BERGEN PIPE SUPPORTS

A Guide to the Selection, Application & Function of Pipe Hangers

A Global Solution

OVER 100 YEARS EXPERIENCE, SUPPLYING POWER GENERATION, OIL, GAS, OFFSHORE, PETROCHEMICAL, PHARMACEUTICAL, CHEMICAL AND WATER INDUSTRIES WORLDWIDE

Mission Statement. “We are committed to being the premier choice pipe support company for our customers, suppliers and employees.”

Global Service. Pipe Supports Limited was formed in 1968 to design and manufacture the Comet rangeof pipe hangers. Now part of the Hill and Smith Holdings PLC group of companies, Pipe Support Group has an enviable reputation for quality, reliability, competitiveness, engineering excellence and financial strength. Our products have been supplied to every continent of the world through an international sales network dedicated to meeting it’s customers’ stringent quality and delivery requirements.

From its origins in the heart of the United Kingdom, Pipe Supports Group has grown into a worldwide organisation with manufacturing plants in the **UK, USA China, India and Thailand.**

In March 2011 we acquired The Paterson Group of companies incorporating Bergen Pipe Support Inc., Carpententer & Paterson Inc., and Process Pipe Support SystemsInc., Canada. This has brought over 100 years of US market experience to the Group.

The Pipe Support Group has a continual development programme resulting in the most comprehensive range of products available from one source.To ensure the products are oh the highest standard, they are produced in manufacturing plants equipped with the latest technology. All of our manufacturing plants offer the same **Bergen Pipe Supports** product range.

Through this global manufacturing presence, we are able to offer competitive prices for projects around the World.

A Guide To The Selection, Application & Function Of Pipe Hangers

This booklet is a guide to the business of pipe supports. It sets out to introduce the reader to the important facts and questions around supporting all sorts of pipework from the complex behaviour in power generation, oil and gas, petro-chemical, water treatment, pulp& paper as well as the renewable energy industries, right through to the more simple requirements of basic commercial applications.

From new people to the industry to experienced pipework designers, this guide contains nuggets of information from our experience supplying the industry for more than half a century. It is not intended to be an authoritative technical manual and should be used only as an informative text. The reader must use the information it provides in the context in which it is written and not apply any part of this as a ‘hard & fast’ rule.

It is hoped that the information will help to provide a broad overview of the topic of pipe hangers and restraints together with better understanding of what is fundamentally a relatively simple product range made complicated by the vast range of combinations and permutations of size, load, temperature, environment and locality!

Contents

1. A Short History of the Pipe Supports Group

The Pipe Supports Group grew out of a long established engineering and fabrication business as a result of strong relationships with the Central Electricity Generating Board (CEGB).

During the fifties and sixties the CEGB constructed many large coal fired power stations in England and Wales. British Industrial Engineering (BIE) built up an enviable reputation for supplying open-mesh flooring, ladders, platforms and hand railing to these major construction projects.

As a result of the relationships created BIE were invited to manufacture a constant effort support under a licence agreement through the CEGB. After just a few years the engineers at BIE had developed their own, improved constant effort support. Shortly thereafter a variable effort support was developed and then a range of pipe clamps and complementary hardware based upon the requirements of BS3974, the British Standard for pipe supporting equipment at the time (Superseded by EN13480 in 2004).

There have now been several generations of the constant effort support, each development incorporating new features and benefits to the user. However, the most important and unique feature was first incorporated in the design of the variable effort support. The multi-lock and balance indicator is a means of allowing the spring to be pre-set at any position throughout its travel range.

The multi-lock was not incorporated in the constant effort support until the late seventies when the Mark V support was developed. Since then this device has featured in all subsequent developments of both the constant and variable effort support.

Through the eighties and nineties we continued to develop both our product range and the services we were able to offer our customers. Our catalogue now offers the pipe support designer the most comprehensive range of products and technical assistance available anywhere in the world and we are still improving and developing.

Much like the growth of our product range, the Pipe Supports Group has grown significantly since being acquired by Hill & Smith Holdings Plc in 1993.

Initially we established a World-wide network of agents then we formed joint ventures and strategic alliances which led to the beginnings of our global expansion. Thailand became our first wholly owned overseas manufacturing facility followed a few years later by China & more recently a large plant constructed in India to meet the demands of the Indian domestic market.

We established our own sales offices in Singapore, Japan, Taiwan, Korea, France, the USA and the Middle East.

Most recently we added The Paterson Group, a large US based hanger business whose history stretches back to 1908. From that acquisition we have re-branded our whole product range which is now known as ‘Bergen Pipe Supports’.

Further expansion is planned with the latest a manufacturing facility now under construction in India and additional facilities coming on-line in the US over the next 18 months.

The Pipe Supports Group offers a truly Global Solution to meet all pipe supporting needs & will continue to expand where opportunities arise.

2. What is a Pipe Support?

a. Background

People around the world use a lot of pipe supports and restraints, spending somewhere in the region of £250million on ‘engineered supports’ each year and over many £Bn on standard brackets and hangers.

The majority of pipes that require support and restraint by engineered hangers are actually in effect long thin pressure vessels operating at extreme pressures and temperatures. In general they connect one large piece of equipment to another and facilitate the flow of fluid between the various processes.

During the operating cycle of the plant there is inevitably a change in temperature. Even changes in temperature between day and night can have significant effects on long pipe-lines or pipes made from non-metallic materials.

Almost all materials expand or contract as their temperature is increased or decreased. A pipe that carries steam from a boiler to a turbine heats up from ambient temperature to 570^{o}C. This change in temperature will cause the pipe to expand by approximately 7.5mm/m, though the change is most prominent in the length of the pipe rather than in its diameter. A 100m length of pipe will therefore increase in length by 750mm.

Imagine if the pipe could not expand or contract freely, the force generated in preventing the expansion to take place would cause substantial damage to either the pipe or the equipment at each end of it!

Consider the pipe work in a power station and liken it to your own central heating system where fluid is pumped around a closed system. In the boiler water is heated under pressure allowing its temperature to be increased to over five times the normal boiling temperature of water. An escape of steam under these conditions could simply cut a man in half.

This steam passes through the piping into the turbine where the pressure drives the turbine and generates the electricity. Inside the turbine the pressure is reduced and the temperature of the steam decreases. It is then sent back to the boiler where it is heated up again and so the cycle continues. The greater the demand on the power station, the higher the operating pressure and temperature will be.

The analogy with the central heating system is that when your heating comes on or goes off you hear all sorts of creeks and bumps as the system heats-up or cools-down. That is simply because the piping is expanding and contracting between fixed points and the noises are due to the pipe moving against the joists and floor-boards of your house.

On a large, coal fired power station the boiler may be as tall as a ten storey building and the turbine will be perhaps 500m away from the boiler. The length of pipe could quite easily be 1km between the two. When you consider the amount of the expansion mentioned above, the whole pipe will grow in length by 7.5m.

Peel away the insulation around the pipe when it is hot and you will actually see the pipe glowing a dull cherry red - at this temperature the metal from which the pipe is made becomes like plasticine. If it is not supported correctly it will sag and deform and this will cause problems for the subsequent operation of the plant. Drainage slopes will become disturbed, excessive forces will be transferred to the boiler and turbine connections and eventually the power station will not be able to operate.

An example of what can go wrong under such situations occurred at a large coal fired power station in Ireland some years ago. Steam was released into piping where a pool of water had gathered, the pressure of the steam forced the water through the pipe causing severe damage to the pipe, the supports and even the building structure. A very costly repair followed!

b. What type of support is required?

Where expansion and contraction occurs it is important that the supporting system allows it to take place without exerting additional forces on the pipe. Spring hangers, both constants and variables allow the pipe to move vertically while hanger rods and slide bearings allow the pipe to move horizontally. Dynamic restraints control the pipe during undesirable events such as earthquakes or system disturbances like that described above.

To support a piping system properly there will be a combination of rigid hangers or supports, variables and constant effort supports. There will be a secondary restraint system used for protection that should not have any influence on the supporting system.

After deciding the layout of the main items of plant the plant designer will route his pipe work. From this information the piping engineer will carry out the piping analysis. Some analysis programmes will actually specify the type and size of spring or snubber to be used but they do little more from our point of view.

The minimum information required is that the support spacing and location will have been identified; temperature, loads and movements will have been calculated and most probably the type of support will have been identified.

From the above conditions we can identify which spring units or snubbers are suitable. However, it is not quite finished there as we have to design or select all of the other parts of the hanger.

Ideally the pipe will have been routed and the supports located beneath or above the building structure and the space where the support fits will be clear of obstructions - unfortunately it is rarely this easy. It is often necessary to supply secondary steel work and to support a pipe that passes beneath another pipe. These factors will affect the choice of the equipment we use.

In power stations the task of supporting a pipe is often relatively simple because there is quite a lot of space in which to fit the support. Additional steel work can be fitted and other pipes or equipment can be easily avoided.

In the petro-chemical industry the problems are often different where offshore oil and gas platforms are built to very tight space and weight constraints, which impose substantial restrictions on what can be supplied. Chemical and Oil processing plants have similar space constraints applied often being constructed in modular form.

Driven by ever reducing space & weight demands we redesigned both our Constant & variable effort supports and now offer supports that are as small or smaller than any of our competitors.

With the very different requirements between power-generation and petro-chemical installations and the wider development of the petro-chemical side of the Group we saw opportunities to develop new products. High density polyurethane foam (HD PUF) and Comlin isolation products are just two such ranges that are rarely applied to the power-generation industry.

HD PUF is predominantly used in the LNG, gas transportation & storage industry where cryogenic or very low temperatures are experienced. Comlin was developed to eliminate galvanic corrosion and reduce vibration, wear and noise that often occurs between the pipe and the structure.

Our philosophy has also been to offer the piping engineer and pipe support designer a comprehensive design package within our product catalogues. This includes the wide range of other products such as slide bearings, insulation and isolation materials.

It is important to remember that these are engineered product or solutions and are primarily sold to engineers.

Worldwide there are perhaps only ten or twelve similar manufacturers that can supply these products, and normally on an international bid list there will only be four or five suppliers asked to submit offers.

All of these companies except one offer conceptually the same type of constant effort support as we do and all offer conceptually the same type of variable effort support. A major competitor from Germany differs in their design of constant effort support substantially from the rest of the World in that their unit utilises a main spring opposed or assisted by two smaller springs whereas everyone else uses a single spring operating through a bell-crank. Recently, a competitor in the US has copied the German manufacturer and is marketing a similar constant effort support.

The advantages and disadvantages of the in-line type of unit will be covered later in the booklet.

Spring Hangers - The Selection of Variable and Constant Effort Supports

a. Why use a spring in a support?

From the previous discussion you will recall that constant and variable effort supports are used when it is desirable to provide a support that will allow the pipe to alter primarily its height during expansion and contraction.

In this discussion we will look at the specific reasons for selecting a spring hanger and the factors that influence whether we use a constant or a variable effort support.

First we will consider why we call these devices a variable or a constant effort support and the significance of the word effort.

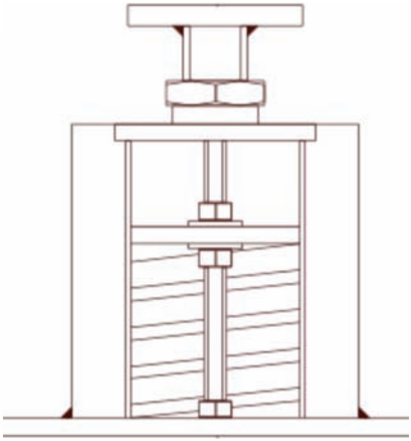
b. Variable Effort Supports

The word effort means exactly what it implies that there is effort generated by the spring to support the pipe. In a rigid support a fixed length hanger or pedestal carries the pipe and, although it is difficult to imagine, that rigid element is exerting an upwards force identical in magnitude though opposite in direction to the weight of the pipe at that position.

Isaac Newton was the first person to define the behaviour of solid bodies and identify the phenomenon of gravitational force. His work showed that for every action there is an equal and opposite reaction such that a body will continue to move in one direction unless acted upon by another force.

Imagine a set of kitchen weighing scales where you place one kilogram of sugar or rice into the dish and the dish settles down a few millimetres until the pointer becomes stationary on the 1kg mark. Place more material into the weighing dish and the dish drops even lower.

A variable effort support reacts in exactly the same way to an external force as the scales the only difference being that we have pre-compressed the spring in our test rig to balance the pipe weight. By so doing we have taken the uncertainty out of the installation process.



When the variable effort support is installed and the weight of the pipe is transferred onto the spring there should be little or no further compression or extension of the spring.

When the spring is unlocked it should remain at its pre-set height until the pipe begins to move then as the pipe moves upwards or downwards the spring force either reduces or increases. Hence the supporting effort is variable according to the displacement of the spring.

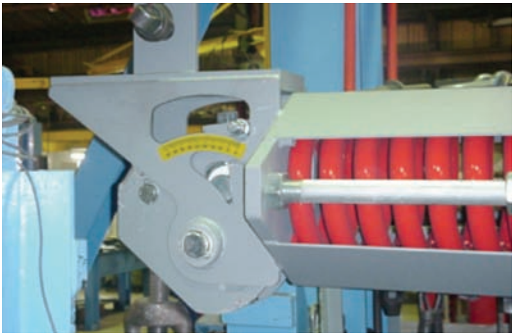
c. Constant Effort Supports

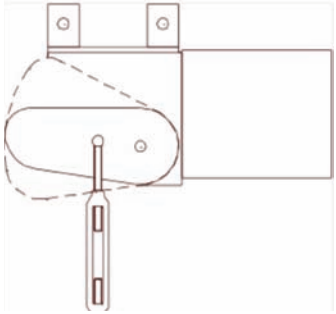
Unlike a variable effort support a constant effort support has a mechanism that alters the characteristic of the spring making it behave very differently.

You will recall from the previous discussion that the majority of support manufacturers use the same concept for their constant effort supports with the exception of one competitor. We shall discuss this type of support later.

The Bell-Crank type of constant effort support, used by Bergen Pipe Supports utilises a rotating bell-crank connected at one side to the spring and the other to the pipe.

As an analogy consider the bell-crank as a seesaw where the spring is pressing down on one side of the fulcrum and the pipe is resting on the other side of the fulcrum.

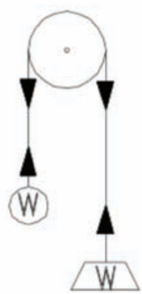




As the pipe moves further away from the fulcrum its weight must reduce if the seesaw is to remain in balance.

A further analogy for the constant effort support is that of a frictionless pulley carrying the pipe on one side of a wire rope and on the other a mass having equal weight to the pipe.

The tension in both sides of the rope is equal such that if the pipe moves downwards the weight moves upwards with zero effort or change in rope tension.



The purpose is therefore to allow the pipe to move up or down with no change in force other than that necessary to overcome the frictional resistance within the support.

When the support is installed, the locking device can be removed and because we have calibrated the unit to the exact design load, perfect balance is achieved. (Well nearly perfect balance!!)

The term constant effort means literally that: the tension in the hanger rod remains constant throughout the full range of movement that the support can accommodate.

d. Why a Variable rather than a Constant?

In very broad and simple terms a variable effort support is much cheaper than a comparable constant effort support, so if a variable will do the job you require, why pay more?

But what is the job that we want the variable to do?

When we consider the selection criteria for a spring unit there are three basic factors that wwill influence our choice –

- The weight of the pipe we wish to support.
- The vertical displacement due to thermal expansion or contraction that is predicted at that specific support location.
- The allowable change in force that the pipe can tolerate between its design load and the supporting effort. This is often called the variability or allowable deviation.

Making the obvious point first, variable effort supports have a maximum travel range of 280mm, therefore if we know the pipe will move more than this our selection has to be a constant effort support. (There are exceptions when we may design a very special variable effort support but for the purpose of this discussion we shall consider standard catalogue products.) Constant effort supports can accommodate up to 750mm of travel depending upon the combination of load and travel required.

But what if we want a support to accommodate only 75mm of travel and we assume the travel is downwards and the design load is 1660kg. We now have the choice of either a constant or a variable to do the job.

Reference to the variable effort supports section of our catalogue will show the kgf selection chart. If we consider our selection to be a V3-20, the spring stiffness (rate) is 5.43kg/mm. Multiply 75mm by 5.43kg/mm and we get a change in load of 407.25kg. If we take this from our design load we obtain a pre-set load of 1252.75kg. The minimum load of a V3-20 is 921kg and the maximum is 1681kg.

Turning now to the constant effort support section of the catalogue to find the kgf selection chart and assuming a minimum over-travel of 25mm we are looking for a support that allows 100mm of travel. In this case we would select a C5-16, which at 100mm travel provides a supporting effort of 2050kg. Referring back to the seesaw analogy, we only want 1660kg.

$$\frac{2050 \text{ x } 100}{1660} = 123.5\text{mm}$$

This means that we would have to increase the distance that the pipe acts from the fulcrum by 23.5% to give us the perfectly balanced situation we desire.

We therefore have two apparently acceptable solutions when we consider only load and movement though with the variable being less than 50% of the cost of the constant it is reasonably obvious which option the customer will take.

However, when we introduce the third criterion of variability we can discard one of the above selections.

Deviation or limiting variability is expressed as the allowable change in load between the pre-set condition and the design or operating load. In the majority of cases this is normally limited to 20%.

The significance of deviation is that it limits the application range of a variable effort support and forces us to select a constant before we would perhaps want to.

If we now re-consider the above example where we have an operating load of 1660kg and a displacement of 75mm

$$\text{Deviation } (\delta) = \frac{5.43 \times 75 \times 100}{1660} = 24.5\%$$

So immediately we can exclude the V3-20 as a viable selection in this instance.

There are occasions when the customer may specify other criteria that will restrict the application of variable effort supports. For example some Japanese specifications often state that constant effort supports shall be used when the displacement exceeds 50mm. Such requirements will normally necessitate the use of more constant effort supports than if we apply the simple deviation limitation.

As a guide when selecting variables you can use the above equation for δ and transpose it to calculate the maximum spring rate that can be tolerated for the given selection criteria –

$$k\ max = \frac{\delta \times W}{\Delta}$$

Where: Δ = Thermal displacement

W = Design Loadw

k = Maximum Spring Rate

By using this equation it is possible to quickly decide whether you require a V1, V2, V3, V4 or V5 variable effort support or if in fact you need to select a constant effort support.

$$k\ max = 0.2 \times \frac{1660}{75} = 4.427\text{kg/mm}$$

This indicates that our selection above could not have been viable since the maximum spring stiffness could only be 4.427kg/mm and reference to the selection chart in the variable effort support section of our catalogue shows that the nearest spring would be a V4-20 with a stiffness of 3.62kg/mm. The cost of the V4 variable is still a little lower than the cost of the constant effort support but in this situation it falls to customer preference.

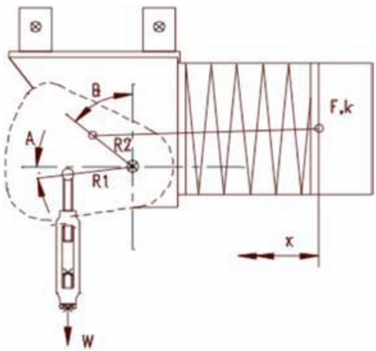
e. What is a Constant Effort Support?

Having discussed in broad terms that a constant effort support delivers a nominally constant resisting force through its full range of travel and that it behaves something like a see-saw we will now look at the specific theory behind the functioning of the support.

The dilemma felt by most people when faced with the workings of a constant effort support is – 'how can a spring that is being compressed give a constant load output?'

Simple! It's all in the mathematics.

Consider the schematic diagram –



WR1cosA = FR2cosB

For any given spring size F and R2 are fixed dimensions, the angles A and B are also fixed relative to each other and restricted within the rotational range of the bell-crank. R1 however, can vary and it decides how much vertical displacement the rotation of the bell-crank translates into.

Relating back to the seesaw analogy, the support must always be balanced, that is to say, the spring side of the bell-crank must be balanced by an equal force on the supporting side of the bell-crank.

$$\text{So} \qquad WR1 = \frac{FR2\cos B}{\cos A}$$

Since the only thing that we are able to vary is R1 then W must also vary inversely with R1. If R1 is doubled W must be halved.

It is that simple.

This philosophy can be clearly seen by looking at the selection charts in the constant effort support section of the catalogue. Take the first column; if you multiply the load by the corresponding travel at any position down the column you will obtain nominally the same answer. The larger the spring size the less sensitive this calculation is to rounding error and the more accurate the correlation is.

Because constant effort supports are so precisely balanced it is vitally important that we select and specify the most accurate W and R1 we can, otherwise the balance is not achieved and the operation of the support is compromised.

Armed with the above information about both variable and constant effort supports the basic selection of spring size can be accomplished. With the constant effort supports there are a few basics limitations to when various types of support can be used. These restrictions are shown on the selection charts by both a heavy black line and a heavy red line.

Having established the spring size that we require we must then establish which configuration is best suited to the situation. This is dependent on the boundary connections of the spring unit, for example a pedestal type such as the BM variables or the HBMCS type of constant will be used if the pipe is being supported from below.

If there is substantial horizontal movement of the pipe it is desirable to provide maximum articulation within the hanger assembly where ideally a TS1 type of variable or a VS-TS3 constant using weldless eye nuts or spherical washers will facilitate this.

The whole hanger/support assembly will be discussed in the next chapter when we consider ancillary equipment.

f. Types of Constant Effort Support

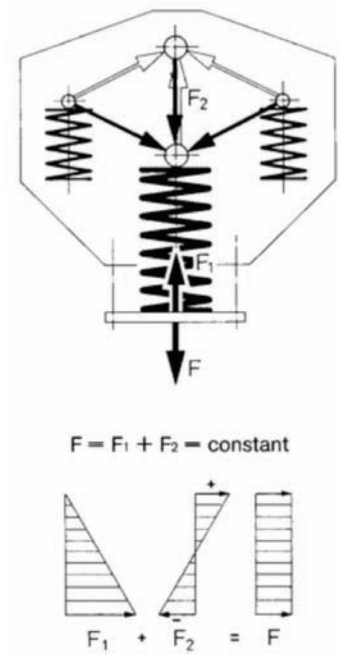
You will recall that the constant effort support manufactured by a German company is fundamentally different in its operation from the traditional bell-crank type of support. This comapny offer a much more limited range of products with only 15 spring sizes to cover their traditional range of variable supports whereas we have 145.

The principal of operation of their constant effort support is to use a main central spring in the same way as a variable effort support where the spring acts directly on the pipe.

The schematic diagram above illustrates the principal of operation; as the large spring begins to compress the two outer springs are pushing upwards against the compressive load and are therefore increasing the apparent force required to cause the spring to compress.

As the large spring reaches the mid-point of its travel the two outer springs are acting horizontally against each other and their effect on the large spring is zero.

Beyond this mid-position the two outer springs are helping to compress the large spring and so the apparent force required to compress the large spring is reduced. The net result is a constant effort output.

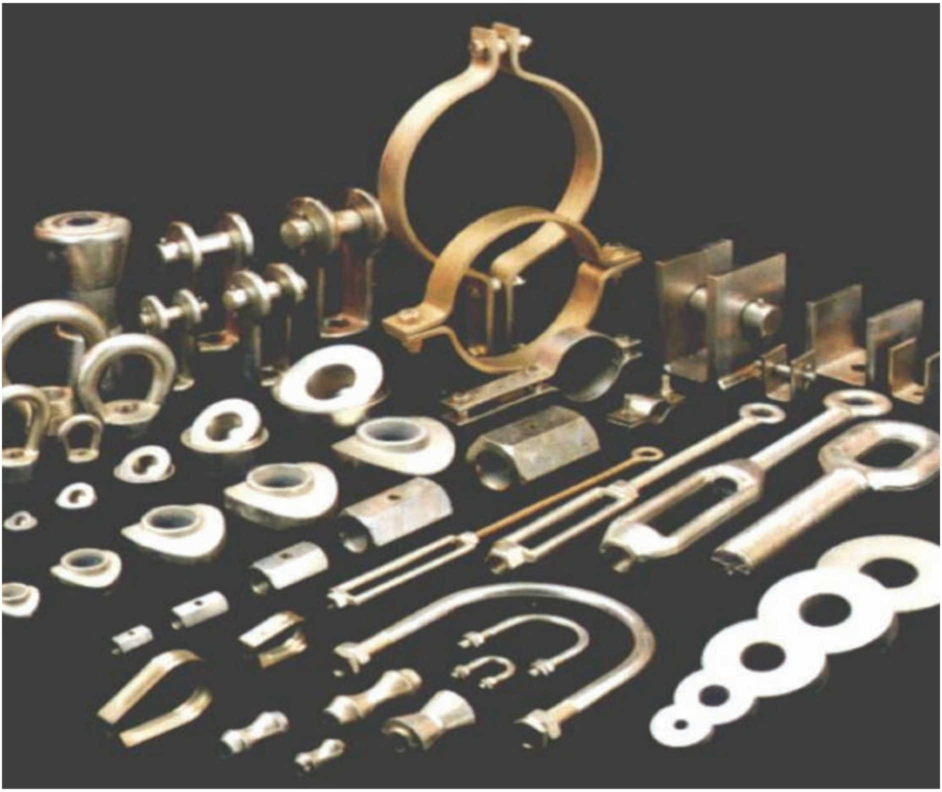


The key benefit of this type of support is that the load-line is symmetrical through the centre of the support & any structure it is connected to reducing stresses in the structure. However, there are some significant disadvantages that should be considered;

- The cam on which the spring act is prone to degradation over time leading to an increase in frictional resistance.
- Load adjustment is made more difficult by the need to adjust two components in smaller supports with larger supports being constructed from two, three or even four smaller units fixed in parallel.
- Changing the load of the support also changes the available vertical travel the support can deliver.
- These disadvantages should be considered in the ‘life-time’ cost of using this type of support.

A fundamentally different concept from our design of support!

4. Ancillary Items



What is an Ancillary Item?

Ancillaries are the hardware that complement spring supports and allow the connection of the pipe to the building structure. As simple as a pipe shoe or comprised of many items from a beam clamp through hanger rods, spreader beams and pipe clamps.

This photograph shows a good selection of the many standard ancillary items detailed in the Pipe Clamps and Ancillaries section of our catalogue.

b. Selecting Ancillaries

The three main factors that will decide on which ancillary items you require are –

- The weight of the pipe being supported.
- The general arrangement of the support being designed.
- The temperature of both the pipe and the surrounding environment.

When thinking about the weight of the pipe or the load that the ancillaries will be expected to carry it is important to consider all possible loadings.

- Normal operating load, including the weight of heavy pipe clamps, riser clamps or spreader beams should be taken into account.
- Beam attachments may carry substantially higher loads than the actual design load of the pipe. Eccentric loading on beam attachments such as our figure 172 needs very special design consideration and should be shown to a competent engineer before final detailing.
- Hydraulic test loading must be considered in conjunction with the additional weight of the hanger assembly. Our components are designed with a safety factor that allows up to 100% additional loading. If the combined loading is greater than twice the specified safe working load this must be reviewed.
- It is important to consider any other factors that may cause increased loading during the whole operating life of the plant, examples are snow loading, wind loading, surge loading, temporary loads due to access and many other possibilities.

With regard to the actual support arrangement, there are many factors that will influence the choice of ancillary to be used.

- How is the support fixed? Is it hanging from or standing on steelwork or concrete?
- Is there a clear path to the pipe from the point of attachment to the structure?
- Is the pipe moving horizontally and vertically?
- In which direction are the forces being applied?

Finally, temperature has a significant influence on the ability of steel to withstand stress. High temperatures (above 350°C) cause steel to lose strength and we must begin to consider the phenomenon of creep.

Low temperature, below 0°C, causes steel to become brittle and reduce its ability to withstand sudden increases in load.

The temperature of the fluid within the pipe will also affect the pipe clamp or attachment to the pipe. The material of the pipe will be specified to suit its operating temperature and this may also dictate the material of the pipe clamp regardless of the actual design temperature.

The temperature of the surroundings may affect the choice of ancillary and the type of material we can use. A plant in Siberia will experience ambient temperatures as low as –45°C and so all components of the pipe support will need to be manufactured from low temperature carbon steel or even austenitic stainless steel.

Similarly, a pipe suspended within the boiler casing of a power plant may operate at a temperature of 570°C dictating that we use a CrMo alloy pipe clamp. However, the load bolt of the clamp, the hanger rod and weldless eye nut will be exposed to the same temperature because they too are within the boiler casing.

c. Some Words of Wisdom

Some simple do's and don'ts that will help in deciding what support configuration is best;

- Look critically at the technical specification for hanger design as it will affect your choice of ancillary components –
  - It may specify the minimum rod diameter to be used or whether continuously threaded rod is permitted.
  - There may a requirement for higher than normal safety factors or specific requirementsfor certain situations such as tandem type hangers. Such requirements will need Engineering involvement.
  - Thin type locking nuts may not be permitted. Instead two full nuts may be specified. This will affect bolt and thread lengths.
  - Are welded beam attachments permitted? If not we will need to consider simply clamping to the existing steelwork.
- Take account of all loadings, especially the additional weight of large clamps and spreader beams and the self-weight of DS (tandem) type variables as these will affect the size of spring hanger and may preclude the use of variable hangers due to increased deviation.

[1] Deviation is calculated by taking the change in load between design and pre-set conditions and expressing it as a percentage of the specified design load, normally this is limited to 20 or 25%. Do not include additional self-weight in the specified design load for this calculation.

[2] The inside diameter of the clamp must allow for the pipe outside diameter tolerance of +1%, the thickness of the liner and the normal manufacturing tolerance.

- The support configuration must allow all movement to take place freely but within normal limitations –
  - Hanger rods should always remain within 5o of vertical.
  - Guides shall be designed to allow for the full thermal movement and include an adequate margin for safety and load bearing contact.
  - Moving parts of spring hangers and angulating rods shall not collide with other supports, pipe work, equipment or building structure.
- If using lining materials such as Comlin an allowance must be made to accommodate the liner in the pipe clamp. This will mean the clamp shall have a special inside diameter. Also be aware that controlled bore pipe will have substantially larger outside diameters than standard nominal bore pipe.
- When special materials are required, such as stainless steel always check to see if the catalogue safe working load is acceptable. At ambient temperatures stainless steel is not as strong as carbon steel and either larger sections or reduced safe working loads will need to be specified.

5. Dynamic Restraints

a. Restraint verses Support

The restraint system performs an entirely different function from that of the supports. The latter is intended to carry the weight of the pipe work and allow it to move freely under normal operating conditions.

The restraint system is intended to protect the pipe work, the plant and the structure from abnormal conditions while it should not impede the function of the supports.

Conditions that necessitate the use of restraints are as follows –

- Earthquake

In areas that are situated on or near to geological fault lines it is common practice to protect the plant from potential earthquake activity. In such plants there will be a very large requirement for dynamic restraints.

- Fluid disturbance

Fluid disturbance can be caused by the effect of pumps and compressors or occasionally fluid in a liquid state entering a pipe intended for the transportation of gas or steam

- Certain system functions

Some system functions such as rapid valve closure, pulsation due to pumping and the operation of safety relief valves will cause irregular and sudden loading patterns within the piping system.

- Environmental influences.

The environment can cause disturbance due to high wind loadings or in the case of offshore oil and gas rigs, impact by ocean waves.

The restraint system will be designed to cater for all of these influences.

b. What is a Restraint?

A restraint is a device that prevents either the pipe work or the plant to which the pipe work is connected being damaged due to the occurrence of any one of the above phenomena. It is designed to absorb and transfer sudden increases in load from the pipe into the building structure and to deaden any opposing oscillation between the pipe and the structure.

Therefore dynamic restraints are required to be very stiff, to have high load capacity and to minimise free movement between pipe and structure.

The standard components that make up dynamic restraints are –

- Hydraulic and mechanical snubbers.
- Rigid struts.
- Stiff clamps.
- Welding Clevises.

c. Hydraulic Snubbers:

Similar to an automobile shock arrestor, the hydraulic snubber is built around a cylinder containing hydraulic fluid with a piston that displaces the fluid from one end of the cylinder to the other.

Displacement of fluid results from the movement of the pipe causing the piston to displace within the cylinder, resulting in high pressure in one end of the cylinder and a relatively low pressure in the other. The velocity of the piston will dictate the actual difference in pressure.

The fluid passes through a spring-loaded valve, the spring being used to hold the valve open. If the differential pressure across the valve exceeds the effective pressure exerted by the spring, the valve will close. This causes the snubber to become rigid and further displacement is substantially prevented.

The hydraulic snubber is normally used when the axis of restraint is in the direction of expansion and contraction of the pipe. The snubber is therefore required to extend or retract with the normal operation of the pipe work. The snubber has low resistance to movement at very low velocities.

d. Mechanical Snubbers

Whilst having the same raison d'être as the hydraulic snubber, retardation of the pipe is due to centrifugal braking within the snubber. A split flywheel is made to rotate at high velocity causing steel balls to be forced radially outwards. The flywheel is forced apart by the steel balls causing braking plates to come together thus retarding the axial displacement of the snubber.

Rotation of the flywheel is generated by the linear displacement of the main rod acting on a ball-screw or similar device. Mechanical snubbers are a complicated and expensive option.

e. Rigid Struts

When the disturbed displacement is at an axis normal to the thermal displacement it is preferable and considerably less expensive to use a rigid strut. Literally rigid, this is a strut capable of rotation at either end through close tolerance spherical bearings but it will not allow any axial deflection whatsoever.

f. Stiff Clamps

Complementing both snubbers and struts these clamps are very close fitting, highly rigid clamps for attaching to the pipe.

g. Welding Clevises

The point of attachment to the structure and occasionally the pipe. Like stiff clamps these items are highly rigid with very close fitting pins to eliminate free play.

h. Comparison of Hydraulic and Mechanical Snubbers

The major comparison between the two types of snubber is related to the level of maintenance required in order to keep the snubber functional. Hydraulic snubbers require occasional inspection and replenishing of the hydraulic fluid otherwise air can enter the cylinder and prevent the valves from functioning correctly.

Mechanical snubbers are simply lubricated prior to installation. It is difficult to visually examine a mechanical snubber to ensure that it is functioning correctly. Inspection normally requires physical testing to ensure functionality and mechanical failure normally results in seizure or substantially increased resistance to movement.

Caution must be exercised when high temperatures are likely to be experienced. In such conditions it is very important that the hydraulic cylinder is isolated from any high temperature as this will cause expansion of the hydraulic fluid and increased pressure within the snubber.

i. Selection of Rigid Restraints

Rigid restraints are selected to suit the force that they will resist and the space available to fit them. The anchor point to the structure is the most simple to select since it is only dependent on the size of the rigid strut. The pipe attachment is dependent on both pipe size and strut size but is also influenced by the orientation of the strut relative to the pipe.

The strut is often more difficult to specify because it may be resisting forces in the three primary axes, x, y and z. It is therefore necessary to use some simple trigonometry to resolve the given forces into an axial force acting on the strut and to calculate the actual length of the strut between the fixing point and the pipe attachment.

Because the strut is held between two pinned connections its ability to resist compressive force is greater the shorter the strut is. A long strut will have a lower safe working load in compression than a short strut. However, its length does not affect the tensile load capacity of the strut.

The strut is therefore selected by considering the direction and magnitude of the axial force and if compressive forces are acting, the length between the fixing pins of the connections.

Having selected the strut size the welding clevis is automatically specified to suit the strut size.

The pipe attachment is selected now by considering the pipe size, temperature, the strut size and the connection requirements between the strut and the clamp. It is essential that the strut can attach to the clamp without obstruction and any thermal movements are able to occur without the strut interfering on the clamp. It is therefore very important to consider the transition of the assembly during all expected displacements.

j. Selection of Snubbers

The snubber is influenced by the same factors as the rigid strut: the magnitude and direction of axial force, but it is also necessary to consider the thermal displacement the snubber will undergo.

Again it will be necessary to use trigonometry to calculate the force and the length of the snubber but also to determine the actual displacement applied to the snubber. Displacements in the primary axes cannot simply be combined to determine the snubber displacement. It is necessary to calculate the overall length of the snubber in the various installed and operating conditions in order to determine the required stroke.

Having calculated the actual stroke it is good engineering practice to allow a margin of excess travel at each end of the design travel and so select a snubber capable of allowing greater displacement than is theoretically required.

Orientation of the snubber may be important for both hydraulic and mechanical types. Access to either lubrication points or inspection points may be required and must be considered during the design and installation of the restraint. It may also be a requirement to allow in-situ testing of the snubber to validate its functionality and so access may be a permanent requirement.

k. The Use of Secondary Steelwork

Often it may be more economic to 'shorten' the distance between the primary structure and the connection point to the pipe by designing a rigid frame of secondary steelwork.

This will have the benefit of reducing the size of struts and snubbers, especially if they are exposed to compressive forces. The cost difference between a very large snubber and a smaller snubber may be significantly more than the additional cost for providing the secondary steelwork.

6. Sway Braces

a. Description and Application

A sway brace is a special type of variable effort restraint and is built around a standard or non-standard spring. It is used to restrain piping or equipment and is not intended to support.

The construction of the sway brace enables a pre-loaded spring which sustains both compression and extension displacement to provide a pre-determined restoring force.

For example, a pipe that is exposed to cross wind will sustain high transverse force during strong winds. If the pipe is subject to thermal expansion and contraction it will have a certain amount of flexibility. If allowed to displace freely during strong winds the pipe may become unstable and possibly sustain permanent deformation.

By installing a sway brace the pipe can be held in position during the application of forces less than the pre-set force within the spring. At higher forces the pipe will be allowed to displace but the further from its neutral position it is pushed the greater the restoring force will become.

When the storm recedes the sway brace will push or pull the pipe back to its neutral position.

b. Specifying Sway Braces

Like all devices that exert a restoring force to a pipe the magnitude of force that can be applied and the amount of acceptable displacement will be decided by the allowable stresses within the pipe. This information will be defined by the piping engineer during his analysis of the system.

The level of pre-load within the sway brace shall be defined by the minimum force required to restore the pipe to its neutral position. This may be a function of the dead weight of the piping and the magnitude of frictional resistance thus created at sliding surfaces or it may be the amount of force required to restore an unstable, out of balance mass.

For simplicity if we consider a pipe crossing a bridge structure where thermal expansion of the pipe is predominantly in the axial direction and so the pipe is carried on three sliding supports each having a coefficient of friction of 0.1.

The total supported mass of the pipe is 10,000kg. Therefore the frictional resistance in the transverse direction is 1000kg.

If we select a sway brace that delivers a pre-load of 1000kg and has a spring stiffness of 100kg/mm the minimum transverse resistance to sliding is 2000kg increasing by 100kg/mm of displacement.

Assume now that the wind pressure on the pipe exerts a force of 2500kg; the pipe will displace by 5mm. If the pipe is sufficiently flexible and without the influence of the sway brace it may not be able to generate sufficient elastic energy within itself to return back to its neutral position. Subsequent axial loading may then cause further deformation of the pipe because it is not offering a rigid shape to the applied force.

With the sway brace installed the restoring force is at least that which is necessary to overcome friction and so the pipe is returned to its neutral position.

When in the neutral position the sway brace exerts zero restoring force and so the pipe is free once again to move with the thermal cycle.

Any practical combination of pre-load and spring stiffness may be defined and any spring within our standard range of variable and constant efforts supports can be applied to the product.

In the Variable Effort Supports section of our catalogue we offer a basic range of sway braces but it will normally be necessary to design the device to suit the specific requirements of the customer.

7. Slide Bearings and Isolation Products

As well as the traditional pipe hanger products there are a number of allied products. These are materials and applications that have historically been supplied by specialist companies and therefore ordered separately. For convenience, cost-control and to ensure a co-ordinated design process with the pipe supports they are used in conjunction with the Pipe Supports Group has incorporated them into our standard product range.

a. EasiSlide

The purpose of using low-friction slide bearings is to reduce stress due to the pipe sliding in a horizontal or occasionally vertical direction; stress both in the pipe and in the structure that it is sliding against.

In the previous example of where a sway brace could be used we see a potential application for low friction slide bearings. The pipe bridge where the pipe is expanding axially and is carried on simple pipe shoes. Without the use of low-friction slide bearings the structure of that bridge would have to be considerably heavier to withstand the friction force that would be generated.

The physical property that defines the amount of friction existing between two sliding surface is called the coefficient of friction and is given the symbol μ (Greek for mu). It has no units and so is considered to be a constant.

The value of μ depends on the type of materials that are being brought together and their surface finish. We all know that a non-slip surface such as those you find on stair treads is a very abrasive surface, this would have a high coefficient of friction approaching $\mu = 1.0$. Conversely a non-stick frying pan will have a very low coefficient of friction, $\mu = 0.1$ or less.

Certain materials are inherently slippery. Graphite, bronze and zinc all possess 'self-lubricating' properties and are commonly used to manufacture 'dry' bearings or bearings that require little or no lubrication.

Highly polished steels and other materials are very slippery, hence the use of non-slip surfaces for stair treads and road surfaces at particular hazards. Certain plastics are naturally slippery; such as Teflon. This is a trade name for surfaces containing a small amount of Poly Tetra Fluoro Ethylene or PTFE as we perhaps know it.

To quantify the coefficient of friction that exists between materials we commonly use, mild steel on mild steel with a shot-blasted surface has a coefficient of friction of 0.5 or greater. Highly polished stainless steel on PTFE has a coefficient of friction less than 0.1 hence a structure that uses steel on steel for sliding will be exposed to up to five times the frictional forces of one using stainless steel on PTFE.

An unusual concept about slide bearings is the fact that the greater the bearing pressure the lower the frictional resistance. It seems very odd that a high load on a small bearing pad can have lower friction than a low load on a large bearing pad.

For example, consider two people of similar weight and size sliding across a frozen lake, one of them is wearing shoes and the other ice skates. Which one will get across the lake first and with the least effort?

The contact area of the skate is considerably smaller than that of the shoes and so the bearing pressure is much greater. In fact the ice immediately beneath the skate blade is turned momentarily to liquid and so the ice skate aqua-planes across the ice.

The concept of a standard bearing to suit a range of load is not an ideal proposition. The bearing will be designed for the largest load in its range and so at lower loads the optimum coefficient of friction is not achieved.

To achieve the optimum coefficient of friction it is necessary to design the slide bearing to suit the design load so that we have the absolute minimum bearing area. This can create its own problems because it is possible to have a pipe shoe for a 500NB pipe sitting on a piece of PTFE little bigger than a postage stamp.

Stability of the slide bearing is very important. Normally the thickness of the PTFE is 2.5mm though it can be as much as 5mm or as little as 1.5mm. This is all that is separating the metallic faces and so any tendency to tilt could cause metal to metal contact and result in binding.

It is therefore preferable to use two, three or even four separate pieces of PTFE to achieve a good load distribution. The shape of each piece is dependent upon the amount and direction of displacement.

Displacement predominantly in the axial direction of the pipe would suggest strips of PTFE aligned parallel to the pipe. Equal displacements in both the axial and transverse directions may suit a square pad of PTFE. Good engineering practice and practical knowledge are required to arrive at the optimum design.

For the major part of our business we supply finely ground stainless steel on PTFE for low friction bearings. Other materials are available and may be specified.

There are two basic methods of constructing a slide bearing where the PTFE may be either bonded to or recessed into the backing plate. A bonded bearing is more economic to produce than the recessed type due to the latter normally having 5mm thick PTFE and an expensive machined recess in the backing plate.

There are some advantages that the recessed type has when compared to the bonded type.

- There is no need to glue the PTFE into the recess.
- The PTFE can be removed from the recess during installation allowing welding to take place without the risk of damage to the PTFE.
- Un-etched PTFE can be used.
- The PTFE can be removed and replaced in situations of excessive wear. However, this facility must be considered in the design of the plant and provision for separating the sliding faces or removing the bearing must be included.
- It is possible to justify higher unit loading for a recessed bearing.

Bonded bearings, however, can have curved surfaces and are relatively cheap and easy to manufacture.

PTFE is available in several different grades.

- The most common form is Virgin PTFE without any reinforcement and can be used in most moderately loaded applications. Caution must be exercised when high temperatures are possible. At 0ºC the recommended bearing pressure is 14N/mm2 whereas at 50ºC it is reduced to 4N/mm2.
- Glass-filled PTFE has a reinforcement of fibre glass strands and is available with either 15% or 25% reinforcement. The glass fibre has the effect of strengthening the material by between 10 and 20%. Again temperature will substantially reduce the allowable bearing pressure. Coefficient of friction is generally less than 0.1.
- 60% bronze-filled PTFE is occasionally specified and unlike the previous grades which are extruded, this is a sintered composite. Powders of the

constituent materials are mixed together and formed into a solid by the application of pressure. This material is capable of working at temperatures up to 150°C and still retaining good load bearing capacity. Coefficient of friction is typically between 0.1 and 0.15.

- Graphite-bronze is a cast bronze plate with pockets filled with a solid, high-temperature graphite based grease. It can be used for temperatures of up to 300°C and bearing pressure up to 25MPa. Coefficient of friction is less than 0.16 though the material is relatively expensive.
- Finally, we often use pure graphite which can operate at temperatures up to 400°C and bearing pressure up to 13.8MPa. Under these conditions the coefficient of friction will be 0.15. However, the disadvantage of using graphite is that it is very easily broken (it has the same properties as pencil lead!).

Other materials are specified from time to time when PTFE is not permitted; in the food or tobacco industries for example, so other polymers such as nylon or polypropylene are used in these circumstances. These materials will have different temperature limitations. As a general rule try to limit the temperature at the sliding face to not more than 100°C by incorporating thermal insulation such as Monolux 500 or similar products.

The sliding component also deserves some discussion and again there are various materials that can be used and various theories as to which is best. We prefer to use finely ground stainless steel because it is free of surface defects and is relatively hard compared to the PTFE.

Other practical reasons for using stainless steel are that it is readily available in a range of suitable thickness, it can be sheared, rolled and welded. However, some people prefer to use PTFE sliding on PTFE because they believe this gives the least possible coefficient of friction. That may well be the case but there is a problem that arises with this combination of material.

Notionally, the bearings are effectively static because displacement takes place at a very slow rate and very low frequency. This means that for most of the bearings life it is stationary.

Because the upper sliding area must be larger than the lower bearing pad to prevent dust and particles falling onto the surface of the bearing it has a tendency to settle onto the lower pad. The upper pad deforms to create an impression of the lower pad in its surface. When the bearing is made to slide it must first overcome this deformed bearing surface. Use of a soft material sliding against a hard material prevents this from happening.

A further consideration when designing and specifying slide bearings is the local environmental conditions; a dusty environment will lead to wear of both the PTFE and the sliding surface. Dust seals can be used to reduce the effect though normally with 2.5mm or thicker PTFE dust is not a significant problem because it is simply absorbed into the PTFE.

A final word about hydro-static test loads. Testing is carried out at ambient temperature, is short-term and will not involve sliding of the bearing surfaces. It is therefore permissible to allow the bearing pressure at the PTFE surface to increase to 14N/mm2 during this condition.

b. Comlin Isolation

Comlin is used to isolate the pipe work from one or more phenomena and is manufactured from various grades of Thermo Plastic Elastomer or TPE's. It is manufactured by a process of continuous extrusion and competes with several other manufacturers products.

Comlin provides three basic functions-

- It will prevent galvanic corrosion associated with dissimilar metals being brought into contact in the presence of an electrolyte.
- It reduces the effects of vibration on both the pipe and the structure to which it is connected.
- It reduces wear and the tendency to crush non-ferrous and non-metallic pipe.

Comlin is manufactured in several extruded profiles and combinations of material. Clamp strip is produced in four different grades from the very soft RG45 developed for use on GRP/GRE pipe and suitable for irradiated applications through FR80 and HTFR65 both flame-retardant high temperature grades and finally FR80LF our co-extruded low-friction material.

Our U-bolt sheath is produced in three different grades, FR80, FR80LF and HTFR65. We also have various plain strip extrusions to suit the U-bolts and some over-strap components.

By far the largest market for Comlin is the petro-chemical industry, especially offshore platforms. Galvanic corrosion and wear protection are the main reasons Comlin is used since the structures are all coated or protected by zinc and many of the pipes are stainless steel or themselves coated in exotic protection systems.

Comlin provides positive separation between the pipe and structure and therefore prevents damage to coatings and corrosion saving millions of pounds per year in maintenance and replacement of pipe work.

Another benefit, especially offshore where living quarters are incorporated into the platform, is the reduction of noise transmitted through the structure by vibrating pipes. Vibration also causes metal fatigue and so by fitting Comlin the engineer is again preventing damage to the pipe.

A potential growth area for Comlin is the increasing use of GRP and GRE piping

in lieu of traditional cast iron and steel pipes for ambient and warm temperature services. FGD (Flue Gas Desulphurisation) plant uses a large amount of GRP/GRE pipe, the majority of which is supported
on steel shoes resting on steel structures. Expansion and contraction of the pipe can cause rapid wear of the pipe if it is not protected from the steel.

Current practice is to use low-cost rubber wraps, however, the rubber will be prone to degradation by ozone and uv light. Comlin grades FR80 and HTFR65 both have extremely good resistance to these effects.

One of the most unique features of the Comlin range is the ability for our HTFR65 grade of material to withstand continuous operating temperatures up to 300°C and occasional temperature exposure of 350°C. This is unusual in the market where maximum temperatures are generally around 150°C.

8. Cryogenic Pipe Supports

The term 'cryogenic' refers to the use of very cold temperatures to preserve or change the state of something. It is the word used to describe temperatures lower than –100°C and all the way down to absolute zero (-273°C).

High Density Polyurethane Foam (HD PUF) is a product intended for use at cryogenic temperatures though it may still be used for services operating below 0°C and can sustain temperatures up to 140°C. Other products such as glass reinforced resins and laminated wood are often used for cryogenic applications though they perform a different role.

a. Isolation vs Insulation

This discussion depends on your perspective; from our point of view these material types act as isolators because they separate the steel or concrete structure of the pipe support from the extreme temperatures of the pipe.

Low temperature causes normal carbon steel to become brittle. The lowest recommended working temperature for carbon steels is approximately –50°C, below this there is a possibility that the steel will shatter under shock loading conditions.

When water is absorbed into the surface of concrete it can begin to cause the concrete to break-up at temperatures not much below 0°C.

The use of wood, glass and HD PUF as a thermal break eliminates these problems and allows us to design the structure of the hanger for ambient temperature conditions.

From the process engineer's perspective HD PUF is primarily used to insulate the pipe from the ambient temperature. The plant engineer, however, is looking for isolation from cold temperatures, minimisation of condensation and the ability to transfer the pipe load into the supporting structure.

The following extract from a spreadsheet compares the insulation and isolation performance of HD PUF with densified wood and Durolight S (a glass-reinforced polyester resin). We shall discuss the use of densified wood later.

[1]Durolight S is a registered trade mark of Röchling Engineering Plastics KG

Basic Data					Durolight S			HD PUF			Lignostone		
Design Temp (°C)	Pipe O/D (do)	Insu'n Thickness	Insu'n O/D (dn)	dn/do	Thermal Resistance (R)	Heat Transfer Rate (q)	Surface Temp. (T2)	Thermal Resistance (R)	Heat Transfer Rate (q)	Surface Temp. (T2)	Thermal Resistance (R)	Heat Transfer Rate (q)	Surface Temp. (T2)
-190.0	26.9	50	126.9	4.717	0.08	-2557.63	-12.12	0.71	-294.09	14.54	0.08	-2557.63	-12.12
-190.0	33.7	50	133.7	3.96736	0.09	-2275.55	-13.86	0.79	-263.95	14.30	0.09	-2275.55	-13.86
-190.0	42.4	50	142.4	3.35849	0.10	-2036.14	-15.68	0.87	-238.35	14.06	0.10	-2036.14	-15.68
-190.0	48.3	50	148.3	3.07039	0.11	-1918.83	-16.72	0.92	-225.81	13.91	0.11	-1918.83	-16.72
-190.0	60.3	50	160.3	2.65837	0.12	-1745.57	-18.48	1.00	-207.27	13.67	0.12	-1745.57	-18.48
-190.0	76.1	50	176.1	2.31406	0.13	-1594.83	-20.29	1.09	-191.15	13.41	0.13	-1594.83	-20.29
-190.0	88.9	50	188.9	2.12486	0.14	-1509.22	-21.46	1.14	-182.00	13.24	0.14	-1509.22	-21.46
-190.0	101.6	50	201.6	1.98425	0.14	-1444.12	-22.43	1.19	-175.03	13.10	0.14	-1444.12	-22.43
-190.0	114.3	50	214.3	1.87489	0.15	-1392.51	-23.26	1.23	-169.52	12.98	0.15	-1392.51	-23.26
-190.0	139.7	50	239.7	1.71582	0.16	-1315.76	-24.60	1.29	-161.31	12.78	0.16	-1315.76	-24.60
-190.0	168.3	50	268.3	1.59418	0.17	-1255.57	-25.76	1.34	-154.88	12.60	0.17	-1255.57	-25.76
-190.0	193.7	50	293.7	1.51626	0.17	-1216.24	-26.56	1.38	-150.68	12.48	0.17	-1216.24	-26.56
-190.0	219.1	50	319.1	1.45641	0.18	-1185.59	-27.23	1.41	-147.40	12.38	0.18	-1185.59	-27.23
-190.0	244.5	50	344.5	1.409	0.18	-1161.02	-27.78	1.44	-144.78	12.29	0.18	-1161.02	-27.78
-190.0	273.0	50	373	1.3663	0.18	-1138.67	-28.30	1.46	-142.39	12.21	0.18	-1138.67	-28.30
-190.0	323.9	50	423.9	1.30874	0.19	-1108.16	-29.04	1.49	-139.14	12.09	0.19	-1108.16	-29.04
-190.0	355.6	50	455.6	1.28121	0.19	-1093.42	-29.41	1.51	-137.56	12.04	0.19	-1093.42	-29.41
-190.0	406.4	50	506.4	1.24606	0.19	-1074.43	-29.90	1.53	-135.54	11.96	0.19	-1074.43	-29.90
-190.0	457.0	50	557	1.21882	0.20	-1059.59	-30.30	1.55	-133.95	11.89	0.20	-1059.59	-30.30
-190.0	508.0	50	608	1.19685	0.20	-1047.55	-30.63	1.57	-132.67	11.84	0.20	-1047.55	-30.63
-190.0	610.0	50	710	1.16393	0.20	-1029.36	-31.13	1.59	-130.73	11.76	0.20	-1029.36	-31.13
-190.0	762.0	50	862	1.13123	0.21	-1011.12	-31.66	1.62	-128.78	11.68	0.21	-1011.12	-31.66
-190.0	914.0	50	1014	1.10941	0.21	-998.84	-32.02	1.63	-127.47	11.62	0.21	-998.84	-32.02
-190.0	1016.0	50	1116	1.09843	0.21	-992.63	-32.20	1.64	-126.81	11.59	0.21	-992.63	-32.20

By comparing the heat transfer rate shown for each of the three materials we can see that the best insulator is the HD PUF; Durolight S & Lignostone are both in the order of ten times more conductive than PUF.

It should be no surprise therefore to see that the surface temperature for the other materials is considerably lower than that for the HD PUF. So why bother to use anything else?

The property that is not shown in the above table is the load carrying capacity. If we compare Durolight S to HD PUF we find that the allowable compressive load for Durolight S is approximately 50N/mm2 whereas for HD PUF it is considerably less than that at approximately 0.7N/mm2. Therefore where very high loads are experienced it is more economic to use Durolight S providing the thermal properties are acceptable.

Comparing cost is more difficult due to the fact that we are not able to correlate the thermal properties with the load bearing properties and the volume of material required for a general set of criteria.

We mentioned densified wood earlier in this discussion. Like Durolight S it is primarily used as a thermal break and is manufactured from laminated timber sheet similar to ply wood. However, the manufacturing process includes forming the finished sheet in a large press, in a vacuum, and injecting a resin which impregnates the whole structure. The result is a very dense sheet of timber with load bearing capacities approaching that of mild steel!

The penalty of the high density can be seen by comparing the various figures in the previous table. Thermal conductivity is high and so insulation properties are poor. However, the material does have some advantages: it is non-metallic and therefore does not corrode or suffer from embrittlement at low temperatures. Nor does it absorb water. It is relatively cheap when comparing it against its load bearing properties and it does act as a thermal break if it is supplied in thick enough blocks.

b.Designing with Durolight S and HD PUF:

We have already identified that Durolight S is significantly stronger than HD PUF in terms of its compressive strength. However, neither is very good in tensile situations. Our design philosophy is always to endeavour to resolve all applied forces into compressive loading on the insulation material. It is therefore important to consider how forces are transferred from the pipe through the insulation and into the structural casing.

Dead weight and transverse forces resolve naturally into compressive forces. Axial thrust and torsion, however, have to be considered partly in shear generated from compressive thrust rings, or by frictional forces, or adhesive

[1]Lignostone is a registered trade mark of Röchling Engineering Plastics KG

bonding between the various elements of the support.

Thrust rings are broadly definable; we have an axial or torsional force that translates into a compressive stress over the contact area. The transfer of the force from one set of thrust rings to the other relies on stress distribution through the insulation, which at best is very subjective.

Friction grip or adhesive bonding, however, are very difficult to define since there are always several laminates involved: the pipe interface with the insulation, the insulation with the vapour barrier, the vapour barrier with the protection jacket and the protection jacket with the pipe shoe.

Axial thrust and torsion combine to give potentially large shear forces at each of these interfaces and being able to confidently predict the strength of bond or the frictional resistance is very difficult. Add to this the fact that the insulation will shrink at a different rate from the pipe, then the complexity of the problem increases considerably.

Generally we adopt simplified design analysis to justify our shoe designs and so far these design methods have been accepted by major customers. We have also conducted full-scale testing at cryogenic temperature for several significant clients & projects achieving success and Exxon approval en-route. Like other products, we do not try to dictate the form of the product the customer should use.

A typical line-stop, fully factory assembled and ready to be installed in the cryogenic pipe line.

9. Steel Work – The Need For Non-Standard Hangers & Restraints

To offer a complete package requires the ability to take a pipe running through free space and provide a complete means of supporting it. The support shall provide for every eventuality from anchoring the pipe, restraining it in any or every axis, allowing it as many degrees of freedom as required and not causing unpredicted and unacceptable stresses in pipe or primary structure.

Some shapes are relatively simple to design, for example a beam or a cantilever carrying a vertical load is very straightforward because it is fully definable. A fabricated shoe connected to a pipe operating at high temperature and providing restraint in one or more directions is less simple.

The use of tools such as ANSYS, a finite element package help engineers to design such items, though an education in design methods, an understanding of the problem and the ability to interpret the results are all essential qualities the engineer must possess. Often such designs are still carried out by hand using basic engineering principles.

a. Basic Design Considerations

When we design something, whatever it may be, there are various thought and developmental processes we follow-

- In our minds we assess the problem and identify a need.
- We then formulate ideas and speculate on the probable outcome of the best or preferred idea.
- We make rough estimates of the time and materials required to complete the project, the resource level we need to commit to the project and the ultimate benefit we will derive from it.
- Finally, if the benefits outweigh the costs we make a commitment to proceed with the project.

All the time we are following this process we are reviewing and reflecting on our progress towards our ultimate goals and fine-tuning the direction we are taking.

Design of special supports, items and structures follows this same principle where we identify a need and formulate an idea. There is an element of guessing (or estimating if you prefer) to kick the process off. We make assumptions and we check those assumptions. If incorrect we alter our assumptions and try again, this is called iteration. We may use different analytical methods to cross-check our findings and refine our results.

If we break the whole process down into manageable parts we can begin to identify how we can all participate in the process and how we each play a valuable role in arriving at the best solution.

- Identification of a need. By applying simple common sense we can examine a situation and identify that it differs from the norm.
- Conceptualisation; the process of identifying possible solutions.
- Implementation; on paper we design the idea and determine the stresses and practicalities of the design.
- Review; we decide from the results of our efforts if the solution is feasible.

The key to successful design is to produce the most cost-effective solution to the problem, and very often it is true to say 'if it looks right it probably is right'.

10. Basic Draughting and Detailing – What does a drawing tell you?

a. Who uses the drawing?

The drawing conveys different information to different parties.

- The selling price of the support is based upon the information given by the drawing.
- The customer will use the drawing to confirm that we have offered what is required.
- The drawing enables the planners to break-down the drawing extracting data from the bill of materials, or BOM, that is then used to manufacture the support.
- The drawing will be used in conjunction with other documents such as engineering standards. It conveys the critical dimensional data to enable the support components to be manufactured.
- The drawing is used by the assemblers to actually put the components together.
- The inspector will check the components and the assembly by reference to key dimensions shown on the drawing.
- The construction people will use the drawing to identify the support and to ensure that it is installed correctly.

From this it can be seen that the drawing needs to convey a great amount of information and meet the needs of a wide array of differing interests. Accuracy and clarity are therefore critical because errors will lead to significant cost.

b. Key Requirements of the Drawing

Taking the seven points listed above it is clear that the drawing is more than just lines and numbers on a piece of paper. It is the primary document used in the conception, manufacture, assembly, installation and commissioning of the support.

In the first instance it is the translation of conceptual design (albeit selection and configuration of standard components) and the record of how the support interacts with both the pipe and the surrounding structure. It should be sufficiently detailed to enable us to establish a cost of the support and an estimate of manufacturing time.

In the next section we will see how one of our software tools enables seamless estimating directly from the drawing file.

Secondly and particularly if we have generated the drawing internally, it enables the supplier and customer to confirm the accurate interpretation of the data and ensure that the components selected meet the required objectives.

Once a full set of drawings is approved the component parts required to make the support can be created, resulting in the Bill of Materials (parts list).

The data given in the BOM is therefore critical and any errors will now be translated into manufacturing instructions for steel to be cut and components to be manufactured.

The manufacturing process treats each part of the support assembly as a discreet and disparate part where a hanger rod that is too short or a clamp that is the wrong size is not obvious at this stage of the process.

Generally at the assembly stages we find errors that have been made at the break-down stage where the technician has incorrectly specified something. If the parts comply with the drawing then the support can be assembled.

Inspection is carried out in accordance with the drawing and if everything complies with the drawing then the support is released either for third-party inspection or else for packing and despatch.

Once received at site the support will be un-packed and checked against the drawing to make sure all parts are available. The drawing will identify where on the plant the support is to be installed; this may be by reference to a number of pieces of data given on the drawing such as the support mark number, the pipe reference, location plan or simply coordinate references and the elevation of the pipe. A mistake in any of these will cause confusion at site and may lead to the support being installed in the wrong location. Often and only because the support will not fit the space provided does the erector realise that there is a mistake, Similarly, it is only at the time of installation that other mistakes are found. A pipe clamp that is the wrong size or a hanger rod that is the wrong length may well have passed through all stages of manufacture and inspection because they matched what was shown on the drawing.

11. Software

The development of software to simplify the specification of software has saved pipework designers many hours of work and led to us developing two key pieces of software.

a. PSL CAD

PSL CAD is a development that works within AutoCAD or AutoCAD LT and gives the user an intelligent ‘tool-kit’ for drafting our full range of constants, variables, hydraulic snubbers, rigid struts and ancillary products.

This is a system that retains the full functionality of AutoCAD enabling the user to detail the complete hanger, including the pipe, the support structure and any other equipment or structure that may encroach on the hanger itself.

The drawing is created component by component, generally commencing with the pipe and the supporting structure. Secondary steelwork can then be selected and by using object snaps quickly placed on the drawing frame.

The selection of components is driven by key information. Spring units are specified by load and displacement; the software will offer the user a range of compliant selections highlighting the most economic. From this point onwards the software will automatically select the correct size of mating components.

Pipe clamps and riser clamps are also selected by specifying operating temperature and insulation thickness – taking the previously entered load data the software will again offer the most economic selection.

All components are drawn to size and where there are dimensions that are dependant upon loading or movement data, these are calculated and drawn to the correct dimensions.

A Bill of Materials is created as the support assembly is drawn. The BOM can be edited, sorted and added to by the operator giving maximum flexibility.

PSLCAD offers the user the choice of working units, the choice of structural steel sections from ASTM, European Norms, British standards, Indian standards and Japanese (JIS) standards.

The drawing frame can be customised to show the user’s own company details and logo and there is the option to include a location plan.

PSLCAD is compatible with the latest versions of AutoCAD and AutoCAD LT though for use with LT it is necessary to install an additional product called CADSTA Max produced by an Australian software developer.

b. PSDesigner

PS Designer is a product written entirely by our own programmers and requires no third-party software other than a basic Windows operating system. It is a drafting system that offers many options from a stand-alone 2-D drafting system to a fully integrated 3-D system, generating models that can be imported into main-stream 3-D plant modelling systems such as Intergraph's PDS, SmartPlant 3-D or Aveva's PDMS.

Each and every selection criterion is set by the user. Company, project, pipe system and individual hanger preferences can be specified. Criteria such as minimum rod diameter, variability, over-travel allowances, selection of constant vs variable, system temperature and insulation thickness can all be set at each level of the software hierarchy.

Unlike PSLCAD, PSDesigner is driven by the user specifying the whole hanger assembly and then providing the selection data as the support is configured. The end result is much the same, resulting in a dimensioned drawing with a parts list and location plan if required.

When PSDesigner is integrated with other software such as PDS or PDMS then much of the data required for selection is passed to PSDesigner by the integrated software including data such as pipe size, operating temperature, insulation thickness, design load and thermal displacement. Other data is derived from the 3-D model such as existing steel size and elevation, pipe elevation and orientation. Any data that isn't automatically passed to PSDesigner is then entered by the operator before PSDesigner selects the component parts, constructs the hanger and passes the information into the 3-D system to enable a 3-D model of the hanger to be constructed.

PSDesigner is an evolving tool; presently we are working on improvements, enhancements and links with other commercial 3-D packages. Our programmers continue to keep abreast of developments in the key plant design packages while adding new features requested by our customers.

Drawings from PSDesigner can already be exported using dxf protocol, enabling them to be imported into most CAD systems where they can be added to or consolidated with other hanger drawings.

Those who have used PSDesigner rank it as one of the most useful pipe hanger drafting tools available from any source.

12. Quality Assurance and Control

Quality assurance and Control is now a fundamental part of manufacturing and, working within a critical area like power generation and the petro-chemical industry, it is fundamental that all component manufacturers meet all the necessary global and local requirements.

At Pipe Supports Group for example all of our manufacturing facilities operate the same basic quality assurance and control systems. Developed by our facility in the UK, we implement the same QA Manual and procedures in each of our manufacturing plants regardless of local requirements.

Where there are local requirements then these are implemented alongside our basic systems.

All of our manufacturing facilities are either approved to ISO9001 or are in the process of establishing systems and procedures that will be audited to ISO9001 in the very near future.

In addition, our UK factory is now accredited to ASME III, Division 2, Sub-section NF and has been awarded the ASME NS certificate for the supply of pipe supports to nuclear installations. The UK facility has also been accepted as a potential supplier to the European Pressurized Reactor (EPR) programme being built by Areva in accordance with the RCC codes.

Our Sister company in the USA, Bergen Power Pipe Supports is also accredited to ASME and has an established track-record of supplying to the US nuclear power program.

Within the Pipe Supports Group our UK, Thailand, India and China plants have all achieved ISO9001:2008.

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