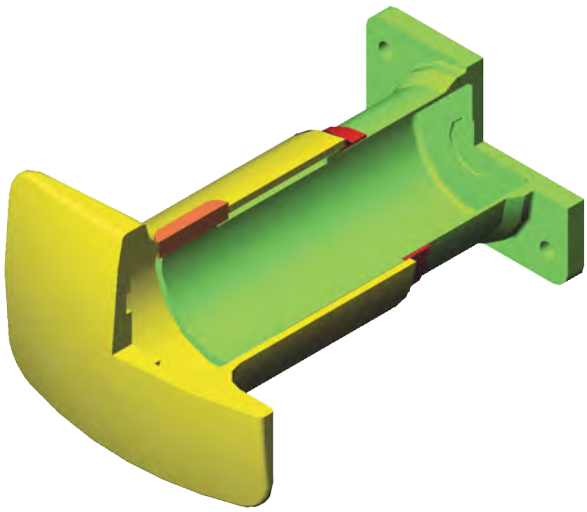
Projection: **665mm**

BUFFER HEAD SIZES:

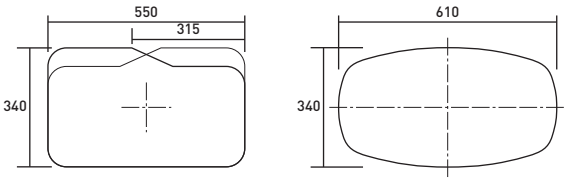
450mm x 340mm

550mm x 340mm

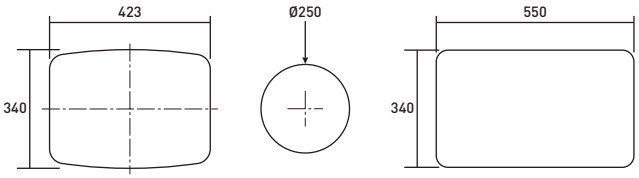
250mm diameter



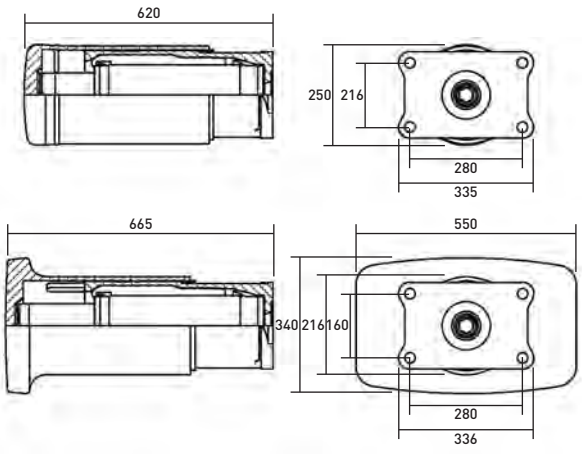
STANDARD BUFFER HEADS AVAILABLE FROM OLEO



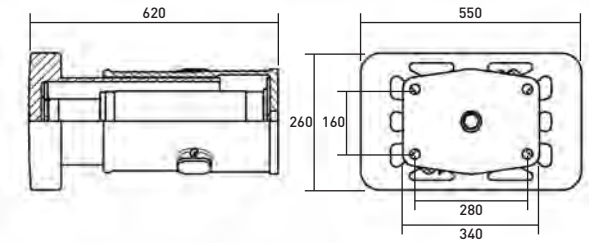
BUFFERS WITH 'NON-STANDARD' HEADS ARE ALSO AVAILABLE FROM OLEO



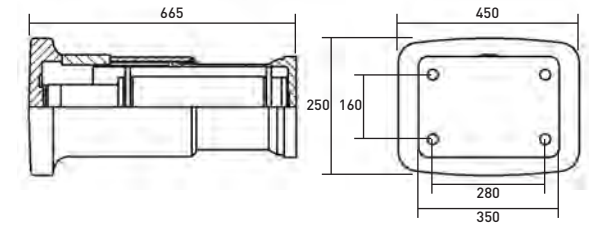
TYPICAL FORGED STEEL BUFFER CASINGS FOR FREIGHT VEHICLES



TYPICAL CAST STEEL BUFFER CASINGS FOR FREIGHT VEHICLES



TYPICAL FORGED STEEL BUFFER CASINGS FOR PASSENGER COACHES



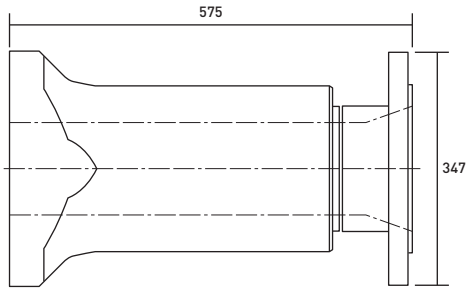
DRAFT GEAR

Outside of Western Europe the majority of freight vehicles are equipped with knuckle couplers rather than hooks, screw couplers and buffers. While this system offers strong coupling between vehicles it provides little impact protection, particularly during train formation, and does not protect the freight from snatch forces when the train is running. Each coupler normally incorporates an energy absorption unit known as a draft gear. The majority of draft gears are equipped with steel springs, or rubber, combined with friction wedges to absorb and dissipate the energy.

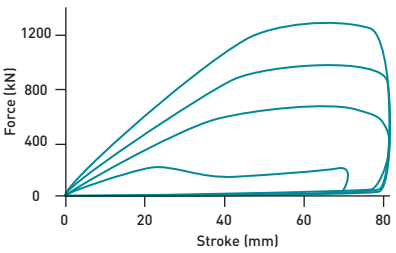
The conventional draft gear is not an efficient absorber of energy and although it is large and heavy it only absorbs a small amount of energy 83kJ. Oleo has developed a hydraulic draft gear which offers 407kJ which is almost five times the energy absorption capability of a conventional draft gear.

This product has been tested by the AAR and conforms to the AAR 901-K specification.

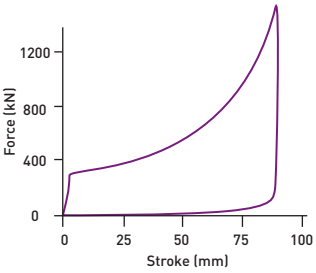
Capsule type: **Gas Hydraulic**
Dynamic capacity: **350kJ**



DYNAMIC DIAGRAM



STATIC DIAGRAM



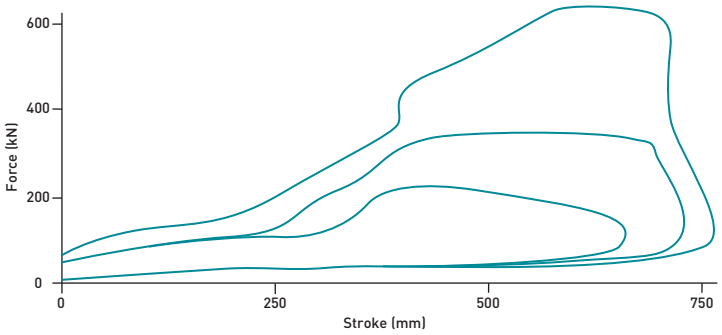
CONTAINER PROTECTION

Some carrying vehicles are equipped with sliding platforms which offer extra protection to the content of containers. Oleo's container protection units provide efficient shock absorption to these sliding platforms to keep longitudinal acceleration of the container to an absolute minimum under all impact conditions. Various strokes are available depending on the degree of protection required.

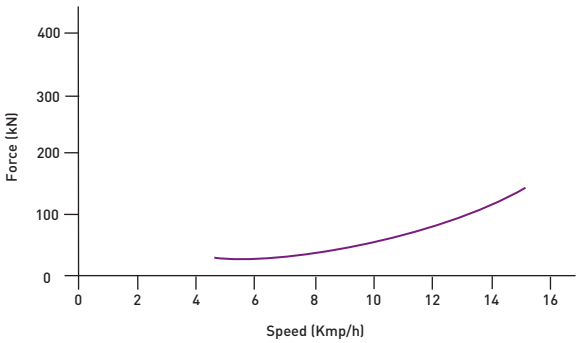
Both UIC and DB tests have been successfully carried out on our container protection units.

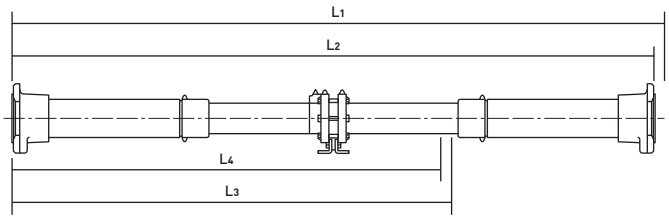
Oleo container protection units are available as standard designs or to a specific requirement.

TYPICAL DYNAMIC CHARACTERISTICS FOR A TYPE 18 BUFFER PROTECTING AN 80 TONNE MASS



FORCE AGAINST IMPACT SPEED FOR A TYPE 11 BUFFER





Dimensions	Type 11	Type 18-500	Type 18-600	Type 18-760
A (Stroke)	350	500	600	760
B (Half stroke)	–	250	300	380
L1 (Free length)	1485	2450	2450	2450
L2 (Installed length)	1475	2435	2435	2435
L3 (Closed length)	1125	1935	1835	1675
L4 (Solid length)	1100	1830	1830	1660

TESTING, VERIFICATION AND VALIDATION

Oleo has been involved in the testing of full size buffers and hydraulic energy absorbers for over forty years, to ensure the predictable and consistently reliable performance characteristics of hydraulic impact energy dissipation. Oleo has extensive capability to do a wide range of tests on laboratory based rigs as well as using full size rail vehicles fitted with our energy absorbers. These facilities are frequently used for type testing as well as correlation of simulations.

In addition Oleo has endurance rigs to test the longevity of units and sub-systems. An environmental chamber enables testing of buffers at temperatures down to -60 degrees C. Oleo also offer accelerated corrosion testing for buffers which may be exposed to extreme conditions or harsh chemicals.

A full size indoor impact rig called the "Titan Rig" designed and built by Oleo at our factory in Coventry is used to assist in validating the predictions for rail and industrial products. Two 30 tonne vehicles impact at up to 20km/h, both vehicles can be fitted with energy absorbers for a wide variety of testing. Typically impact velocity, impact force and energy absorber displacement are measured and the data is captured using high speed data acquisition equipment.

TEST AND SIMULATION

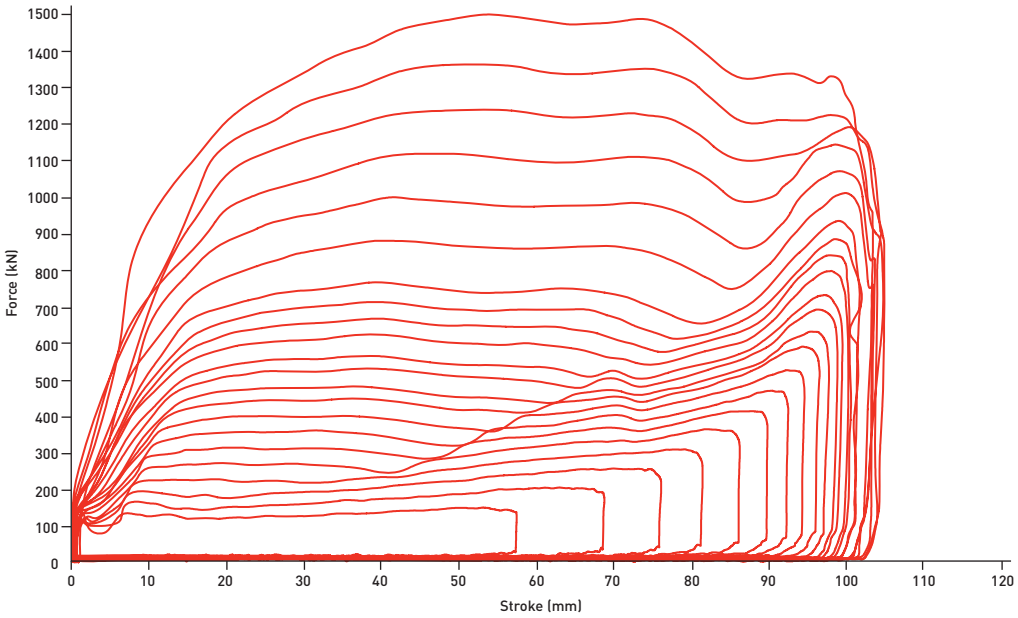
Oleo has always attached great importance to achieving performance characteristics of energy absorbers that are consistently repeatable and predictable.

Oleo has a long history of testing and simulating the performance of its gas hydraulic units for rail and industrial applications. The Hydraulic characteristics are non linear and velocity dependent. Oleo has developed proprietary mathematical algorithms for the purpose of simulating buffer performance.

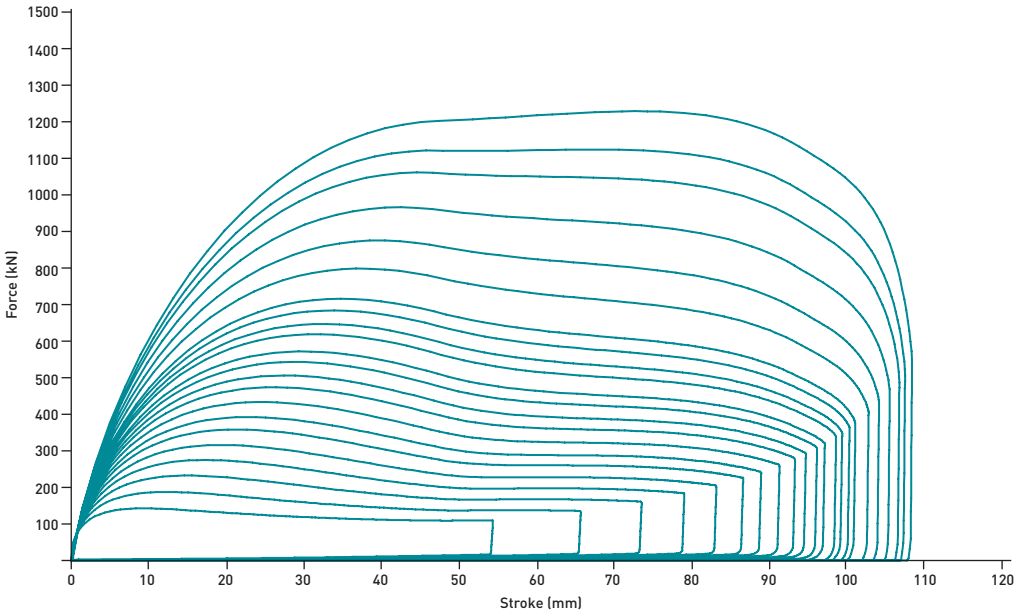
The simulations are matched by a long history of testing full size units to ensure a high degree of correlation.

This simulation software has been further developed into a suite of powerful tools for analysing train collision dynamics that have the ability to simulate various collision scenarios. These tools could be applied to all rail vehicles used in passenger and freight applications.

TEST DATA OF HYDRAULIC BUFFER IMPACTED ON TEST RIG AT INCREASING VELOCITIES FROM 5KM/H TO 20KM/H

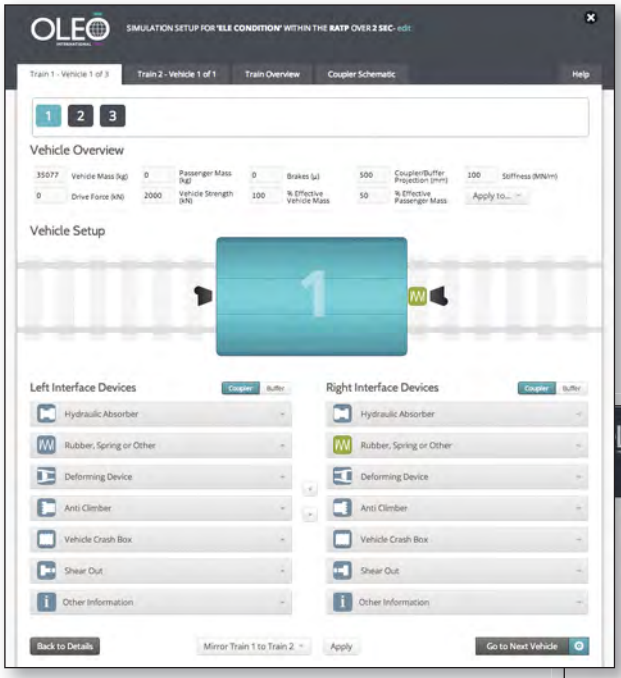


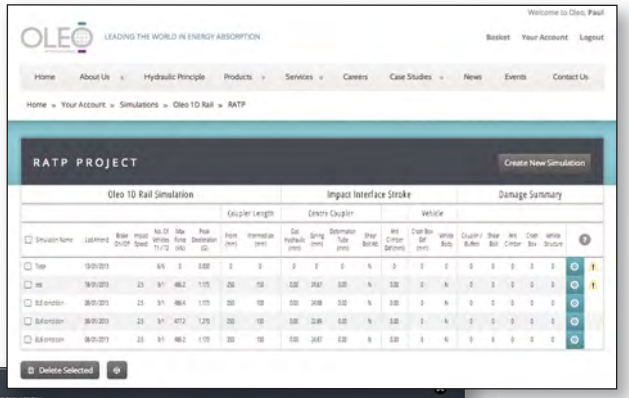
SIMULATION OF NOTIONAL HYDRAULIC BUFFER IMPACTED ON TEST RIG AT INCREASING VELOCITIES FROM 5KM/H TO 20KM/H

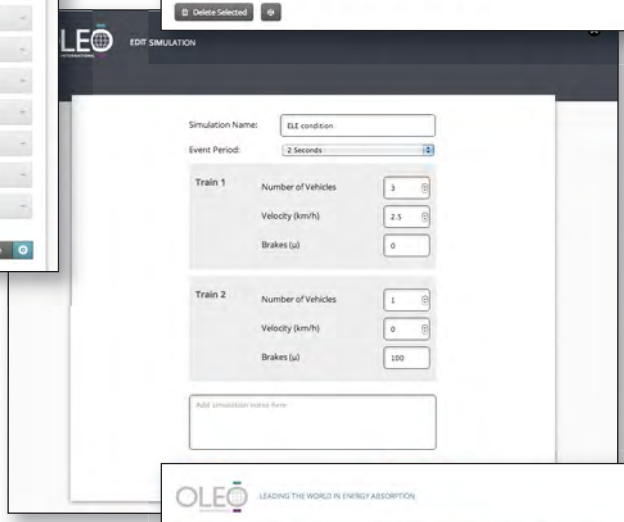


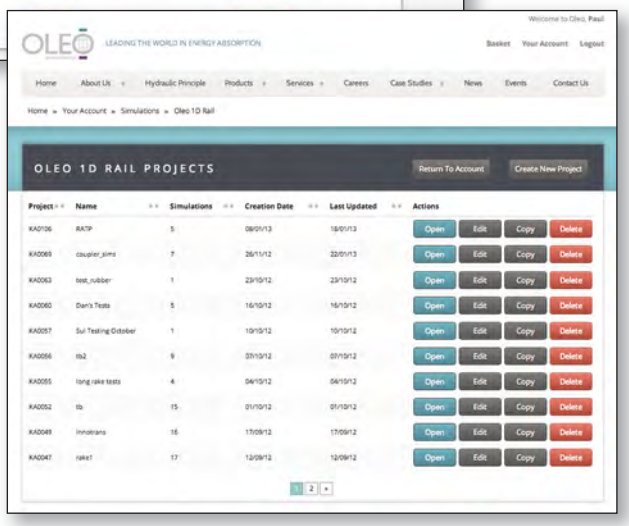
OLEO 1D

Oleo 1D is a one dimensional software program that accommodates the combined effects of couplers, buffers and anti climbers with approximate crush behaviours of vehicle ends. This is useful for investigating the sensitivity of the whole train Crash Energy Management (CEM) system for collision response. The software is specifically designed for evaluating the options for various energy absorption methods used in bolt on devices including couplers, buffers, anti climbers and other crush elements.









The software inputs are flexible so that a specific train can be modelled and various collision scenarios simulated.

Each vehicle in the train is modelled as a single mass with a stiffness value.

Each vehicle can be allocated a separate coefficient of friction to model brakes or rolling friction.

The hydraulic units are selected from a library of designs that can be customised and their specific dynamic behaviour verified by full size physical testing.

The characteristics of linear devices such as rubber, elastomer, deformation tubes, crush boxes and shear out mechanisms can be selected. Specific alternative characteristics can be entered.

The specific geometry accommodating the coupler, buffers and anti climbers can be reflected along with their characteristics for each vehicle in the rake.

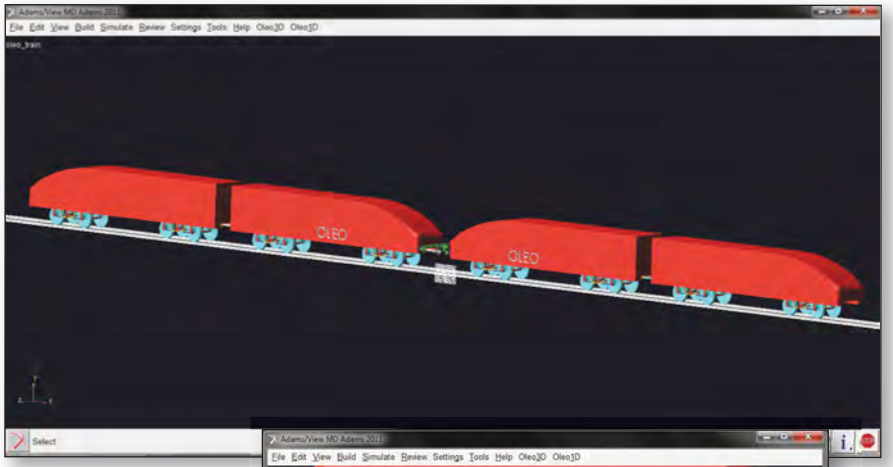
The approximate crush behaviour of the ends can be entered as force vs. displacement data from separate detailed finite element analysis.

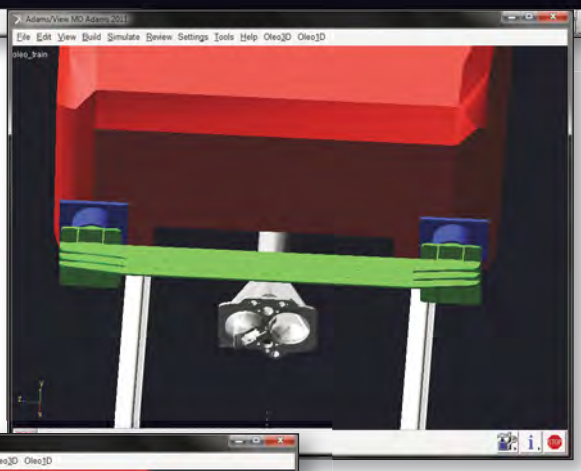
Once the basic train and its energy management setup have been modelled, it is possible to run various collision scenarios including the following:

1. Train into terminal end stops with sliding or fixed end stop solutions.
2. Train into train – either same configuration or a different train configuration altogether.
   a. Moving train into stationary train – with and without brakes.
   b. Moving trains at different speeds and directions.

OLEO 2D

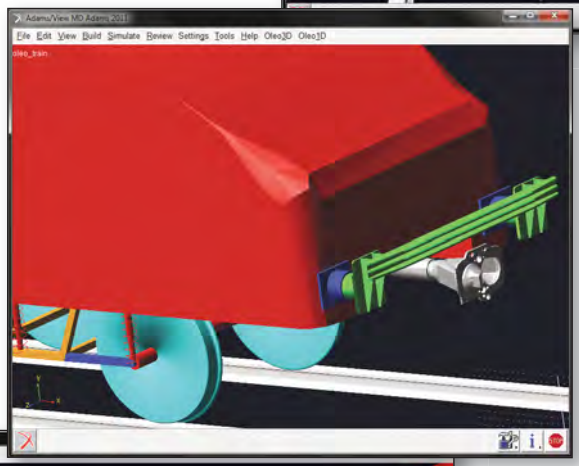
Oleo 2D offers multi body dynamic simulation of train collisions. This uses the well established Adams platform with proprietary Oleo modules. Detailed three dimensional models of vehicles in the train are created including their detailed geometry in key locations, suspension characteristics and crash energy management system incorporating couplers, buffers, anti climbers and crush zones. Oleo can create a simplified model to simulate just the vertical movement to analyse vehicle over riding tendencies on a straight track and also highly complex models that can analyse lateral movement arising from vehicle misalignment and track topography.



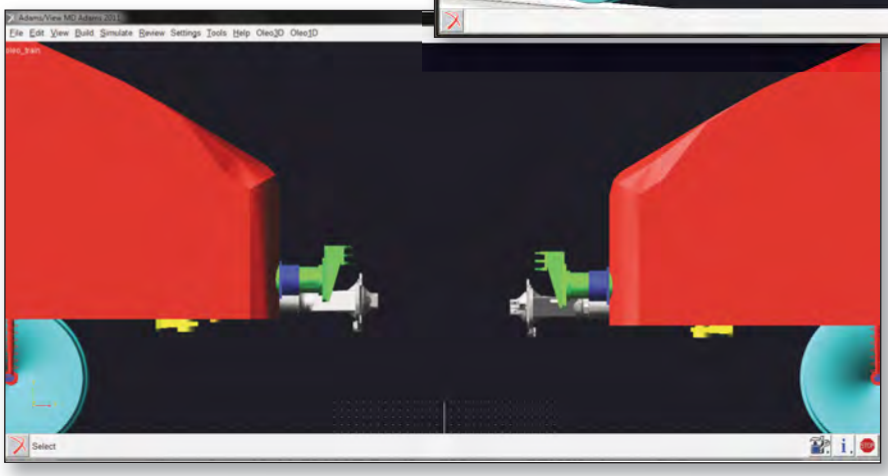


Oleo 2D can rapidly analyse many scenarios and train configurations to optimise the energy management strategy. This assists in selection of key components and their space requirements which will indicate if the solution will work on the preferred vehicle or if customisation is required.

The analysis offered by Oleo 2D can be used at the start of any new train project to select the appropriate energy management strategy at the early stages, indicating the likelihood of achieving a known collision performance.



Early simulation analysis can reduce costs as well as project lead time by reducing the need for customised couplers at a later stage or worse, vehicle geometry modifications.



OLEO MULTI BODY DYNAMICS (MBD) SIMULATION SERVICE

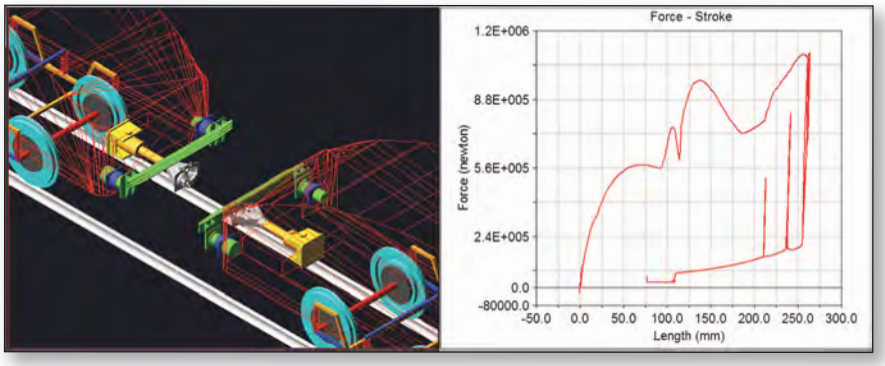
Oleo has developed its own proprietary plug in modules for Adams, a well established platform for Multi Body Dynamics (MBD) simulation for rail applications. The modules have a correlation with Oleo's long history of full size testing of the non linear dynamic characteristics of hydraulic energy absorbers as well as other rail crash energy management elements such as rubber, elastomer, deformation tubes, crush boxes, shear out mechanisms etc.

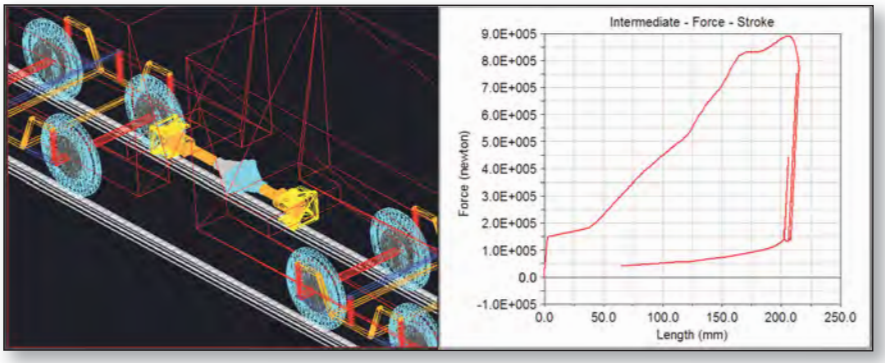
The kinematic behaviour (motion of moving linkages etc.) is usually evaluated and modified during the CAD design stage but can be verified if required.

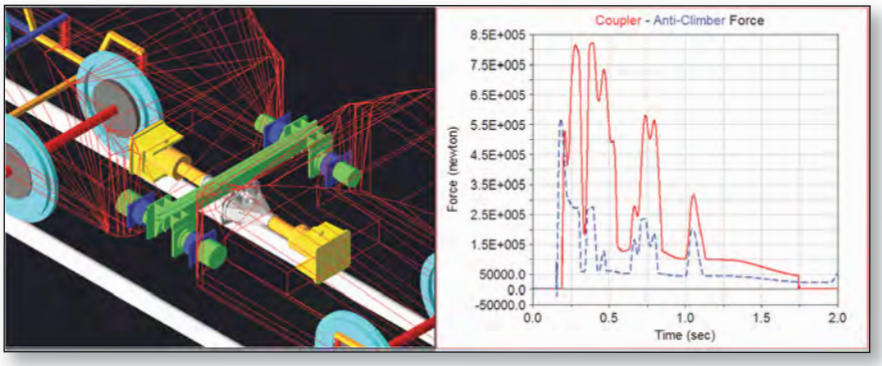
The dynamic behaviour (force application on components and the resultant movement and loads) is effectively under taken using MBD simulation.

The Oleo MBD simulations output a comprehensive set of load cases at the relevant specific locations on the car body, such as the coupler mounting. These load cases can then be input into FEA models of the car body structure in a number of commercial software packages such as Radioss or LS Dyna that then provide all the stress, strain and deflection data.

The Oleo MBD models are full 3D representations but can be used in a simplified way to look at vertical movement only.







RESEARCH & DEVELOPMENT

We pride ourselves on being innovative in response to both customer demands and technological opportunities. Continuous investment in research and development, state of the art technology and modern manufacturing processes has made Oleo leading experts in energy absorption.

Using our in house simulation software and testing equipment it has been possible to develop new technologies. Research and development is ongoing at Oleo with new services being introduced and products patented.

OLEO CONSULTING

Consultancy is a growing part of Oleo's business; we are regularly undertaking work producing bespoke energy absorption solutions for our customers including simulation, design and analysis.

For more information on Oleo's consultancy services please contact us.

END STOP SOLUTIONS

Oleo has extensive experience in delivering end stop solutions including sliding friction end stops, fixed end stops, hydraulic systems with concrete base foundations and bespoke applications.

For more information on Oleo's end stop solutions please contact us.

ELEVATOR

END STOPS

INDUSTRIAL

RAIL

WE PROVIDE SOLUTIONS
NOT JUST PRODUCTS

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