



Graphite Technology

GUIDE FOR ENGINEERINGS AND END USERS

HOW TO PREVENT WATER AND STEAM HAMMER, PIPE EROSION

HOW TO PROTECT GRAPHITE CHEMICAL EQUIPMENT



Graphite Technology



INTRODUCTION

CORROTEC, a group of companies, design and manufacture high quality equipment made of graphite for chemical processes industries and metallurgy applications.

TLV, Japanese company, is a world leader of products and services for steam engineering.

See www.tlv.com for all their steam solutions.

The know-how of these companies combined improves reliability of customer's plant operating heat exchangers, column or reactors made of graphite material.

Our experience showed that 85% of incident occurring on graphite equipment are coming from peripheral equipment or mistake during installation and maintenance which bring overstress on graphite parts.

Water and steam hammer are often the cause of damages and is a difficult problem to solve because this phenomenon is not well understood.

TLV has a long experience and expertise in the field of steam engineering and together with Graphite Technology, knowledge can increase life time, reduce maintenance and steam costs.

This guide, made from our experts, can help you to identify and understand problems and save costs.

Contact us for more details and to study how we can expertise your installation.

Table of content

| | |
|---|----|
| 1. Type of heat exchangers | 4 |
| 2. Quick check list for installation/inspection of graphite equipment | 5 |
| 3. Trouble guide of graphite equipment | 6 |
| 4. Chemical cleaning method for graphite equipment | 9 |
| 5. Chemical media to clean metals components | 10 |
| 6. What is Water Hammer/ Steam Hammer? | 11 |
| 6.1. The Dangers of Water Hammer | 11 |
| 6.2. Water Hammer: The Mechanism | 12 |
| 6.2.1. Water Hammer caused by high-speed condensate | 12 |
| 6.2.2. Water Hammer caused by the sudden condensation of steam | 13 |
| 6.2.3. Water Hammer caused by quick stop of flow | 14 |
| 6.3. How does condensate temperature affect water hammer? | 14 |
| 6.4. Water Hammer: Cause and Location | 15 |
| 6.4.1. Importance of Identifying Cause and Location | 16 |
| 6.4.2. What if slowly operating the stop valve doesn't work? | 16 |
| 6.5. Water Hammer in Steam Distribution Lines | 19 |
| 6.5.1. Branch Piping Methods that Cause and Prevent Water Hammer | 20 |

- 6.6. Water Hammer in Equipment20
- 6.7. Reasons Why Condensate Accumulates in Equipment22
- 6.8. Cases in Which Countermeasures Are Difficult 25
- 6.9. Water Hammer in Condensate Transport Piping 26
 - 6.9.1. Mechanism & Countermeasures27
- 6.10. Water Hammer: Conclusion37
 - 6.10.1. Changes in temperature of piping before and after water hammer 38
- 7. Best Practices for Condensate Removal on Steam Lines 38
 - 7.1. Best Practice #1: Choose Trap Locations Carefully39
 - 7.2. Best Practice #2: Provide Proper Support and Inclined Steam Piping41
 - 7.3. Best Practice #3: Pay Attention to Drip Leg (Drain Pocket) Configuration 42
 - 7.3.1. Sample Guidelines for Drip Leg Dimensions43
 - 7.3.2. Improperly Configured Drip Legs 43
 - 7.3.3. Properly Configured Drip Leg44
 - 7.4. Best Practice #4: Properly Remove Air and Condensate at End of Steam Line 44
 - 7.4.1. Removing Air for Steam Lines44
 - 7.4.2. Installation of Trap at End of Steam Line45
 - 7.5. Trap Location: Close to Piping or Ground?46
 - 7.5.1. Setting Trap Close to Piping vs. Close to Ground47
 - 7.6. Trap Orientation: Vertical or Horizontal?48
 - 7.6.1. Setting Trap Vertically vs. Horizontally 49
 - 7.7. Summary49
- 8. Erosion in Steam and Condensate Piping49
 - 8.1. What Causes Erosion? 51
 - 8.2. Piping Damage Caused by Erosion51
 - 8.2.1. Erosion Occurring in Piping 51
 - 8.3. Other Types of Erosion in Steam and Condensate Piping52
 - 8.4. Erosion Countermeasures53
 - 8.4.1. Countermeasures for Limiting Erosion in Condensate Recovery Piping53
 - 8.4.2. Countermeasures for Limiting Erosion in Steam Distribution Piping54
- 9. Our Technologies for corrosives processes 56



1. Type of heat exchangers

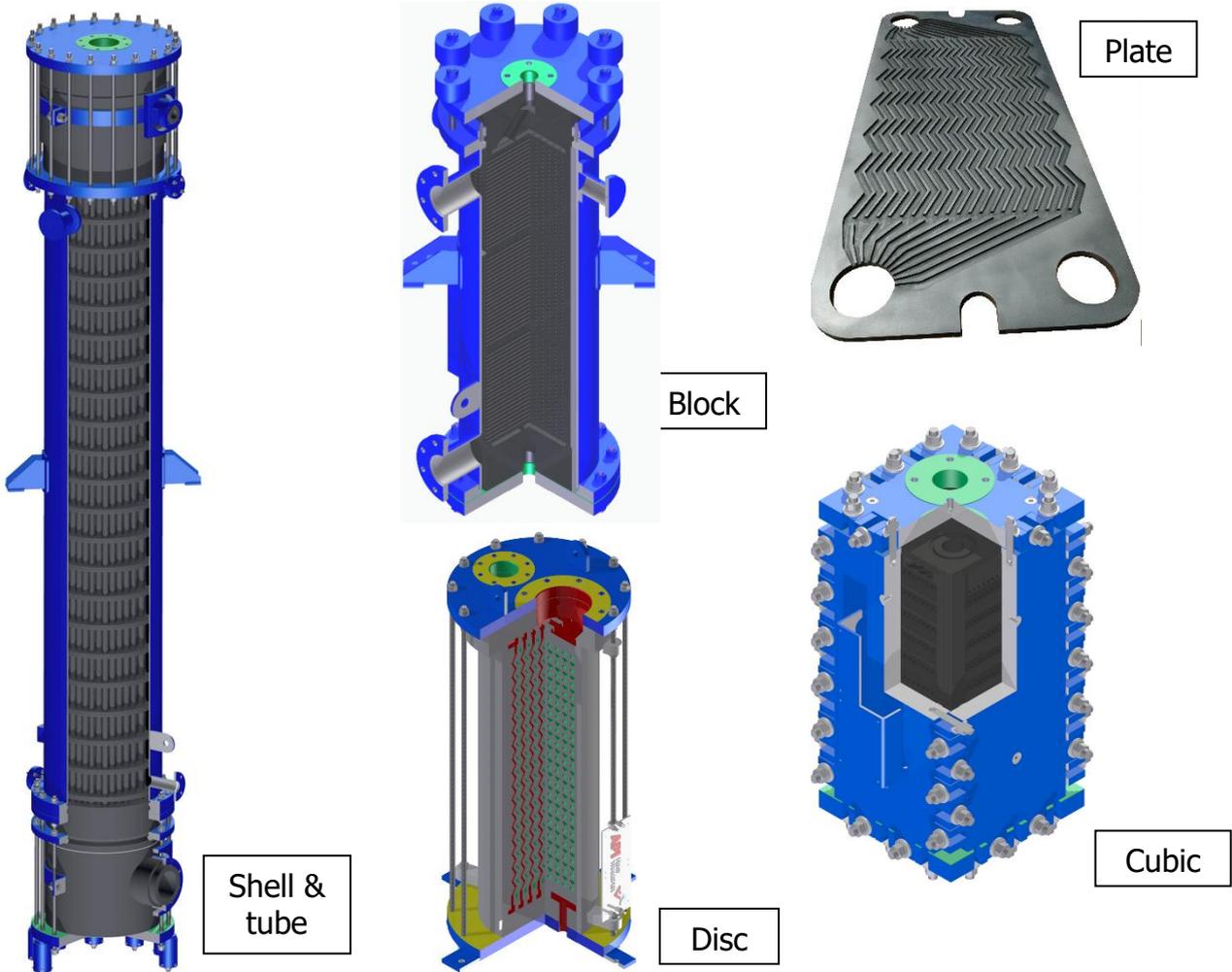
Hereunder, a selection of models of heat exchangers recommended for your process based on few operating parameters.

| Type | Dirty process | Flow >500-700 m3/h | Oxidative media ⁽³⁾ | Low footprint | Low LMTD ⁽²⁾ |
|--------------|---------------|--------------------|--------------------------------|---------------|-------------------------|
| Block | YES | NO | YES | YES/NO | NO |
| Cubic | YES | NO | YES | YES | NO |
| Plate | NO | NO | YES | YES | YES |
| Shell & tube | YES | YES | NO | NO | NO |
| Disc | YES | NO | YES ⁽¹⁾ | YES | YES |

(1) only if discs with gasket, not cemented with phenolic glue

(2) LMTD – logarithmic mean temperature difference between 2 sides media

(3) Sulfuric acid >85%, nitric acid, peroxide,...



2. Quick check list for installation/inspection of graphite equipment

| Question | Yes | No |
|---|--|---|
| Equipment use steam for heating ? | <p>Check valve opening speed to avoid thermal shock or steam hammer.</p> <p>Read part #2 of this guide to insure good condensate draining.</p> <p>Insure that the condensate line has slope to evacuate condensate (see page 41)</p> | |
| Does steel flange of equipment are corroded ? | <p>Check that rust does not block motion of shell floating flange.</p> <p>Check that rust does not block motion of spring system.</p> <p>Identify origin of acid leak to remedy it.</p> | |
| Does expansion bellow is installed on each graphite nozzle ? | <p>Check that expansion/ compression of bellow is not blocked by nut position (misinstallation).</p> | <p>Install expansion below or adopt STRESS FREE© design from GT.</p> |
| Does piping line have a fixed point close to the nozzle connection ? | <p>Check that expansion of the equipment steel shell will not create shear or compression between graphite nozzle and fixed piping.</p> | <p>Install expansion joint between equipment and piping or adopt STRESS FREE© design from GT.</p> |
| For heat exchanger, does temperature between hot and cold side is more than 50°C ? | <p>Check that operation team respect sequence of fluid use (fluid closer to room temperature first) to avoid thermal stress and thermal shock.</p> | |
| Does equipment can be fully drainable ? No zone which can keep liquid after drain. | | <p>Insure that liquid cannot freeze inside equipment during stand by period.</p> |
| Equipment has a system to measure spring compression value ? | <p>Measure compression of spring when equipment is cold and compare it with manufacturer datas. Insure that compression is same for all springs.</p> | |
| Equipment has spring compression system ? | <p>Check that compression of all spring are similar.</p> | |

3. Trouble guide of graphite equipment

| Issue | Possible cause | Solution |
|---|---|--|
| Steam/water hammering (noise evidence) | <p>Condensate line not well drained (see page 41)</p> <p>Steam valve opening/closing too fast</p> | <p>Use reinforced block design SHOCK PROTECT®, use our device HAMMER PROOF® on piping.</p> <p>Modify piping installation and/or instrumentation. Review SOP.</p> |
| Thermal shock break graphite | <p>At startup, sequence of media introduction creates thermal shock.</p> <p>Steam temperature too high.</p> | <p>Use PTFE or carbon impregnation graphite grade (GT FLON/GT CARB) instead of phenolic impregnation. Adopt fine grain graphite (<0.04mm) to improve thermal shock resistance.</p> |
| Corrosion with phenolic impregnated graphite | <p>Strong oxidant in process fluid.</p> <p>Resin not well stabilized.</p> | <p>Use PTFE or carbon impregnation (GT FLON / GT CARB).</p> <p>Use fine or GT TOYO TANSO ultrafine grain graphite (consult us).</p> |
| Nozzle break | <p>Expansion bellow not well installed or designed.</p> <p>Stress on gasket area too high.</p> <p>Thermal shock.</p> <p>Corrosion of graphite material.</p> <p>Flange corrosion sinter graphite nozzle which create stress.</p> | <p>Check bellow settings</p> <p>Choose STRESS FREE® design. Header without graphite nozzle</p> <p>Use PTFE or carbon impregnation graphite grade (GT FLON/GT CARB) instead of phenolic impregnation.</p> |
| Erosion of blocks or tubesheet | <p>Velocity too high (maxi 1,7-1,8 m/s with liquid).</p> <p>Hard particle in fluid.</p> <p>Some process holes plugged.</p> <p>Corrosion of graphite and/or resin</p> | <p>Add C-HARD® “hard” entrance plate. Review design.</p> <p>Adopt FILT-IN®, filter before fluid inlet</p> <p>Unplug holes to reduce velocity.</p> <p>Measure graphite hardness to identify corrosion on going.</p> |
| Fouling | <p>Many causes....complex phenomenon</p> <p>Velocity too low sometimes (wrong design).</p> | <p>Choose GT FLON, PTFE impregnated grade</p> <p>Adapt block design to optimize velocity</p> |

| Issue | Possible cause | Solution |
|--|--|--|
| Gasket leakage | <p>Hammering and gasket slip.</p> <p>Gasket stress too low.</p> <p>Creeping of gasket which require retightening.</p> <p>Gasket corroded or broken.</p> <p>Compression spring malfunction.</p> | <p>Inspect gaskets.</p> <p>Use of expanded PTFE gaskets with GT sealing design.</p> <p>Adopt STABLE LOAD® spring system.</p> |
| Block / header cracked or leak | <p>Hammering, equipment overtight, corrosion, overstress from piping, mechanical shock or hurt (during holes cleaning operation), erosion, frost damage (equipment not drained in winter).</p> | <p>Use reinforced block design SHOCK PROTECT®</p> <p>Adopt STABLE LOAD® spring system or HAMMER PROOF® device</p> <p>Adopt STRESS FREE® design.</p> <p>Expertise with customer to solve issue.</p> |
| Reduced heat transfer performance | <p>Fouling</p> <p>Service side baffle bypass</p> <p>Change of flow parameters in the process.</p> | <p>Clean graphite (mechanically, chemically). See page 9.</p> <p>Inspect baffle.</p> <p>Review original design flow.</p> |
| Hydraulic test pressure going down without leakage find | <p>Slow migration of water into gasket groove.</p> <p>Slow migration of water into closed porosity of graphite</p> <p>Air pocket trap into equipment.</p> | <p>Fill equipment with water under vacuum.</p> <p>Apply pneumatic test (at low pressure) to check if pressure go down also.</p> <p>Remove air pocket by applying vacuum prior to introduce water or to remove air.</p> |



GT graphite equipment feature major unique technologies improvement which prevent main problem occurring during operations.

Contact us to study how to improve lifetime and reduce your maintenance budget.

| Name | Description | Recommended for... |
|---------------|---|---|
| SAFE SEAL | double sealing with leak detection | pharmaceutical / high purity process. |
| STABLE LOAD | spring box with stable load force during operation. Reduce by 90-95% graphite stress fatigue. | process with temperature difference between service/process more than 70°C. Long equipment. |
| SHOCK PROTECT | design of drilling which reinforce blocks mechanical resistance. | all processes. Steam and water hammer protection. |
| FILT-IN | mesh filter in service inlet nozzle to prevent water drop in steam or filter dirty media | steam heater, dirty service liquid media. |
| LOG DATAS | data logger for temperature, pressure, vibration to survey operating conditions | improvement of process, extension of lifetime, harshest process survey. |
| STRESS FREE | design of header without graphite nozzle in contact with external piping | all processes. Not used for temperature process >180°C and media which corrode glass. |
| TURB | Heat exchange coefficient enhancement | viscous media, small flow |
| LIGHT | long tie rods, oring service sealing, light structure | laboratory and pilot equipment. Lack of space for equipment installation. |
| C-HARD | Erosion protection | Pickling and phosphoric acid for fertilizer. All erosive process. |
| HAMMER PROOF | Technology to absorb waves of pressures surge | All equipment |

| Equipment option | Description |
|-----------------------------|--|
| Decontamination | Cleaning equipment with solvent or distilled water |
| Clean in place | Installation spray nozzle for cleaning in operation |
| Inspection nozzle | Nozzle for process inspection. |
| Service side lining/coating | Protection of steel part from corrosion (rubber lining/fluoropolymers lining or coating, glass lining) |
| Service opening | Door for cleaning service side without dismantle equipment |

4. Chemical cleaning method for graphite equipment

Based on the fouling composition you can follow the recommendations hereafter to remove the fouling on the surface on traditional graphite equipment.

Consult also your manufacturer Operating Manual to check compatibility of cleaning media with your graphite grade and/or metal components.

| Fouling type | Cleaning agent | Conditions |
|--------------------------------------|--|---|
| CaCO ₃ /MgCO ₃ | Amidosulfuric acid (also with surfactants added) | Aqueous solution, up to 20%, 100h @ 90°C |
| | Acetic acid | Aqueous solution |
| | Citric acid | Aqueous solution, saturated solution, 100h @ 90°C |
| Silicates | Caustic soda / Caustic potash | Aqueous, up to 20%, 100h @ 50°C |
| | Hydrochloric acid | Aqueous, up to 50%, 50-100h @ 50°-80C |
| Gypsum (anhydrite and semihydrates) | Caustic soda / Caustic potash | Aqueous, up to 20%, 100h @ 50°C |
| | Ethylene diamine tetraacetate | Aqueous solution, saturated solution, 100h @ 90°C |
| Algae, micro-organisms | Phosphoric acid | Aqueous solution, up to 65%, 100h @ 120°C |
| | Hydrochloric acid | Aqueous, 20%, 100h @ up to boiling point |
| Organic compounds | DMF, MIBK, diethylether | 20h @ 30°C |
| | Alcohols | 200h @ boiling point (below 120°C with phenolic grades) |
| | Acetone | 200h @ 50°C |
| | Aniline | 100h @ 50°C |
| | Caustic soda | Alcoholic solution, up to 10%, 100h @ 50°C |
| Waxes | N-hexane | Aqueous solution, up to 80%, 100h @ 130°C |
| Others | Sulfuric acid | Aqueous, up to 80%, 100h @ 130°C |
| | Amines | Max 100h @ 30°C |

5. Chemical media to clean metals components

| Solvent | Base metal / foulant |
|---|--|
| Hydrochloric acid | Inhibited acid can be used for cleaning carbon steel, cast iron, brasses, bronzes, copper-nickels and Monel 400. Not recommended for austenitic stainless steel, Inconel 600, Incoloy 800 and Aluminum |
| Hydrofluoric acid | To remove mill scale |
| Inhibited sulfuric acid | Carbon steel, austenitic stainless steel, copper-nickels, admiralty brass, aluminum bronze and Monel 400. Do not use on aluminum. |
| Nitric acid | Stainless steel, titanium, zirconium |
| Sulfamic acid | To remove calcium and other carbonate scales and iron oxides. Inhibited acid can be used on carbon steel, copper, admiralty brass cast iron and Monel 400 |
| Formic acid with citric acid or hydrochloric acid | To remove iron oxide deposit from aluminum or titanium |
| Acetic acid | To remove calcium carbonate scale |
| Citric acid | To clean iron oxide deposit from aluminum or titanium |
| Chromic acid | To remove iron pyrite and certain carbonaceous deposits that are insoluble in HCl on carbon steel and stainless steel. It should not be used on copper, brass, bronze, aluminum and cast iron. |

Do test on one small area to adjust the time/concentration of cleaning to avoid corrosion damage.

6. What is Water Hammer/ Steam Hammer?

Have you ever heard a loud 'BANG' or hammer-like sound after quickly turning on or off a water faucet? This is the sound of water hammer in the water piping system. In a factory, a pump starting up operation or shutting down, or an air vent suddenly closing are examples of when this might occur.

In addition to water transport piping systems, water hammer also occurs in steam and condensate recovery (i.e. water circulation) systems. This series of articles will focus on water hammer in these latter two systems. Note that as steam is involved, this type of water hammer is also sometimes referred to as 'steam hammer'.

6.1. The Dangers of Water Hammer

When steam is first supplied to steam distribution piping or steam-using equipment, a metallic and repetitive 'bang, bang, bang', or even sometimes a violent 'boom' accompanied by vibration may be heard. Most steam users will probably have experienced one of these at some time.

When water hammer occurs, a momentary abrupt pressure change of over 10 MPa may occur inside the piping.

This impact can severely jar piping, equipment or machinery housing, possibly resulting in damage not only to gaskets in junctions, but also to valve flanges or the valves themselves.



Example of piping damaged by water hammer

As soon as something like this, such as a valve, becomes damaged, large quantities of steam or hot condensate begin blowing out, which could lead to a serious accident. There have even been reports of deaths occurring as the result of water hammer. In spite of this, there is remarkably little research or literature devoted to its causes and prevention, and many steam users find themselves at a loss with how to cope with the issue.

6.2. Water Hammer: The Mechanism

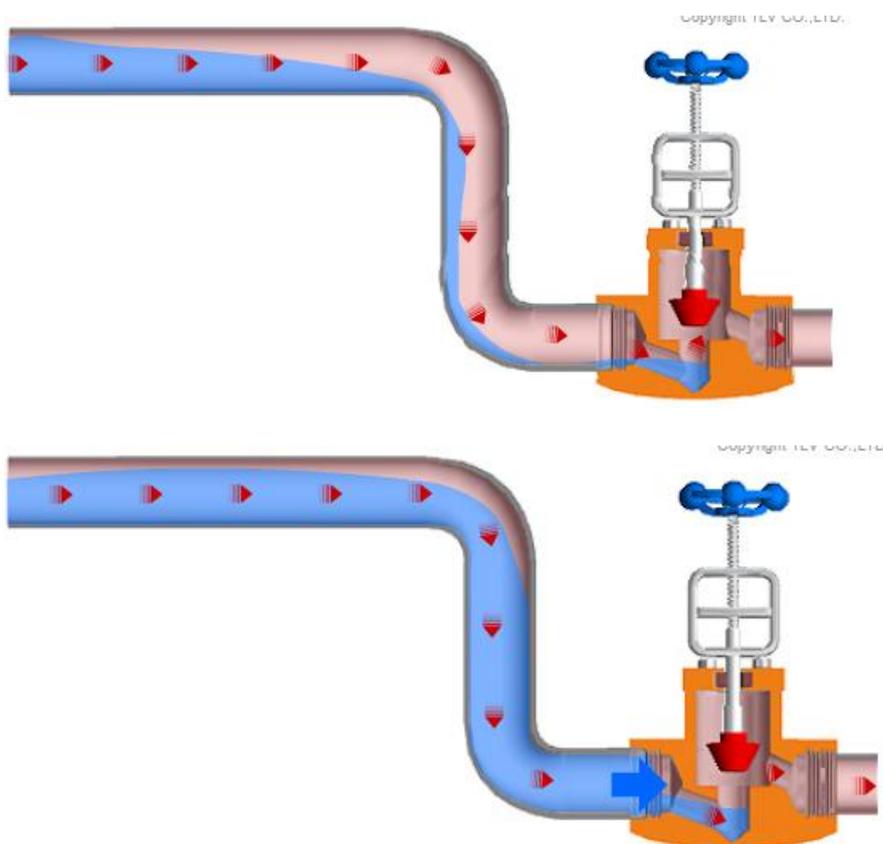
Water hammer generated in steam and condensate recovery systems is usually classified into two main categories:

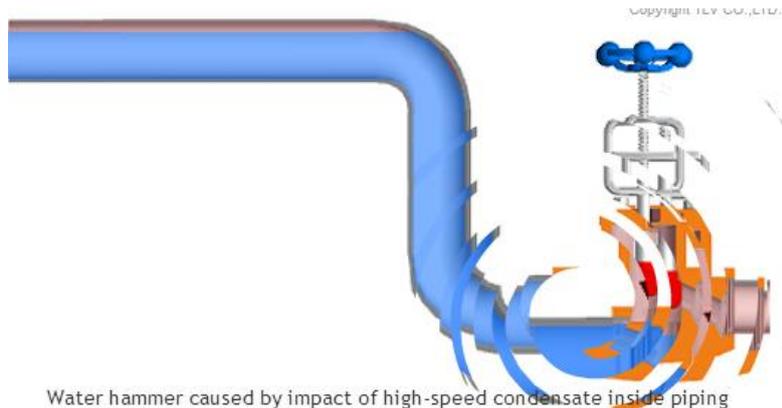
- caused by high-speed condensate slamming into piping, etc.
- caused by the sudden condensation of steam, which produces walls of condensate that crash into each other

6.2.1. Water Hammer caused by high-speed condensate

Radiant heat loss causes condensate to form inside steam transport piping. Steam flowing at high speeds within this piping draws this condensate forward and causes ripples. From this turbulence, slugs of condensate gradually begin to form and are carried along with the steam. This is similar to the high waves formed by very strong wind.

In this case, water hammer occurs when these slugs of condensate strike a curve or valve as they travel through the piping.





Water hammer caused by impact of high-speed condensate inside piping

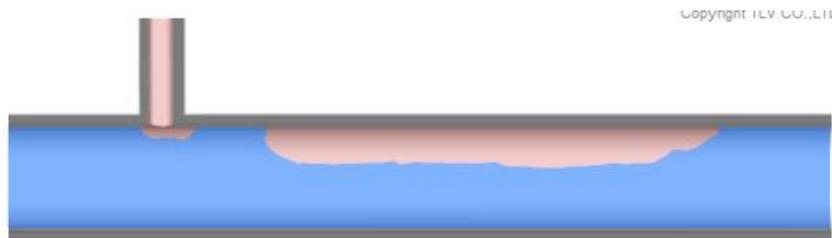
6.2.2. Water Hammer caused by the sudden condensation of steam

When steam loses its heat, it turns into condensate, whose specific volume is more than 1000 times smaller than that of steam. So when steam comes into contact with colder condensate and condenses; its volume is instantly reduced to next to nothing.

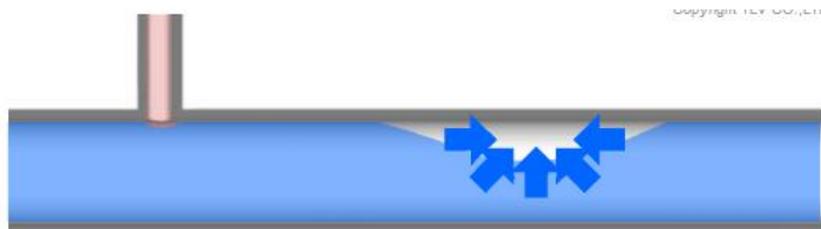
During the condensation process, the space occupied by the steam momentarily becomes a vacuum and the condensate inside the piping surges toward this vacuum. This is the second form of water hammer, which occurs when these surging walls of condensate crash into each other.

In short, it is dangerous for piping to contain a mixture of cold condensate and steam. This is the norm, however, in condensate recovery piping and similar systems, which makes this form of water hammer difficult to resolve.

Note that this type of water hammer isn't limited to condensate recovery systems, but also occurs in steam distribution lines and steam-using equipment.



Water hammer caused when steam rapidly condenses and walls of condensate crash into each other



Water hammer caused when steam rapidly condenses and walls of condensate crash into each other

Powerful impacts can occur in both of the above-mentioned types of water hammer; however, these impacts occur with much greater frequency in the second case.

6.2.3. Water Hammer caused by quick stop of flow

Water flowing inside pipe has a powerful kinetic energy. The higher its velocity in the pipe the higher the potential kinetic energy.

During an electric shut down of a pump or a fast closing of a valve, the water after the pump or after the valve, continue to flow and create at the closed section a vacuum space which will stop the flow and pulling it backward. This back flow occurs at high speed and will bump into the closed pump or valve. This shock will create waves of pressure through the piping filled with water after the closed section. All equipment on the way to these waves will face pressure of 20 to 100 bar (based on the velocity and the speed of flow stop).

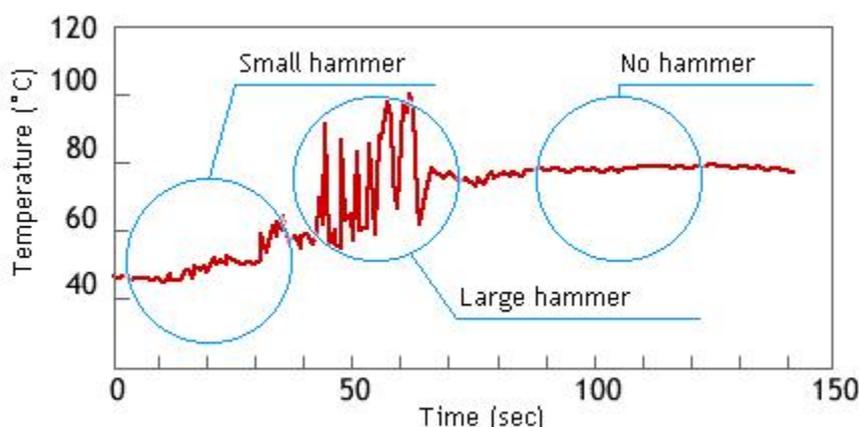
Similar effect happens on a fast closing valve. The column of liquid in the pipe could not decelerate immediately. All the kinetic energy will bump into the closed valve creating a surge of pressure of 20 to 100 bar. In this case, all equipment installed prior to the closed valve will face the waves of pressure.

Water hammer can appear at inlet or outlet of any equipment based on which section of piping is suddenly closed.

6.3. How does condensate temperature affect water hammer?

Previously, it was believed that the lower the temperature of the condensate, the greater the resulting water hammer. However, experiments carried out at TLV revealed a surprising fact. It was discovered that the most severe impacts from water hammer occur when the condensate is at a temperature only slightly lower than that of the steam.

More specifically, at a steam temperature of 100 °C, it was found that condensate between 70 °C and 80 °C caused water hammer on a larger scale than condensate between 50 °C and 60 °C.



In fact, the impact caused by water hammer can be mathematically calculated, and the results of such calculations show a strong relationship between the intensity of the water hammer and the volume of the condensing steam (= called 'pockets of steam').

Taking a closer look at the graph, three zones of condensate temperatures can be identified:

- On the left side of the graph, steam comes into contact with cold condensate and immediately condenses. In this case, condensation happens on the scale of tiny steam bubbles and large 'pockets of steam' cannot form, hence only small water hammer occurs.
- The middle section is of greater concern. Due to the relatively small temperature difference of 20-30°C between the condensate and steam, the steam does not condense all at once, but gradually. As the condensation process slowly occurs, it will reach a point where suddenly all the steam condenses. The delay created between the time the steam comes into contact with condensate and the time it suddenly condenses is what allows the formation of bigger pockets of steam, and hence bigger water hammer.
- On the right side of the graph, steam comes into contact with condensate of the same temperature. In this case, it does not instantly condense and water hammer does not occur. This can be confirmed from the fact that water hammer does not appear right at the outlet of a steam trap where saturated condensate coexists with flash steam of the same temperature.

We know that condensate between 70°C and 80 °C causes an increase in size of the 'pockets of steam' and with this the most severe water hammer. So what triggers the process? Find out in [Water Hammer: Cause and Location](#).

6.4. Water Hammer: Cause and Location

Water hammer can generate a large impact strong enough to instantly damage a valve, etc., or cause smaller damage over a long period of time. Whichever the case, both of these situations can lead to serious accidents, so countermeasures must be taken.

6.4.1. Importance of Identifying Cause and Location

When trying to prevent water hammer, determining its location and timing is important, but even more so is establishing its most likely cause.

Two pieces of advice you might hear around the workplace are: 'Close the stop valve immediately if water hammer occurs.' and 'Operate the stop valve slowly.'

Immediately closing the valve will cut off the flow of steam, and water hammer may cease. Operating the valve slowly, on the other hand, has two objectives:

- To slow the flow of steam, which weakens the force of inertia and thus weakens impacts that occur inside the piping
- To prevent the sudden generation of condensate, which limits the amount of condensate generated per unit of time

By slowly opening the stop valve, condensate cannot flow as rapidly. This might help prevent the first type of water hammer, caused by high-speed condensate crashing into piping, etc.

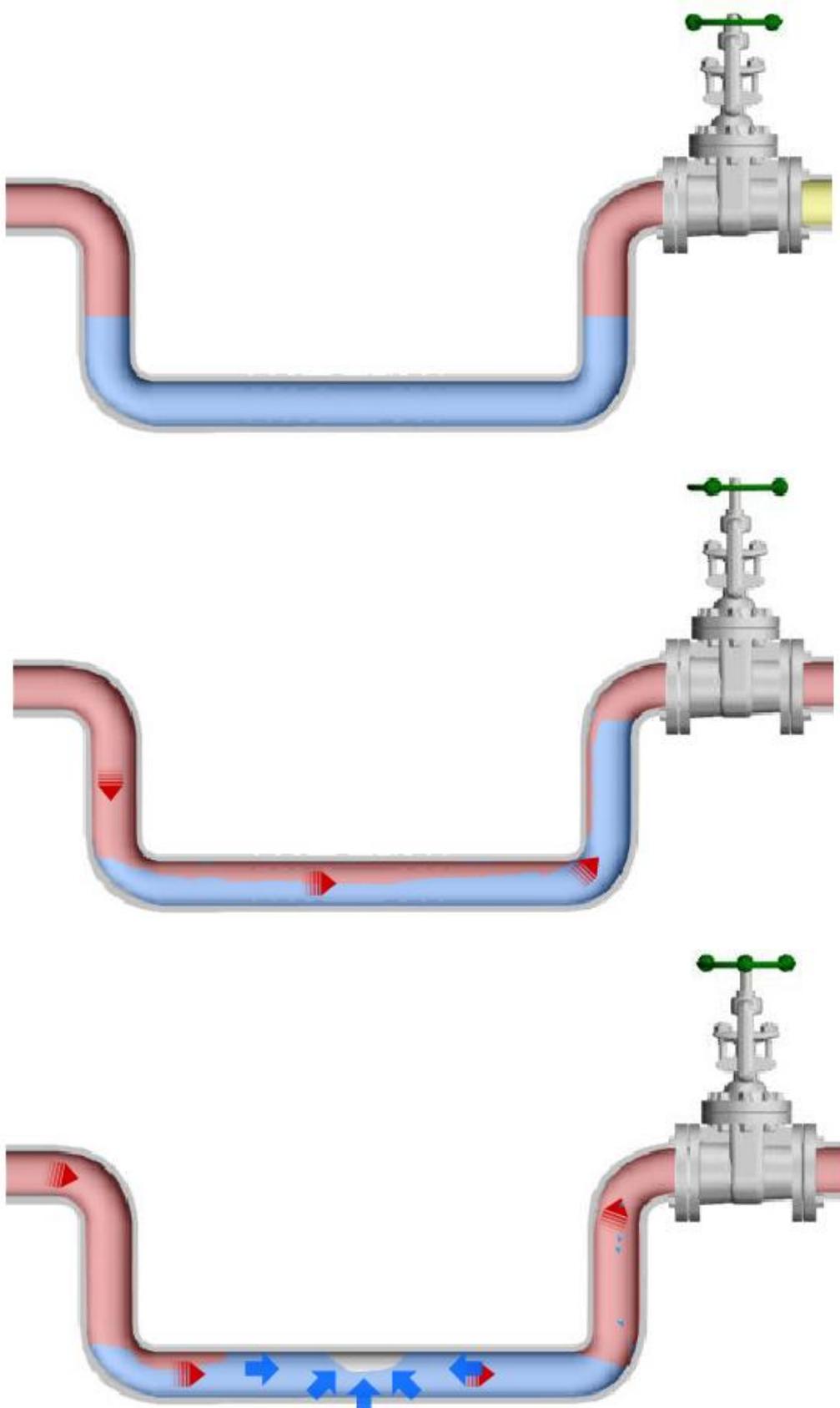
6.4.2. What if slowly operating the stop valve doesn't work?

Water hammer without steam could be avoided with slow valve or pump stop.

Water hammer that occurs even after the steam supply is cut off or when valves are operated slowly is the second type of water hammer, caused by the sudden condensation of steam.

"Waves" are what triggers this kind of water hammer. Nearby waves of condensate isolate or trap pockets of steam, and water hammer occurs. With this type of water hammer, shockwaves created by the initial impact isolate more pockets of steam and help further propagate the water hammer.

6.4.2.1. Water hammer caused by waves

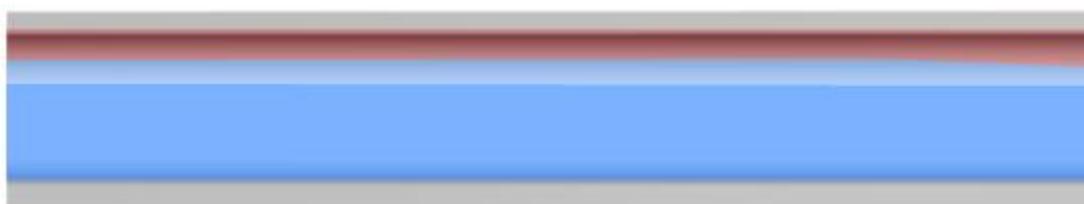


Pockets of steam can be isolated or trapped by waves if the level of condensate inside the piping is high enough to trap or isolate pockets of steam against the walls of the piping. In experiments performed at TLV, water hammer began to occur when the level of condensate rose above approximately 80% of the interior height of the piping.

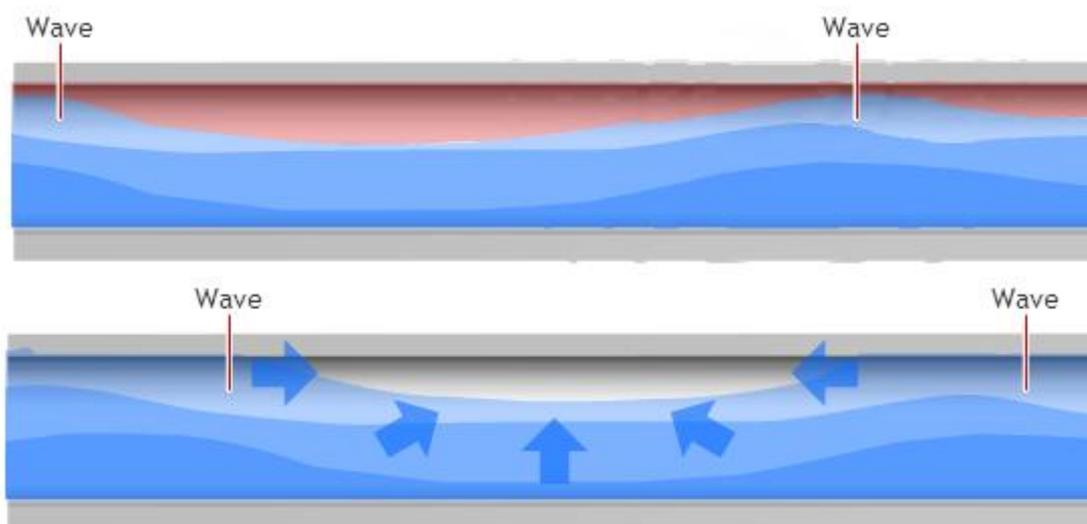
Waves form, but low level of condensate: No water hammer



High level of condensate, but no waves form: No water hammer



Waves form and high level of condensate: Water hammer occurs



Location specific countermeasures are discussed in the following sections.

6.5. Water Hammer in Steam Distribution Lines

Water hammer in steam distribution lines usually occurs when first supplying the steam. The previously mentioned method of operating valves slowly may help if the water hammer is caused by high-speed condensate slamming into piping, etc., but will not be effective if the water hammer is caused by the sudden condensation of steam.

As condensate is directly related to either type, properly removing condensate will lead to the most effective solution. Steam traps must be correctly installed so that the condensate inside the steam distribution lines is rGTdly and completely removed.

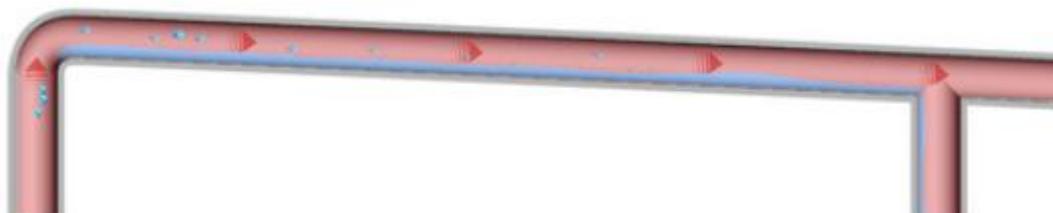
If water hammer still occurs when proper care is given to the number and location of steam traps installed, the problem is most likely being caused by incorrect sloping of the piping. If the piping is not sloped correctly, the condensate cannot flow into the trap as planned, which can lead to high levels of condensate in unexpected locations.

In long steam distribution lines, even a slight rise in piping can result in water hammer. When installing piping using a roofline or the ground as a reference, make sure to double-check the slope of the piping.

Steam piping slopes upwards: Water hammer occurs

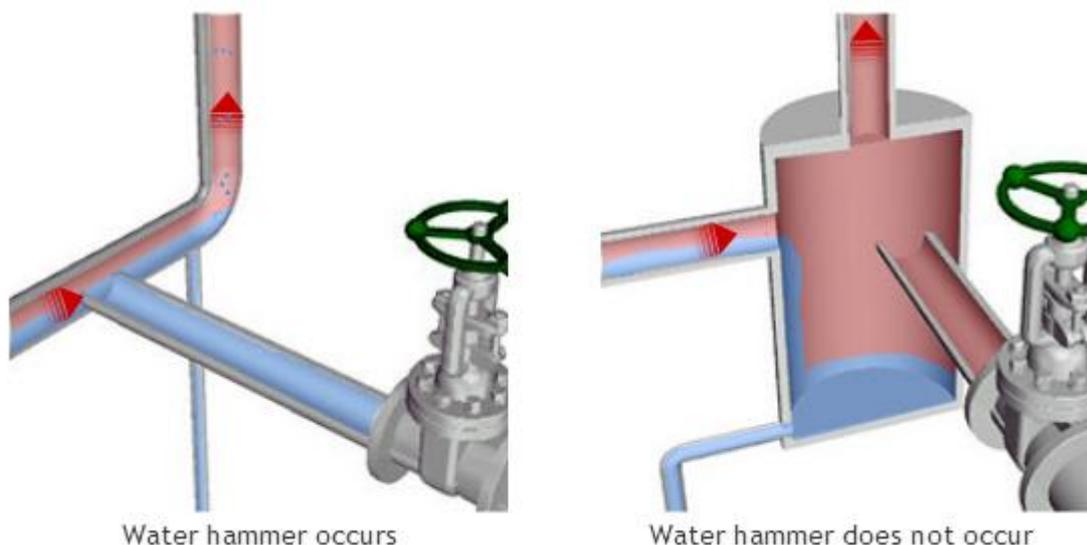


Steam piping slopes downwards: No water hammer



Among other possible causes of water hammer may be the accumulation of condensate where branch lines dead end. This is only a portion of the reasons why water hammer occurs. In order to truly eliminate the problem, a survey of the entire piping system should be performed to pinpoint the exact causes and plan suitable countermeasures.

6.5.1. Branch Piping Methods that Cause and Prevent Water Hammer



6.6. Water Hammer in Equipment

Water hammer inside equipment, just like water hammer in steam distribution lines, is often caused by high levels of accumulated condensate. The difference between the two is that this type of water hammer also occurs during steady operation.

Take for example shell and tube heat exchangers. When the load to the equipment drops (due to factors such as a reduction in the amount of product to be heated or an increase in the product's temperature), the pressure differential between the trap inlet and outlet pressures disappears, and condensate starts to pool inside the shell. This phenomenon is known as 'stall.' Depending on back pressure, the shell can also become full of condensate when the equipment is shut down.

When steam is supplied to an area that has a high level of condensate, it instantly condenses and water hammer occurs. In most cases, this results in small-scale impacts over a brief period, unlike the violent impacts that occur in steam distribution lines.

However, if this small-scale water hammer is allowed to continue over long periods of time, it can weaken the equipment to the point where the equipment suddenly ruptures. This breach often occurs under high pressure, heavy load, full operation conditions. The rGTd discharge of condensate is thus critical from a preventative maintenance standpoint. For more information on this type of problem, visit our [Stall Tutorial](#).

Water Hammer in Shell and Tube Heat Exchangers

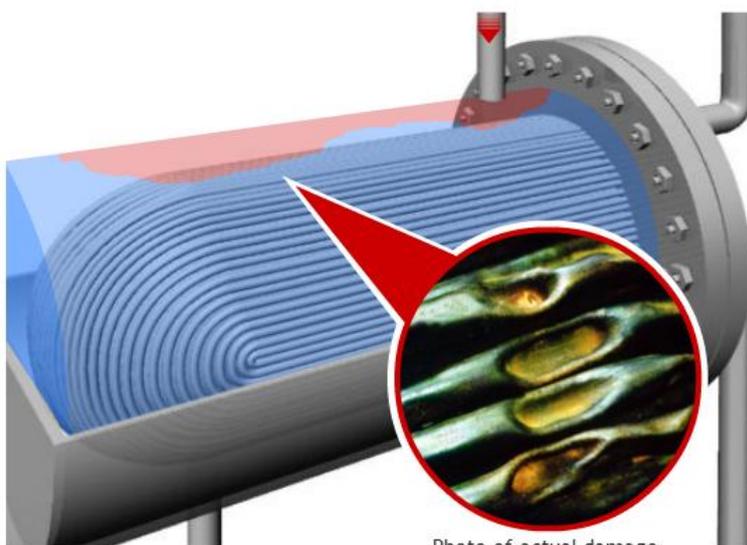
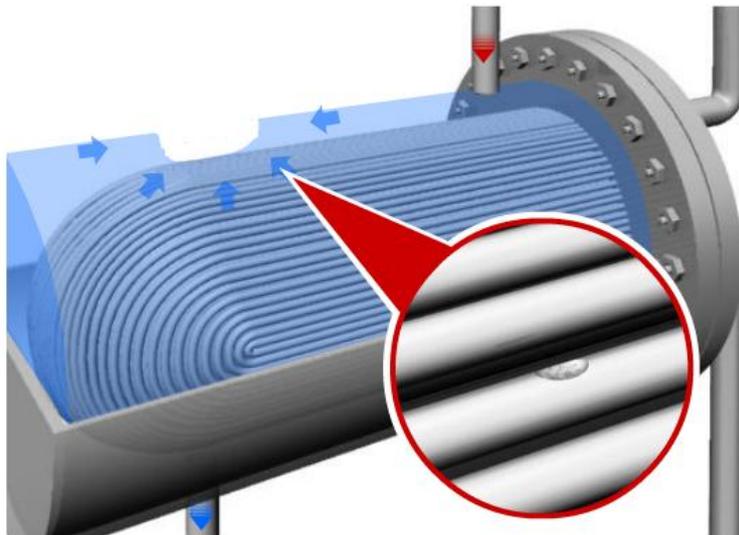
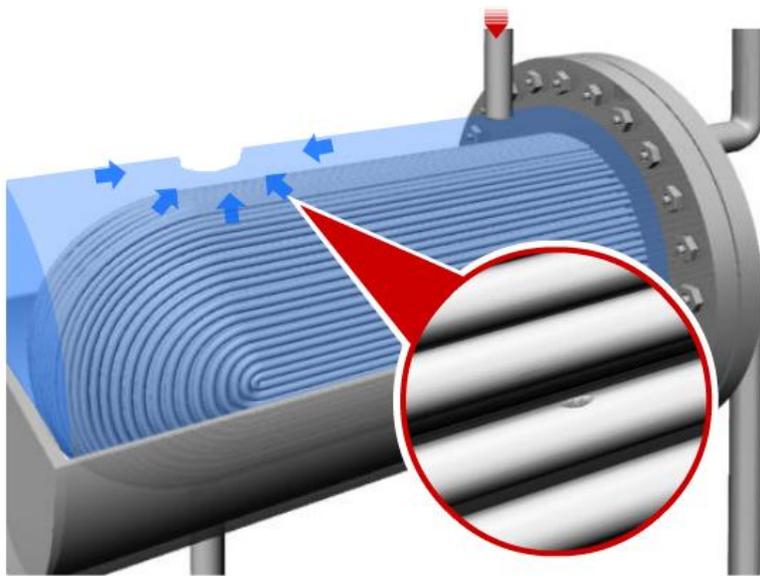


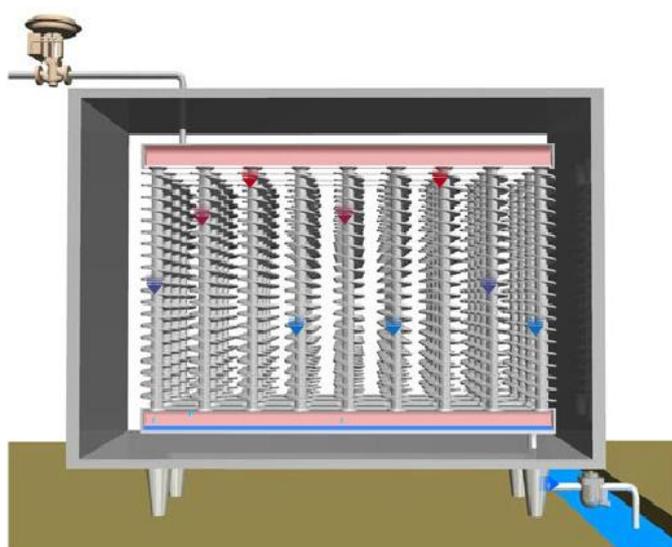
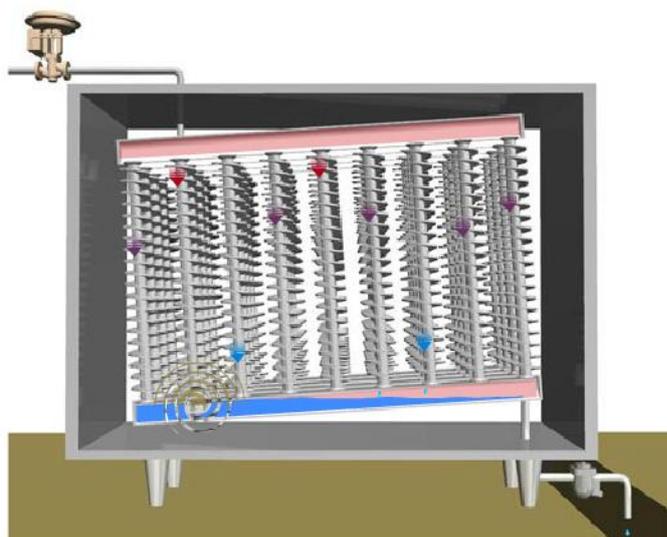
Photo of actual damage

In addition to stall, many other situations can lead to the accumulation of condensate inside equipment. Problems with heat exchanger construction or pressure-balancing lines, improperly installed steam traps and piping, and condensate return lines in bad condition are some examples of these. To identify and correctly prevent the accumulation of condensate, it is necessary to thoroughly determine its cause(s), and apply preventative measures accordingly.

Just as in steam distribution lines, the speed of condensate discharge combined with how smoothly the process occurs are two extremely important factors in the fight against water hammer in steam-using equipment.

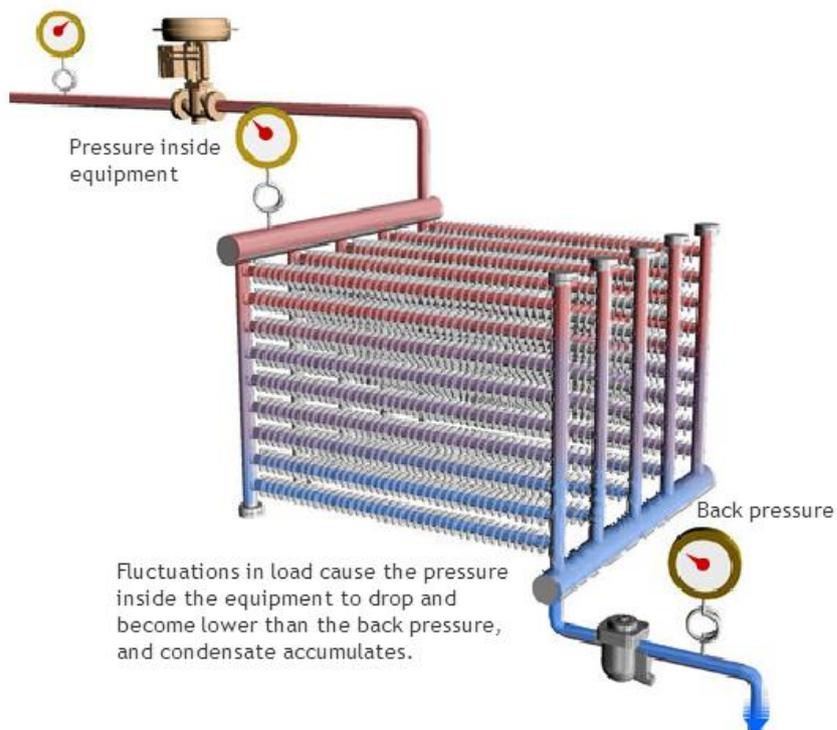
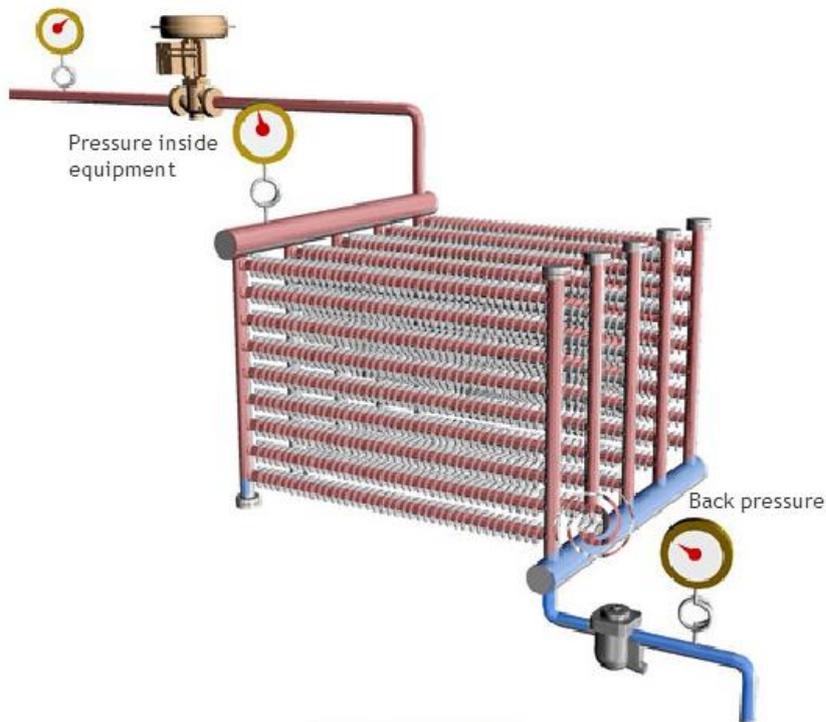
6.7. Reasons Why Condensate Accumulates in Equipment

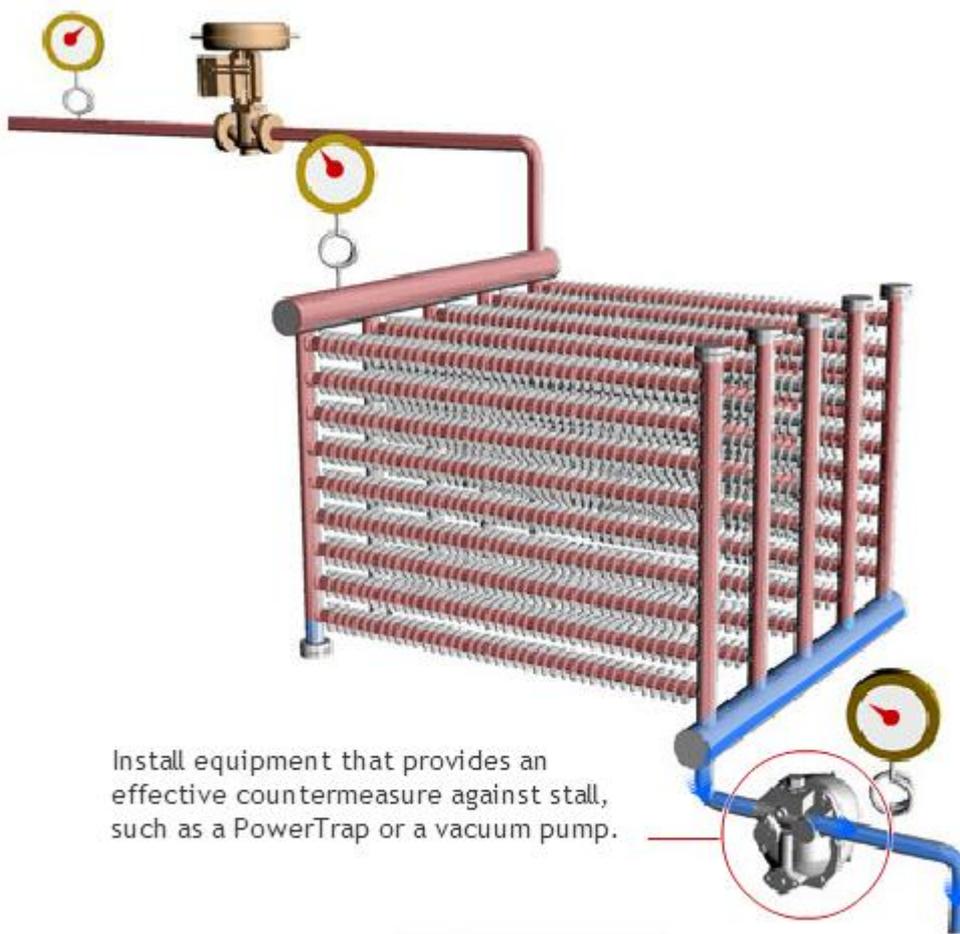
6.7.1.1. Improper equipment construction or orientation



Change the equipment configuration or the relative positioning so that condensate can flow smoothly and naturally by gravity to the steam trap.

Stall

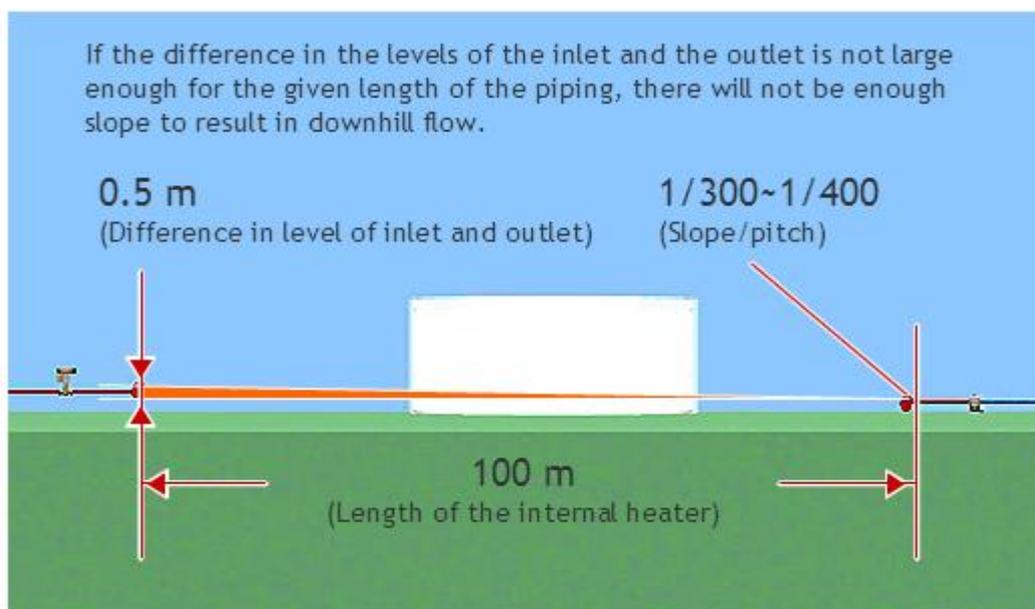
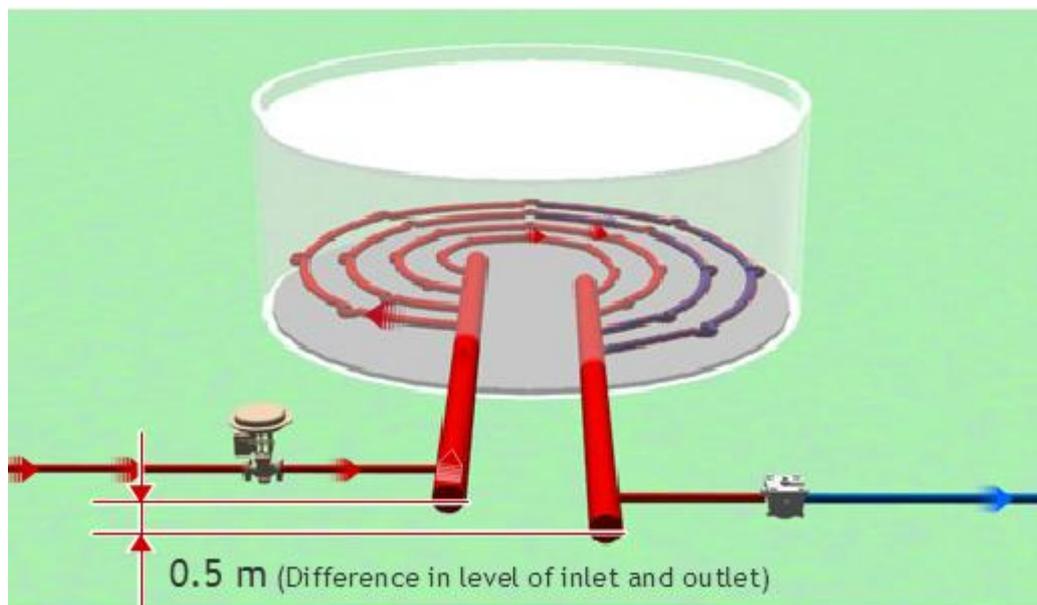




Though these countermeasures may sound quite simple, it is not always actually possible to achieve them.

6.8. Cases in Which Countermeasures Are Difficult

For example, a single coil of a bottom heater on a 30,000 kl heavy oil tank can exceed 100 m in length. The difference in level between the inlet and outlet on the heater results in a slope ratio of 1 in 300 or 400, which is less than half the pitch of typical steam piping (1/100-1/200). With this pitch, it is not always possible for condensate to flow downhill naturally by gravity.



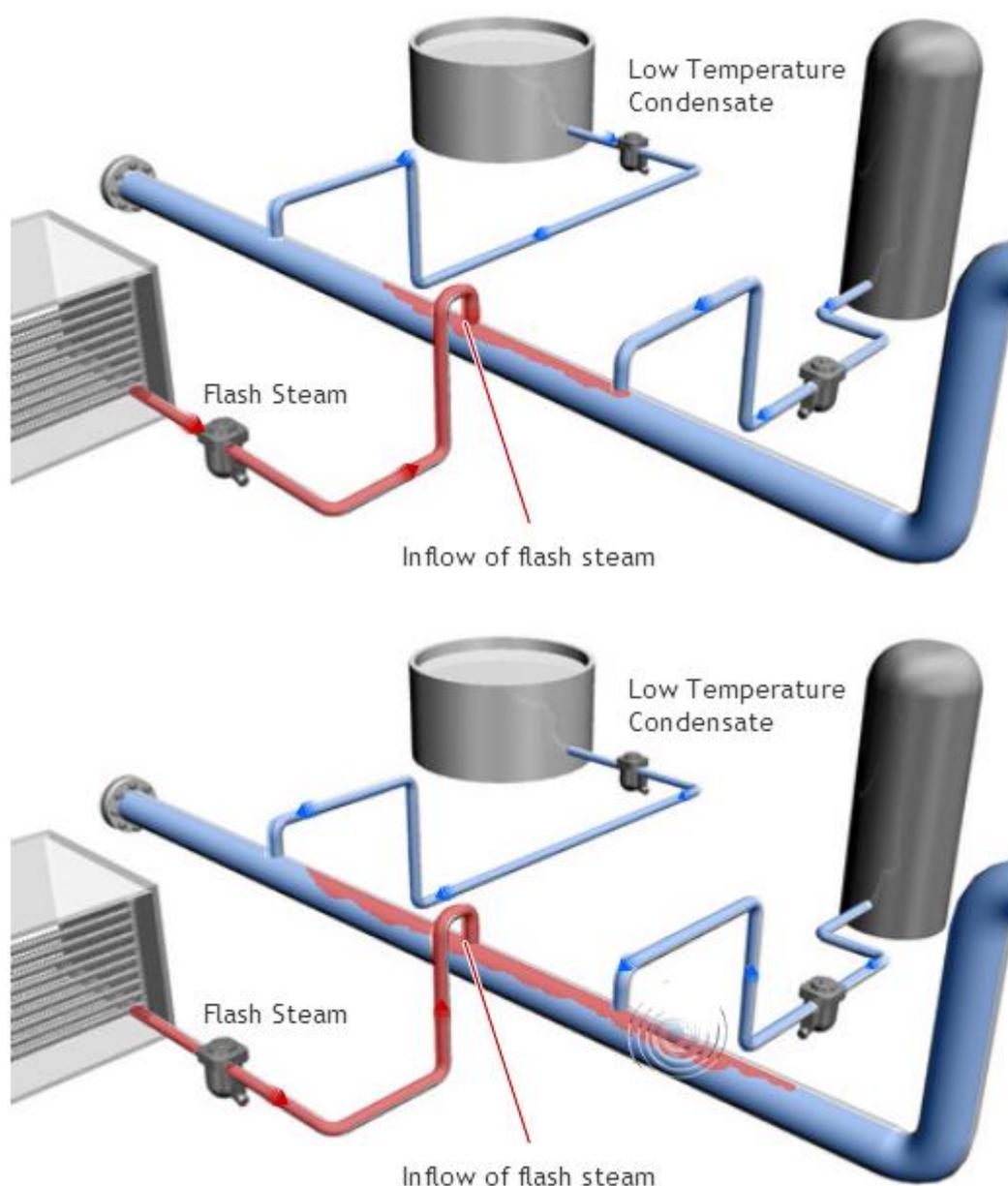
Completely resolving the problem might be difficult in cases like this, where the configuration of equipment does not allow for suitable downhill flow.

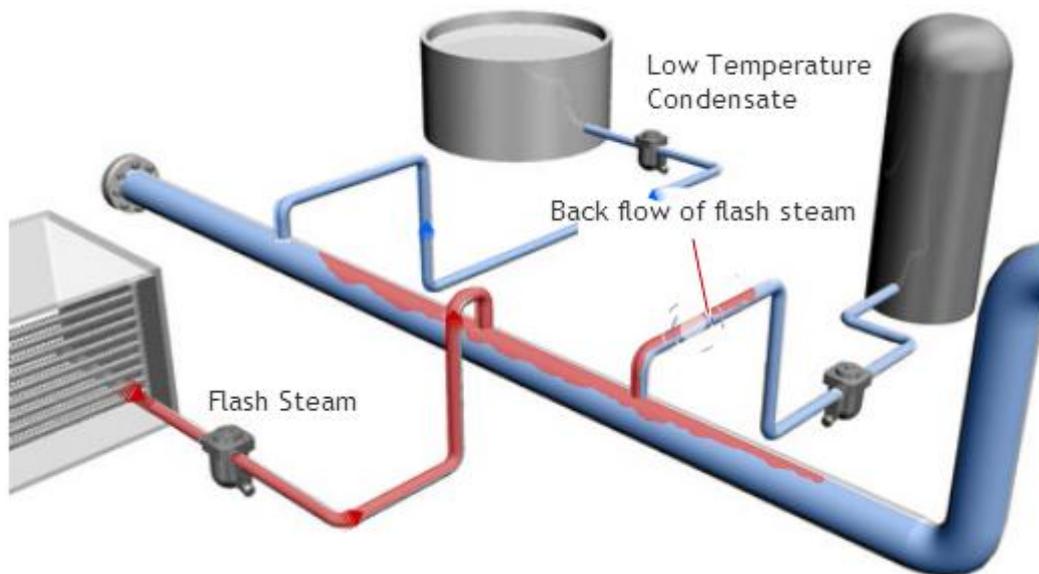
As mentioned above, stall can be another source of difficulties, especially in conventional heaters.

Effective countermeasures against water hammer in these types of situations are, for example, the use of a PowerTrap® (which uses steam to pump and remove condensate) and vacuum condensate recovery pumps.

6.9. Water Hammer in Condensate Transport Piping

Water hammer in condensate transport piping is usually caused by the interaction of low temperature condensate and high temperature steam. These often form from the dual presence of condensate and steam in the piping.





This pattern occurs at junctures where condensate transport lines with large pressure differentials meet, or near points where a condensate transport line meets a flash tank. At these junctures, high-pressure flash steam flows into the low-pressure condensate transport piping and water hammer occurs.

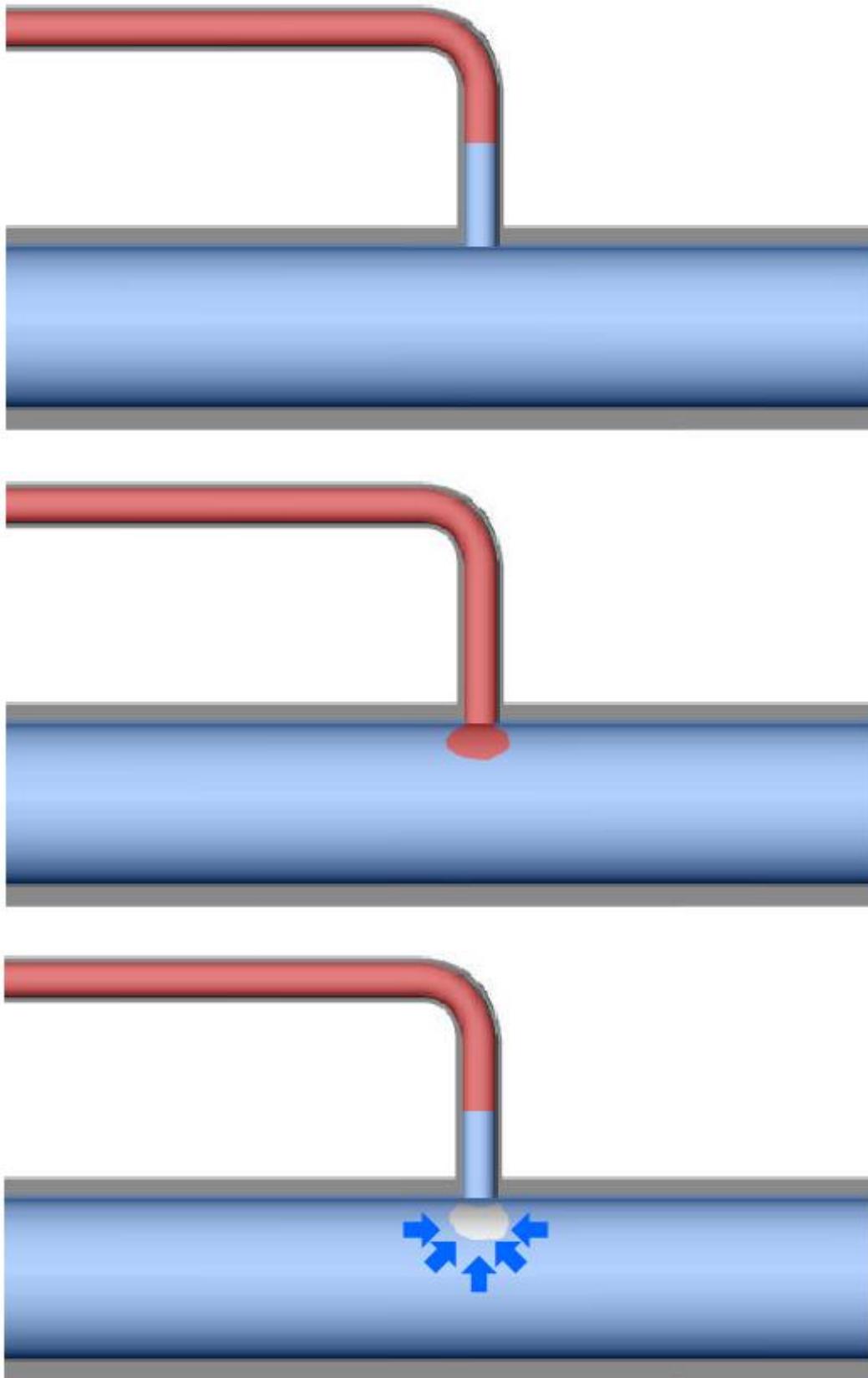
Condensate cannot be removed to solve this type of water hammer because the piping's very function is the transport of condensate. There are thus no direct countermeasures against water hammer in this type of piping, only remedies to lessen its effects.

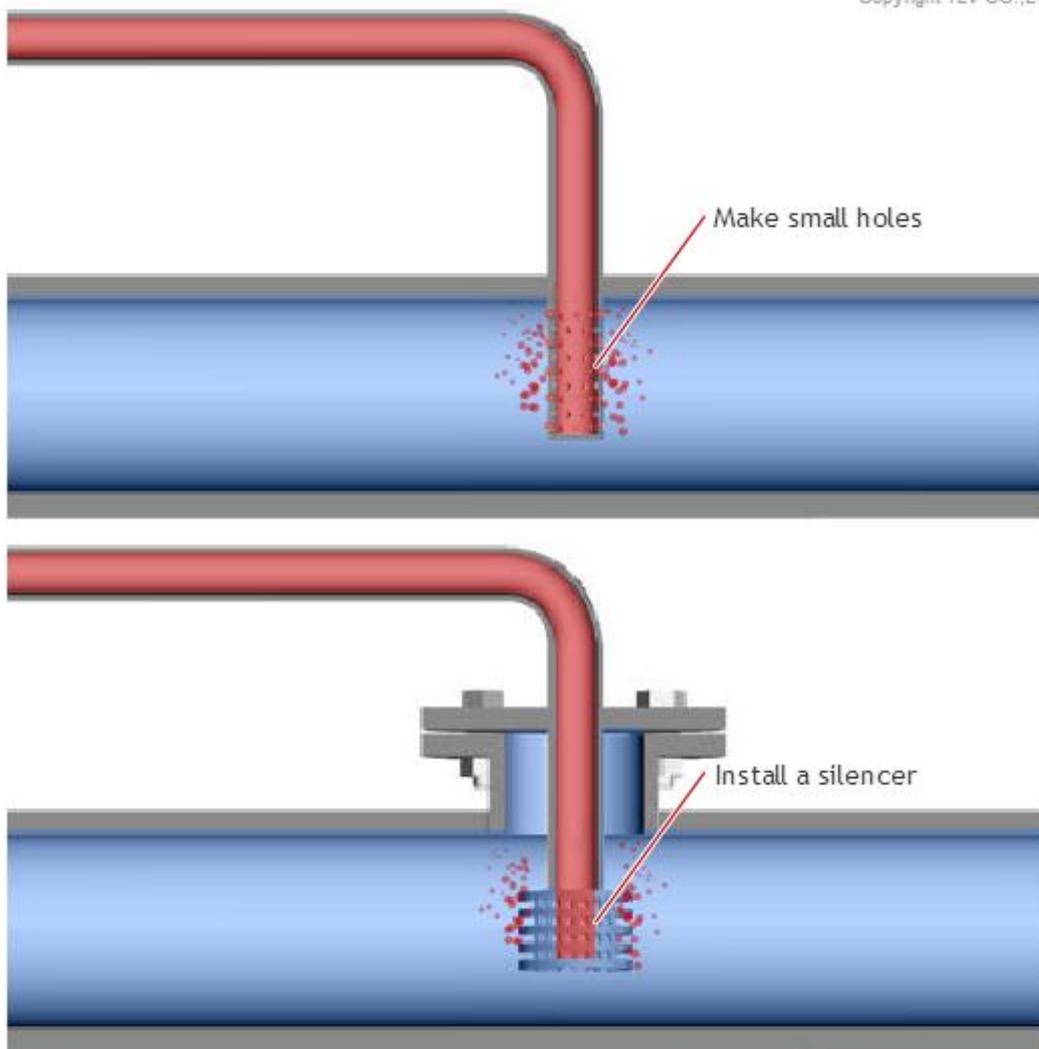
6.9.1. Mechanism & Countermeasures

Water hammer in condensate transport piping occurs in many patterns, which are fundamentally all caused by the sudden condensation of steam. The three most common patterns are discussed below.

6.9.1.1. Chugging

When two transport lines converge, high-temperature flash steam can come in contact with low-temperature condensate. If no large pockets of steam occur, the steam will rapidly condense and cause small-scale, rapidly cyclical impacts known as chugging. The name is derived from the noise produced, which sounds something like an engine chugging. The force of the impact is not great, but the resulting noise becomes a problem.



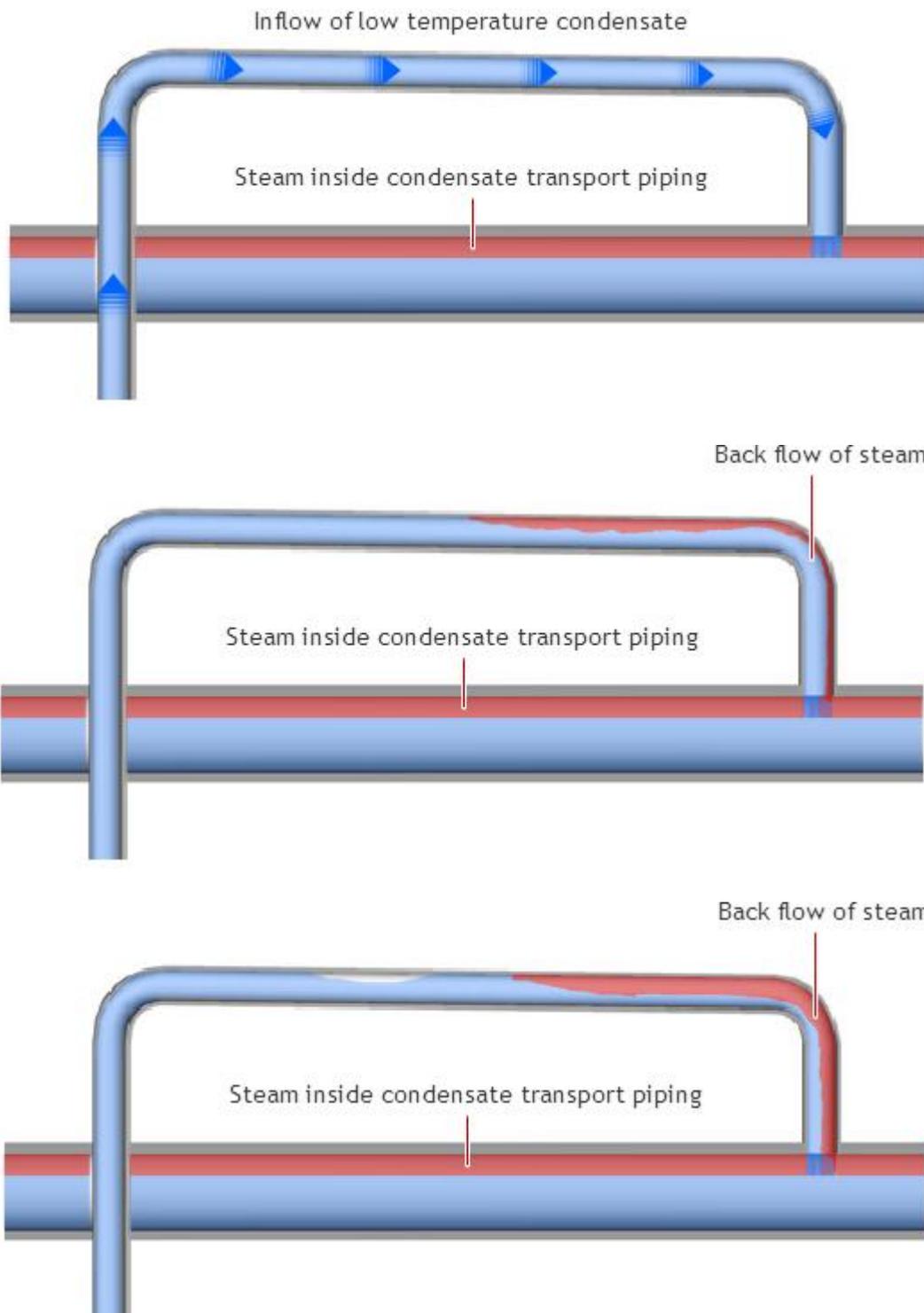


At the convergence point, install a silencer on the piping containing the flash steam, or make small holes in the end of the piping so the steam forms small bubbles when it converges.

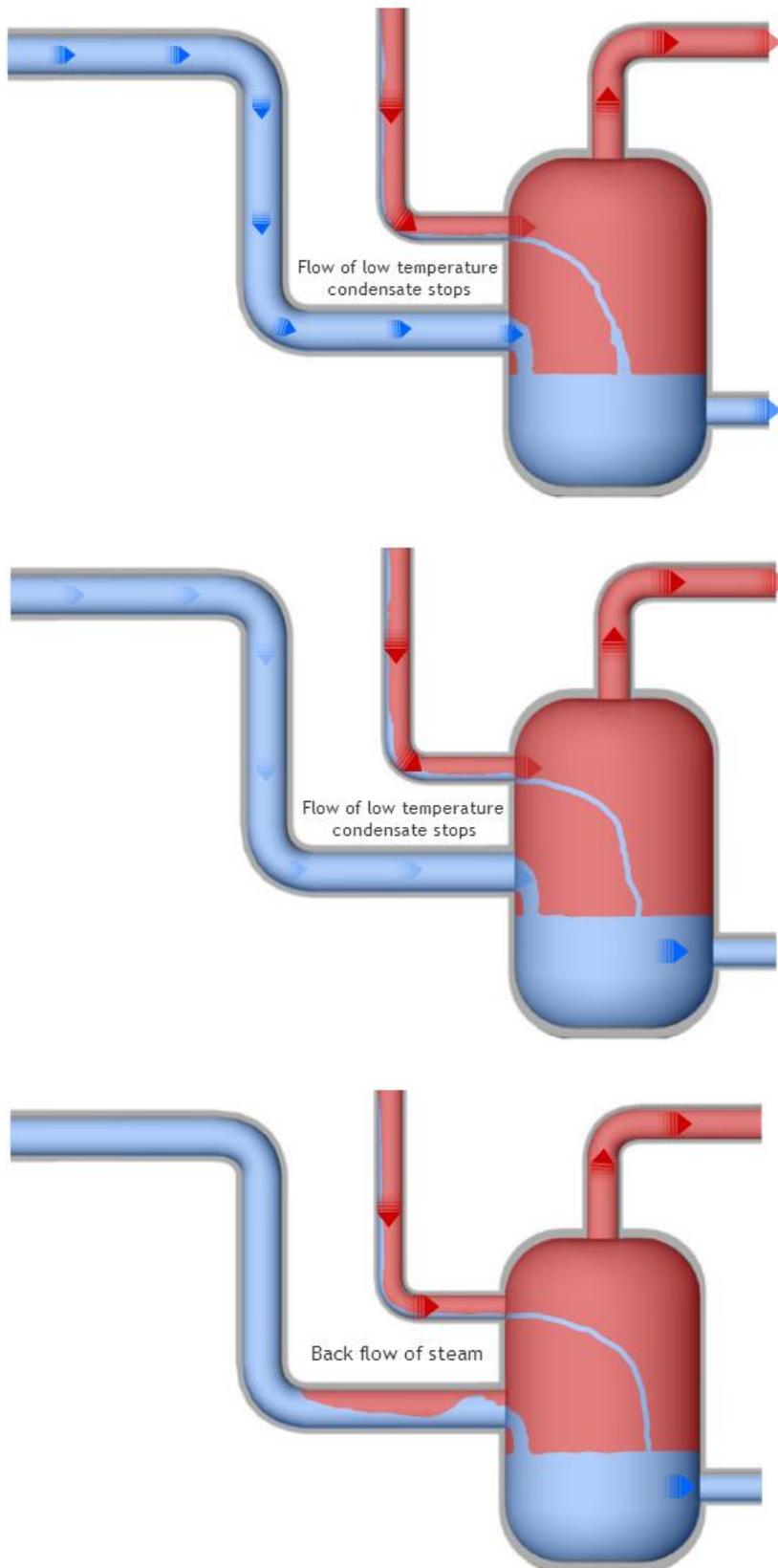
6.9.1.2. From backflow

Water hammer from backflow is caused by a pulsating flow of low temperature condensate in condensate transport piping, and is often seen in factories.

Water Hammer caused by backflow of steam from condensate transport piping



Water hammer caused by backflow of steam from flash tank



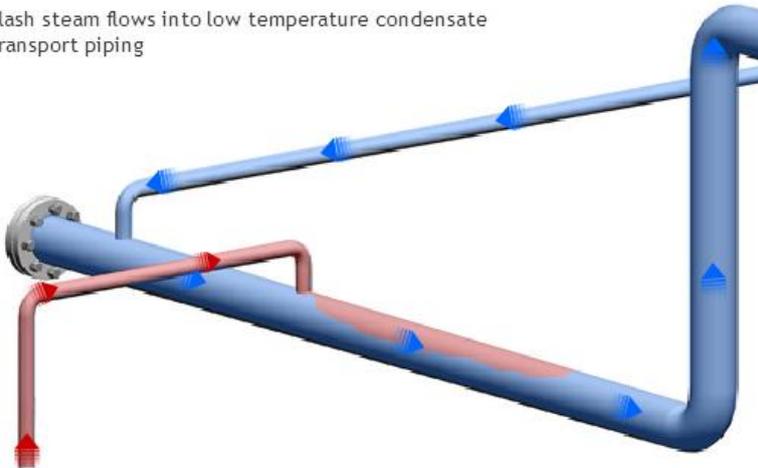
A countermeasure against this is the installation of a check valve to prevent the backflow of steam. However, the effectiveness of this countermeasure is reduced if the location or the type of check valve is incorrect.

6.9.1.3. From the formation of 'large pockets of steam'

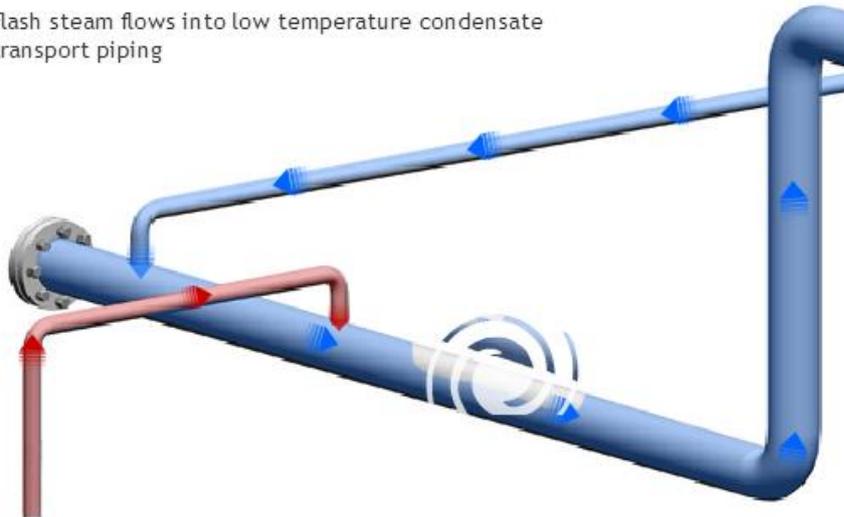
This is the most frequently encountered form of water hammer in condensate transport piping. It occurs at points where piping carrying high temperature flash steam and piping carrying low temperature condensate converge. Unlike water hammer resulting from backflow, steam and condensate do not flow in opposite directions to cause water hammer. In this case the problem is caused by the formation of large 'pockets of steam'.

Just like water hammer caused by backflow, water hammer impacts may occur far away or upstream from the convergence point of transport piping. If such is the case, pinpointing the cause can become quite difficult.

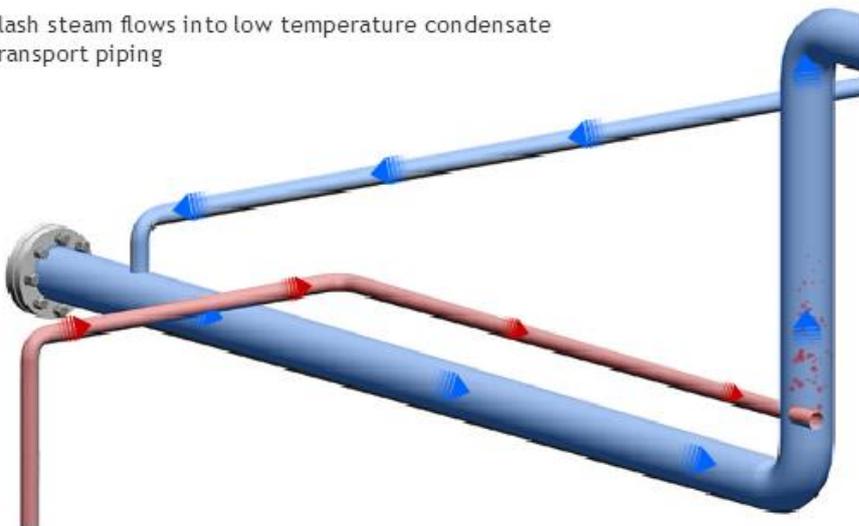
Flash steam flows into low temperature condensate transport piping



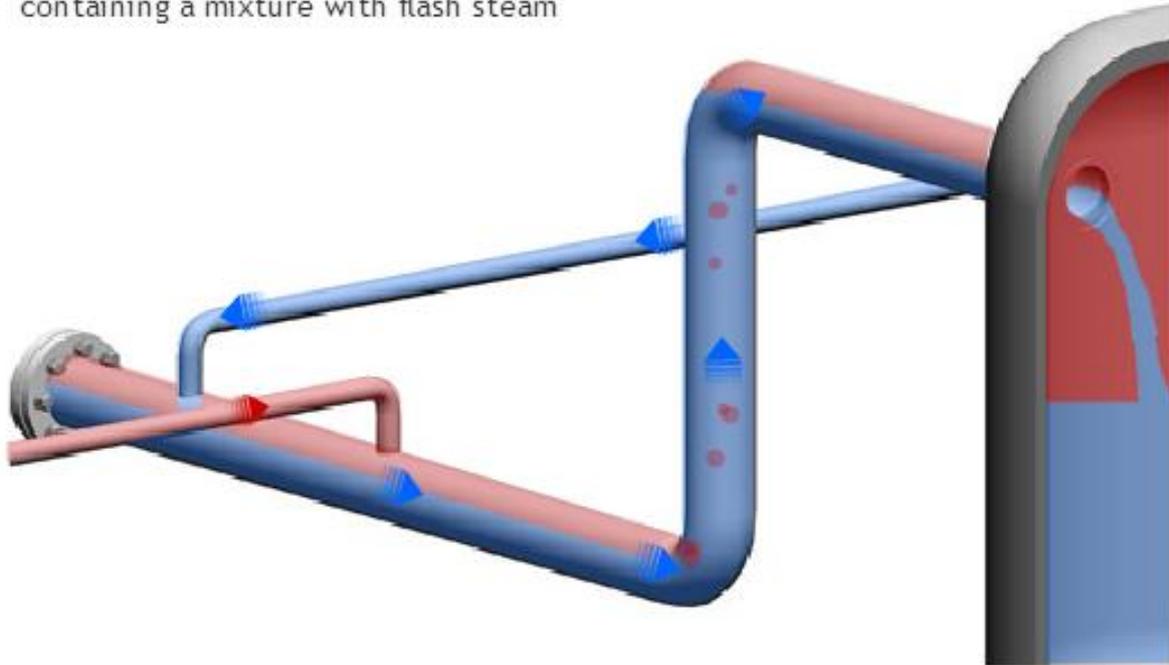
Flash steam flows into low temperature condensate transport piping



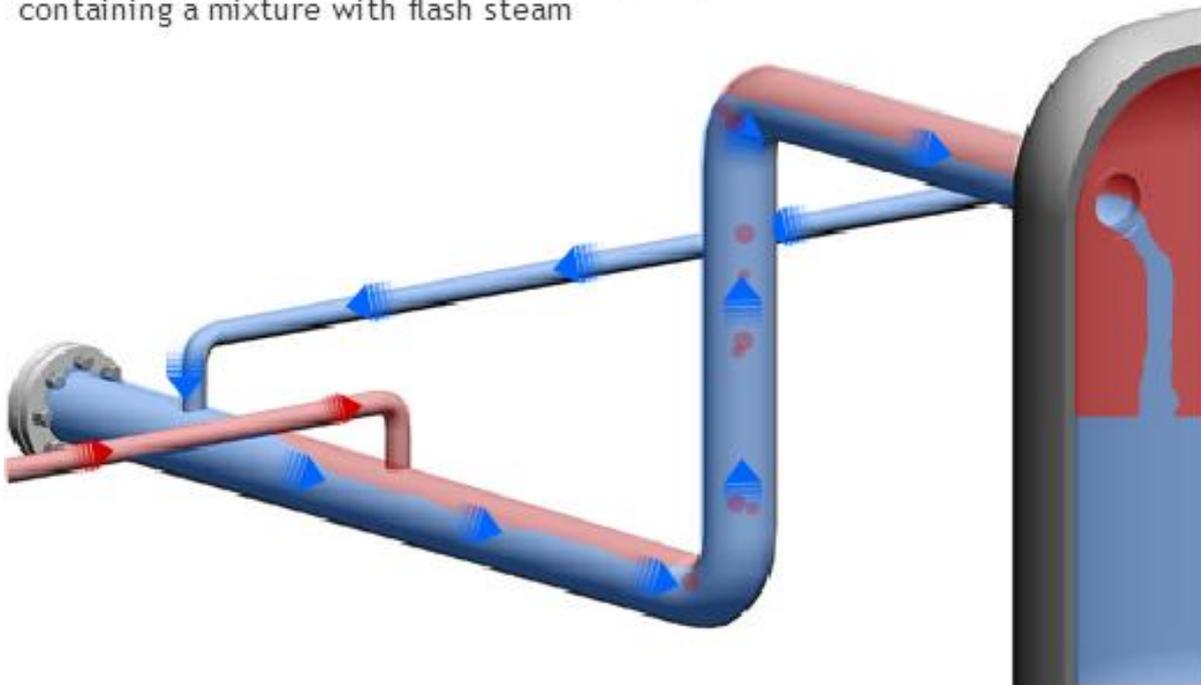
Flash steam flows into low temperature condensate transport piping



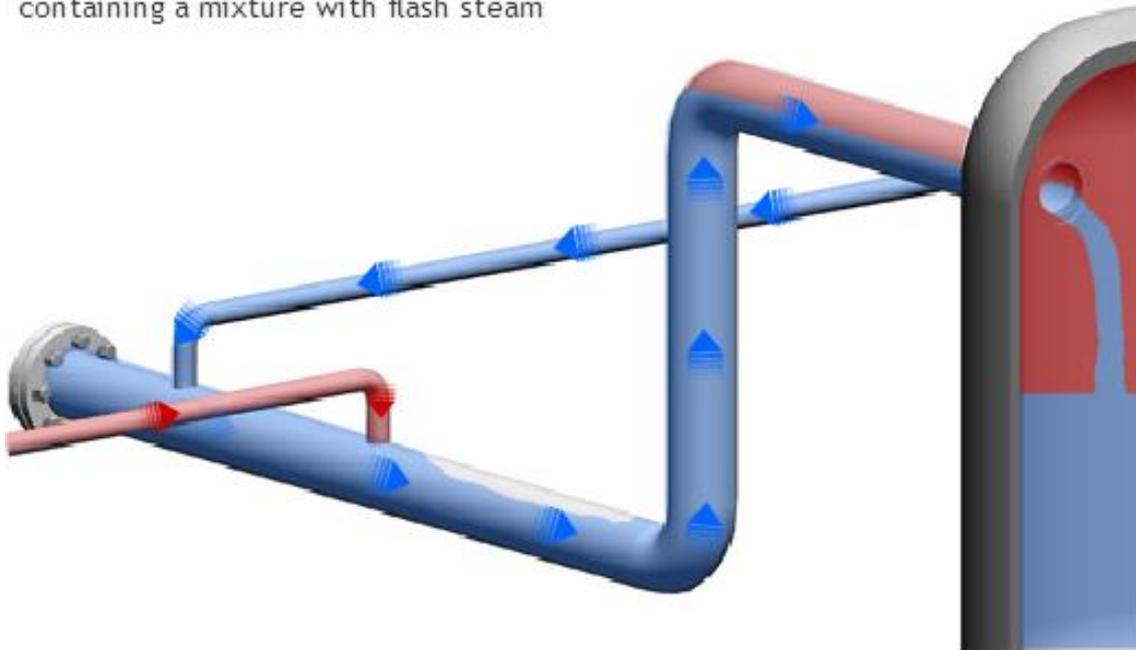
Low temperature condensate flows into piping containing a mixture with flash steam



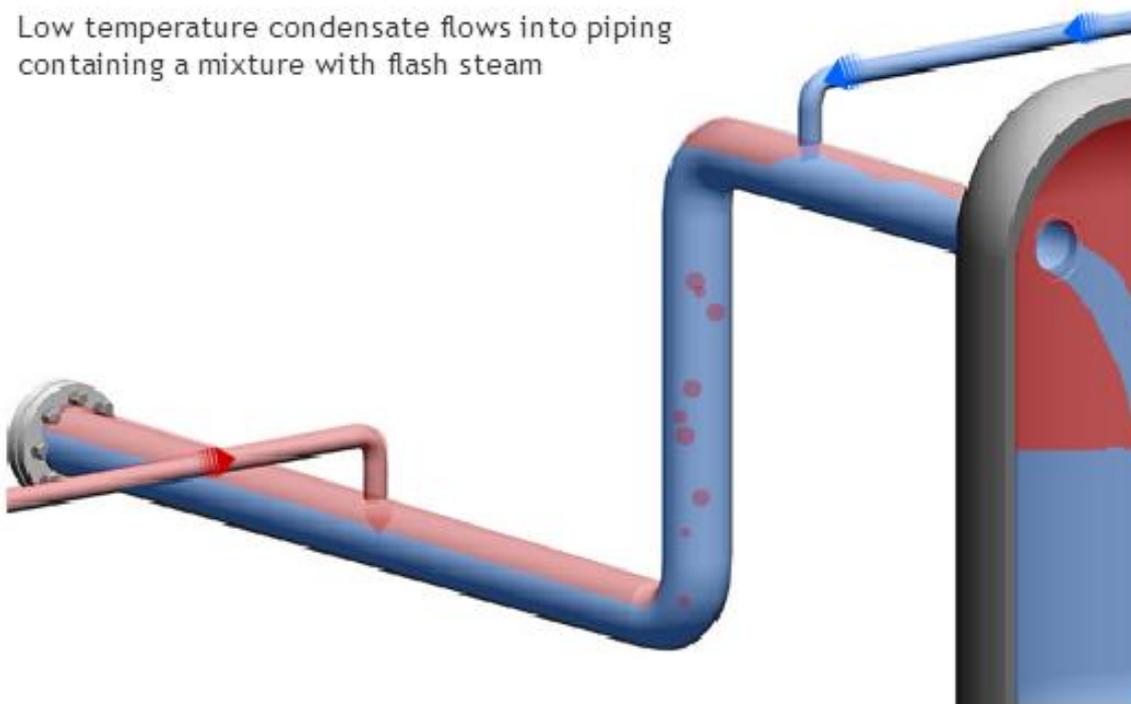
Low temperature condensate flows into piping containing a mixture with flash steam



Low temperature condensate flows into piping containing a mixture with flash steam



Low temperature condensate flows into piping containing a mixture with flash steam



This countermeasure is complicated. You must first confirm the temperature difference between the surrounding condensate flow and the piping, then make any necessary alterations in the piping such as connecting the line to a vertical section of piping in order to make it difficult for the flash steam to form pockets of steam.

Countermeasures for each of these three main patterns of water hammer have several points in common:

- They ensure that pockets of steam remain small.
- They intercept the steam (e.g. flash steam) that is the cause of the trouble or connect it to a different line.
- Wherever possible, they avoid contact between horizontal piping runs of high temperature steam and low temperature condensate.

Note: When water hammer occurs in condensate transport piping, the piping itself is sometimes the cause. This makes it very difficult to predict the occurrence or location of water hammer in advance. Countermeasures are thus often investigated only after the problem arises. On top of this, when the cause of water hammer is equipment that is far away or seasonally operated, a more extensive and long-term investigation may be required.



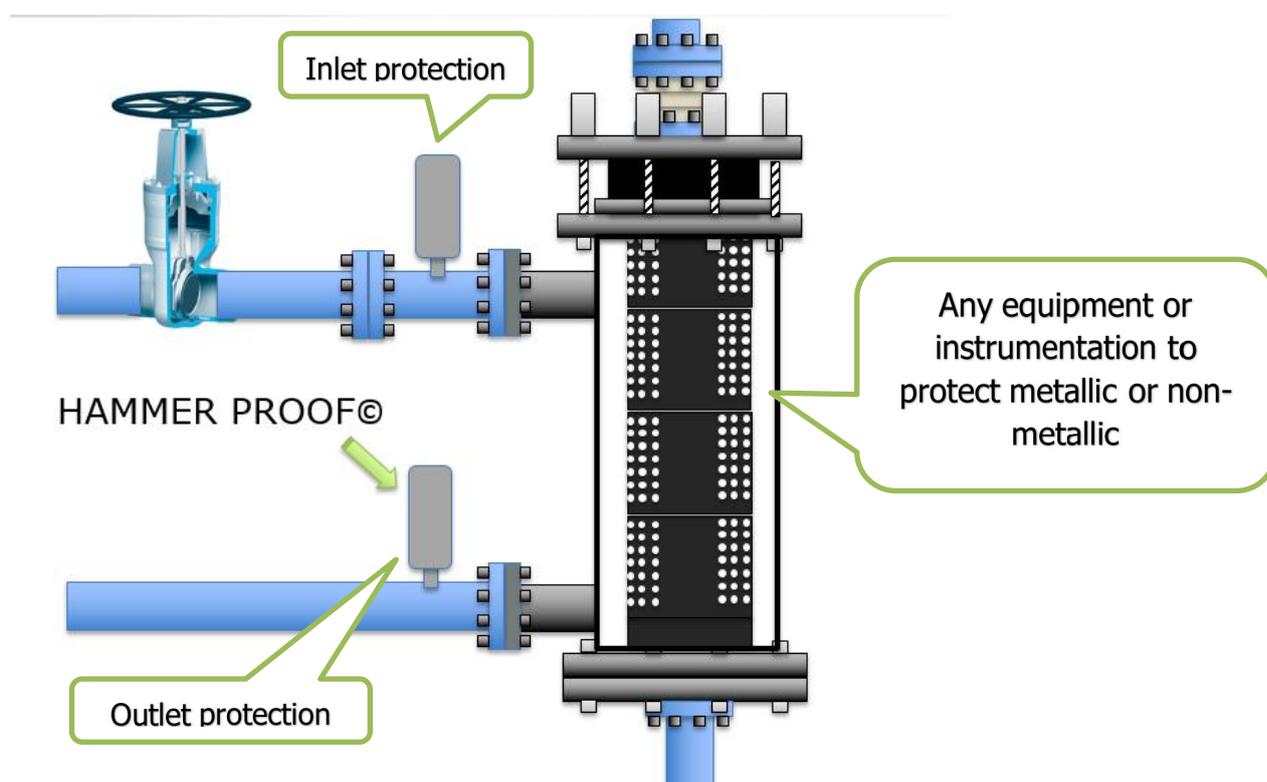
6.10. Water Hammer: Conclusion

It may come as a surprise, but thermal imaging, which provides a visual image of temperature distribution, is a very effective way of identifying the locations where water hammer occurs. As the surface of piping must be exposed in order to be able to use the technique, images should be taken during a trial operation before any insulation is applied. If insulation is already in place, it can be temporarily removed for the purposes of taking the images.

CORROTEC has developed a unique device to prevent water hammer. This device is mounted on GT's equipment and can also be added on the piping of existing installations.

This device HAMMER PROOF insures absorption of waves of pressure up to 80 bar (1160 psi) at 180°C (360°F).

EXAMPLE OF INSTALLATION

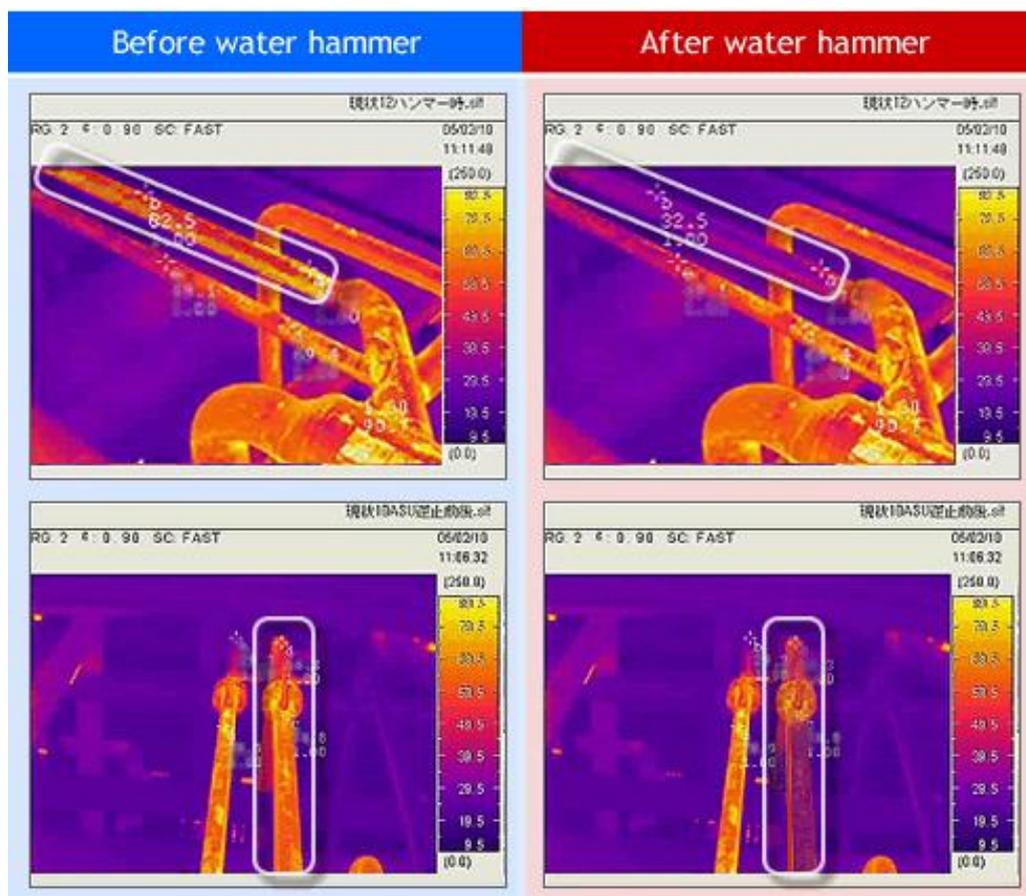


2 models available. Model S for non-corrosive media (steam and water). Model P for corrosives media, made in PTFE.

These devices react instantly to surge of pressure and damp their effect.

Contact us for technical information.

6.10.1. Changes in temperature of piping before and after water hammer



As we discussed earlier in the series, when the temperature difference between steam and condensate is within a certain range, it is particularly easy for water hammer to occur. Pinpointing the locations where this change in temperatures takes place speeds up the process of effecting countermeasures.

Large-scale water hammer can be very dangerous, and everyone understands the need to establish countermeasures against it. On the other hand, small-scale water hammer is often disregarded. Although it takes a longer time, small-scale water hammer often leads to damage too. From a preventative maintenance standpoint, it is critical that countermeasures be taken against this type of water hammer as well.

7. Best Practices for Condensate Removal on Steam Lines

The role of steam distribution lines is to reliably supply steam of the highest reasonable quality to the steam-using equipment. In order for this to be achieved, condensate must be removed quickly and efficiently through steam traps installed in proper condensate discharge location (CDL) installations.

Steam traps can't, however, simply be installed any which way and forgotten. There are certain guidelines to follow when installing them on steam lines. To ensure that steam traps

operate properly, trap installation methods must be carefully respected and installation locations carefully chosen.

The flow of steam is typically much faster in steam distribution piping than in equipment and can reach speeds of over 30 m/s (100 ft/s). At these speeds, when the cross-sectional area of a pipe section is completely filled by water, slugs of condensate can be carried through the piping at high velocity causing water hammer, which can cause personal injury as well as damage piping, valves, and equipment. The higher flow velocities in steam lines must therefore also be taken into account during decisions regarding location and design of trap installations.

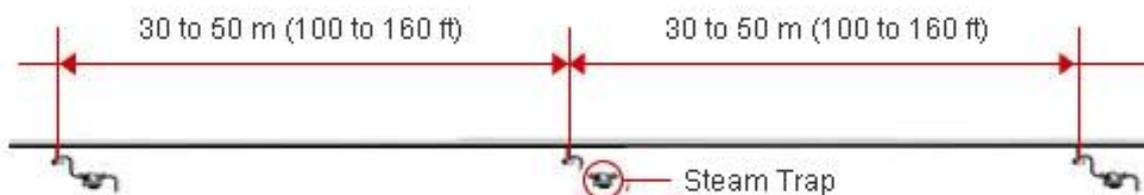
The following four "Best Practices" are guidelines to help ensure the smooth discharge of condensate on steam lines and to prevent the occurrence of typical steam system problems such as water hammer and air binding.

7.1. Best Practice #1: Choose Trap Locations Carefully

Even in cases where a steam distribution piping run is set in a straight line, steam traps should always be installed at least every 30 to 50 meters (100 to 160 ft), and at the bottom of risers or drops. Special care must also be taken to install steam traps in locations where there is a chance of condensate pooling so that condensate does not close off the cross-sectional pipe area, possibly causing it to be propelled at exceptionally high velocity.

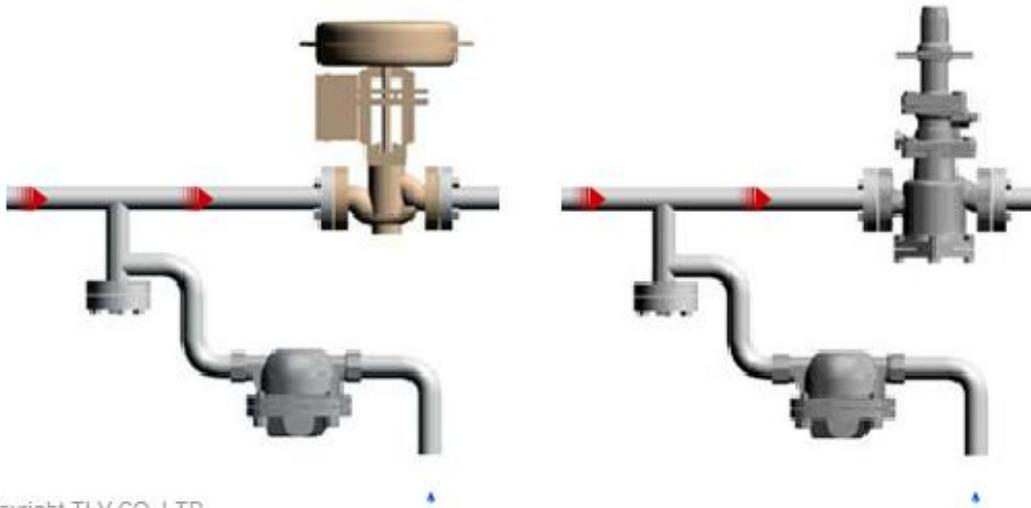
Steam traps should be installed in the following situations:

Every 30 to 50 meters (100 to 160 feet)



Traps should be installed at 30 to 50 meter (100 to 160 feet) intervals on a steam line.

In Front of Pressure Reducing Valves and Control Valves



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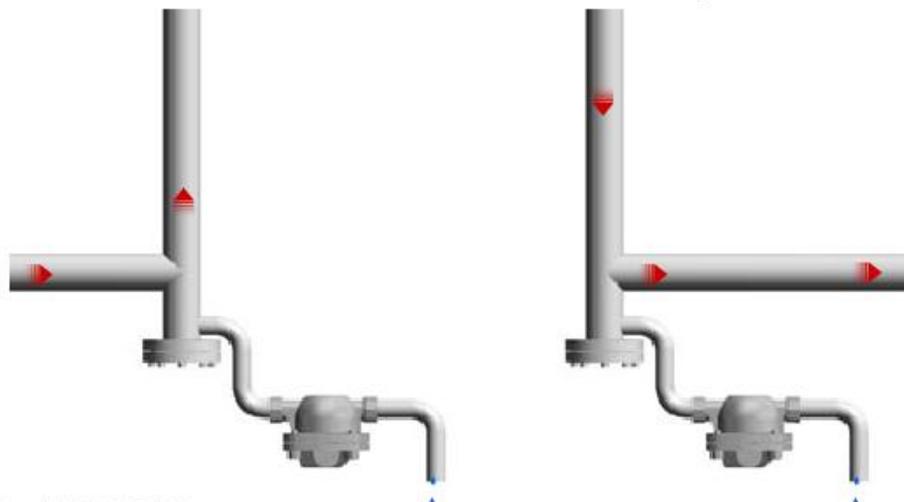
A steam trap should be installed immediately before pressure reducing valves / control valves to prevent condensate from pooling when the valve is closed. The trap also helps reduce erosion of the valve seat from condensate. Similarly, traps are also generally installed between two pressure reducing valves in a series installation to remove condensate trapped between the valves during operation or shut-off.

In Front of Manual Valves Closed for a Long Time



A steam trap should be installed in front of valves closed for long periods of time to help eliminate the pooling of condensate which could otherwise be propelled at high speed down the pipeline when the manual valve is opened. Similarly, a steam trap is needed at the end of a pipe run (end of main) to help drain the system for safe and effective operation.

At the Bottom of Vertical Lifts or Drops



A steam trap should be set at the bottom of vertical piping sections because dis-entrained condensate can accumulate there due to gravity and directional changes.

7.2. Best Practice #2: Provide Proper Support and Inclined Steam Piping

If piping support (e.g. pipe hangers) is set too largely apart, the piping can deflect under its own weight. This type of problem can cause condensate to pool at unwanted locations even if piping is set at a slight inclination, so it is important to both:

- Set piping support at appropriate intervals, and
- Set piping at a slope of no less than 1 in 100.

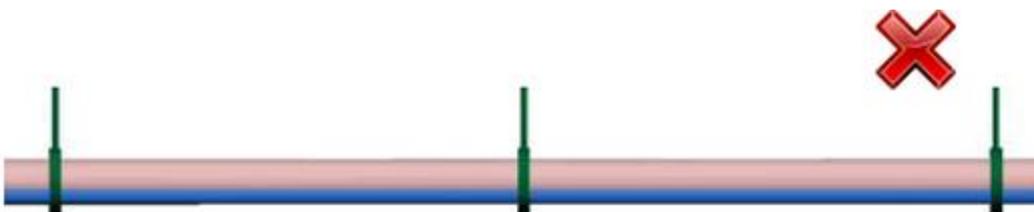
Also, care should be taken when using the eaves of a building to adjust the inclination because the eaves themselves might be slightly inclined, which could adversely affect condensate flow and drainage.

Issues with Piping that lacks support



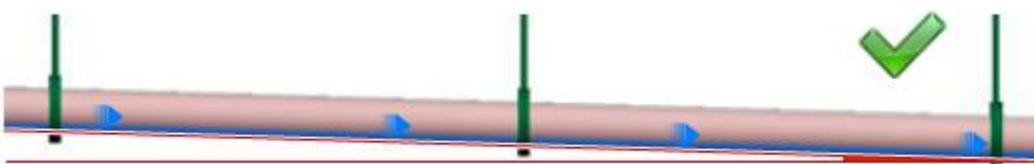
When piping lacks support, it is likely to deflect and lead to condensate pooling.

Issues with Piping set parallel to the ground



Piping shouldn't be set parallel to the ground as this can impede condensate flow.

Correct by Piping set at an incline



7.3. Best Practice #3: Pay Attention to Drip Leg (Drain Pocket) Configuration

Steam trap connection sizes for applications other than heating or process typically range between 15 mm (1/2 in) and 25 mm (1 in). In some cases, piping of the same diameter as the steam trap is used to directly connect the trap to the steam line. However, this practice is not recommended in most cases because if the steam line is of a significantly larger diameter, then it is possible that rapidly flowing condensate cannot easily drop and enter into the rather narrow opening and will instead mostly pass by the collecting leg. Instead, properly sized, wider piping called a drip leg (collecting leg, or drain pocket) is typically installed to help enable the efficient and effective removal of condensate.

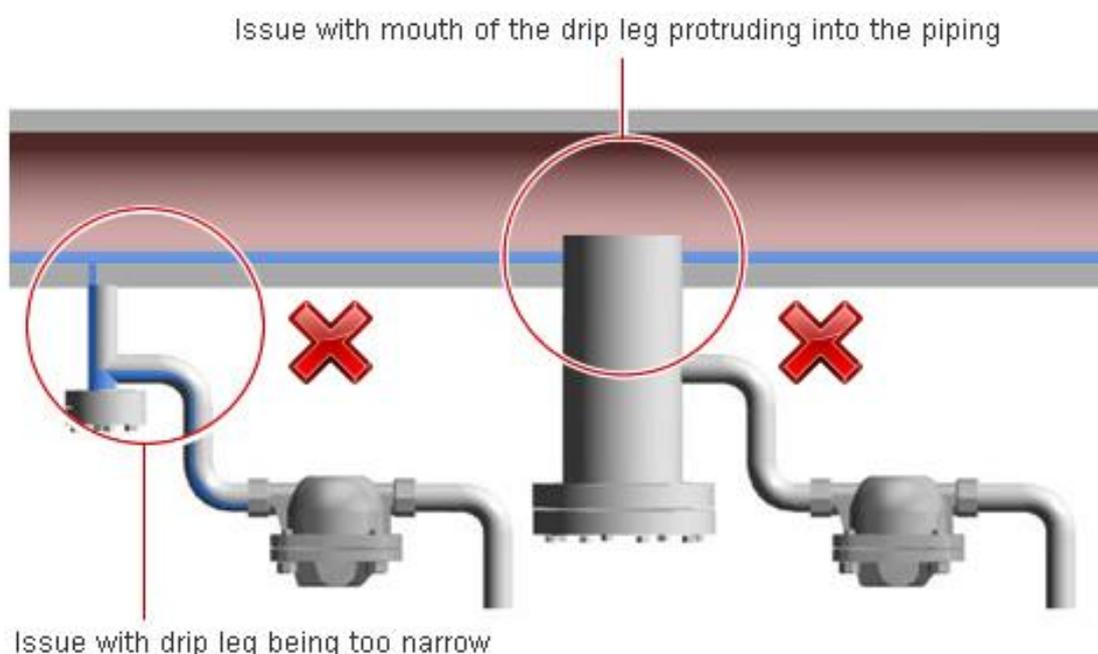
Sample guidelines for drip leg sizes are available in the table below. Also, the connection between the piping and drip leg should be set roughly 50 to 100 mm (2 in to 4 in) from the bottom of the drip leg to help prevent dirt and scale within the condensate from flowing into the trap. With this type of setup, a blowdown valve is usually installed on the mud leg cover to allow for dirt removal.

7.3.1. Sample Guidelines for Drip Leg Dimensions

| MAIN DIAMETER | POCKET DIAMETER | POCKET DEPTH (AUTOMATIC START-UP) |
|----------------|-----------------|-----------------------------------|
| 50 mm (2 in) | 50 mm (2 in) | 700 mm (28 in) |
| 100 mm (4 in) | 100 mm (4 in) | 700 mm (28 in) |
| 250 mm (10 in) | 150 mm (6 in) | 700 mm (28 in) |
| 500 mm (20 in) | 250 mm (10 in) | 750 mm (28 in) |

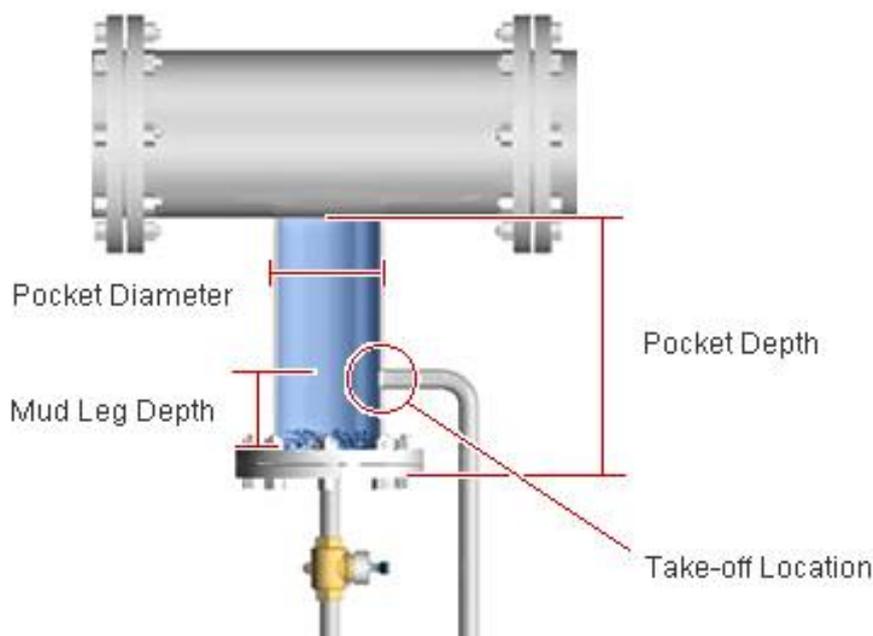
When sizing a drip leg, design with sufficient volume for the mud leg portion, and also for the back-up portion between cycles. The collecting leg can be especially important on start-up operation where slugs of condensate from warming up the piping or condensate released from previously closed valves can be experienced.

7.3.2. Improperly Configured Drip Legs



Drip leg (drain pocket) size must be carefully selected and connections must be carefully set to allow for the smooth removal of condensate.

7.3.3. Properly Configured Drip Leg

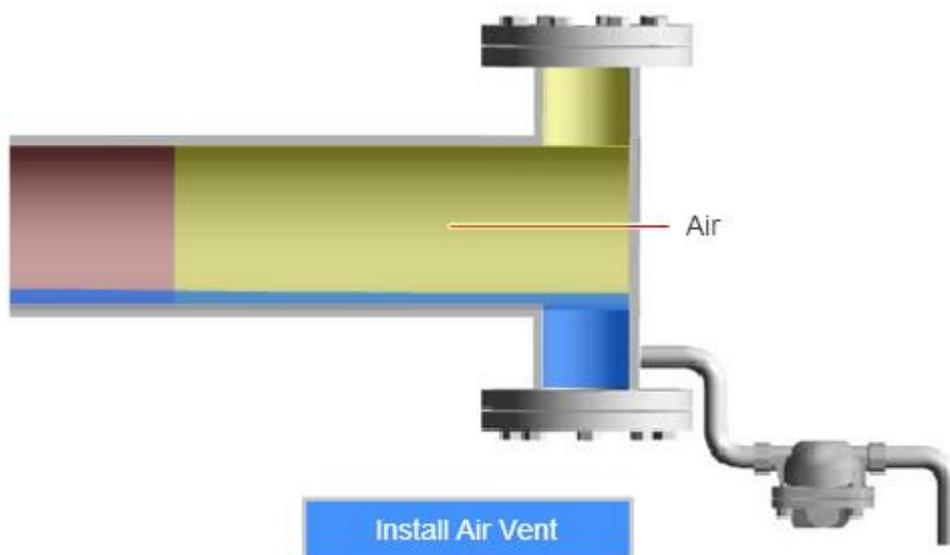


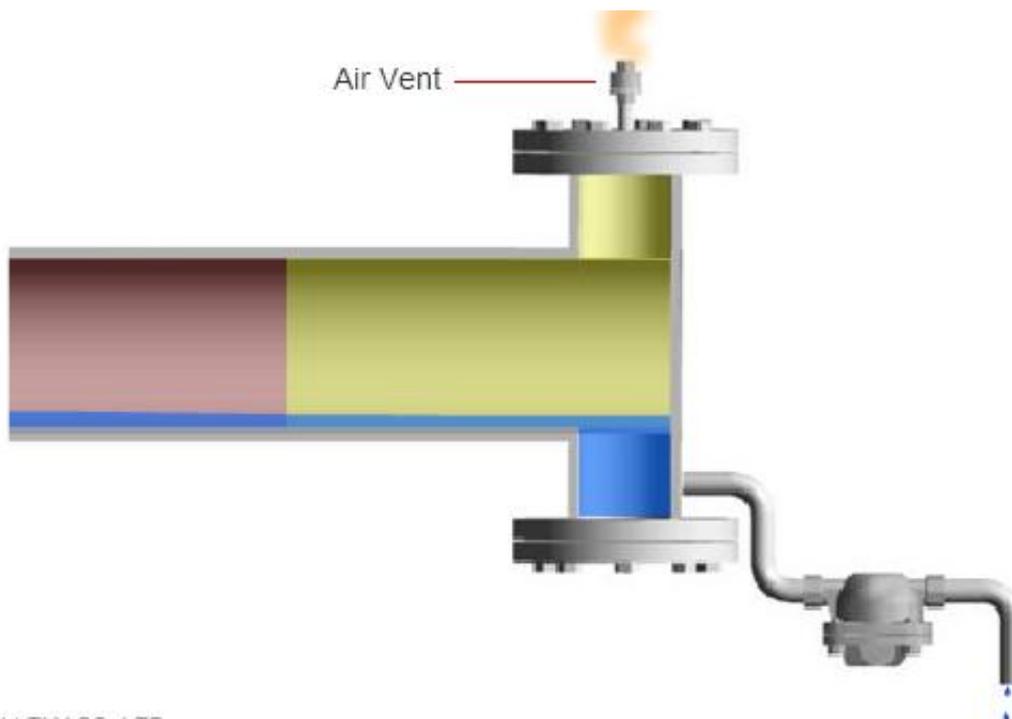
Drip leg (drain pocket) size usually includes at least four factors: pocket diameter, pocket depth, mud leg depth, and take-off location.

7.4. Best Practice #4: Properly Remove Air and Condensate at End of Steam Line

At the end of steam distribution lines, it is important to remove the air that was initially present in the piping at start-up.

7.4.1. Removing Air for Steam Lines



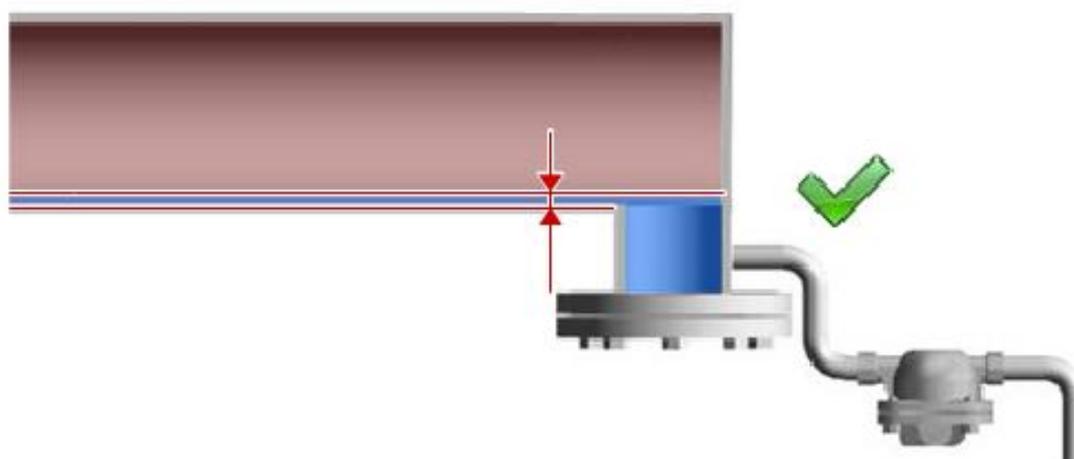


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Steam lines require the installation of an air vent to prevent air from remaining trapped within the piping.

Also, it is just as important to set up a drip leg for condensate drainage at the end of steam lines as it is for the other sections of the steam main.

7.4.2. Installation of Trap at End of Steam Line



Installing a drip leg (drain pocket) at the end of the steam line will allow condensate to accumulate within the drip leg so that it be smoothly discharged.

To summarize, efficient removal of condensate requires at least the following:

- Carefully choosing steam trap locations
- Providing proper support and inclining the steam piping
- Configuring drip legs to allow for the smooth removal of condensate
- Properly removing air and condensate at end-of-lines

Because safety is an extremely important concern with steam piping configuration, always be certain to consult a steam specialist such as TLV when not sure how to proceed.

7.5. Trap Location: Close to Piping or Ground?

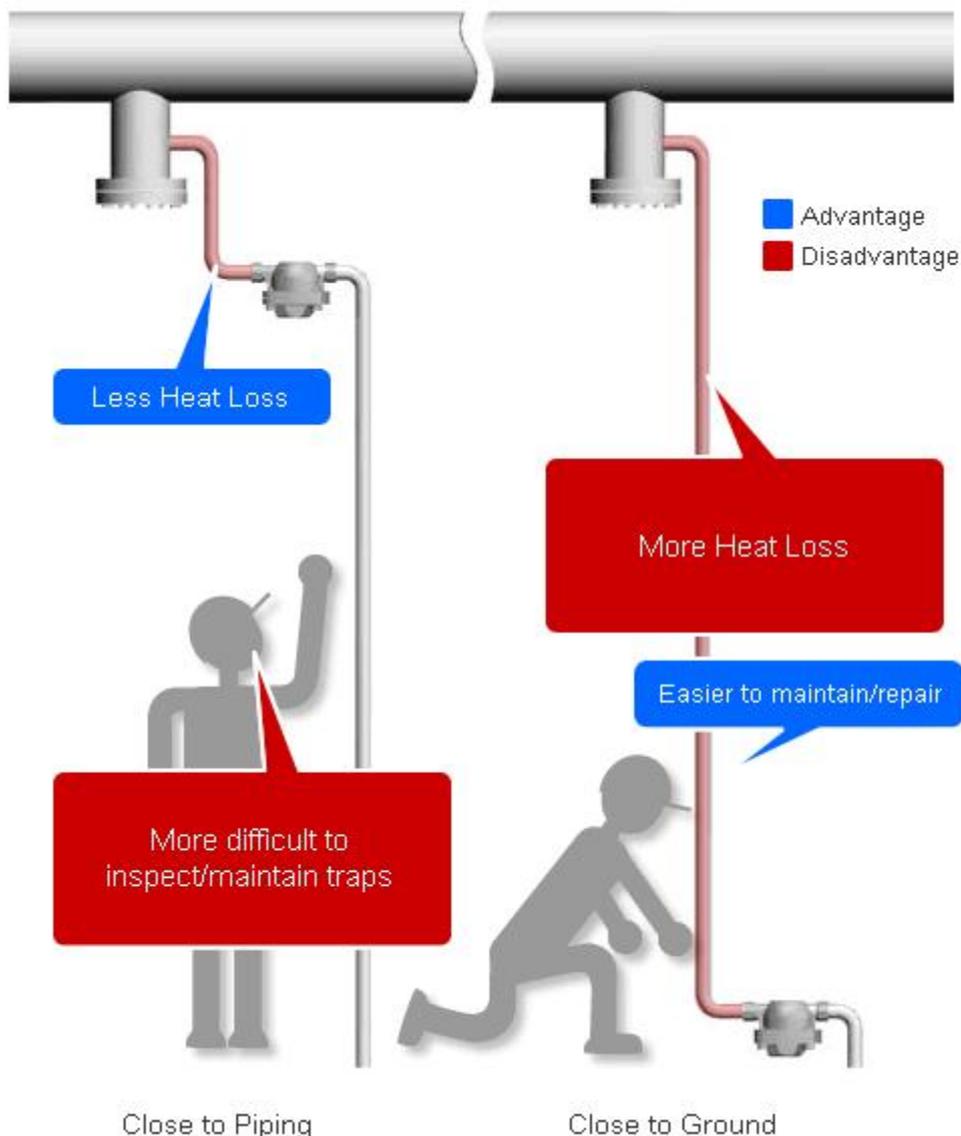
Have you ever wondered about the best location to install a steam trap on a steam main?

Since the inlet side of a trap is simply an extension of the steam main, one method has been to install the trap close to the main line to limit heat loss from radiation.

However, since steam mains are often set in elevated locations, one major disadvantage of setting a steam trap close to the main is that it can make it much more difficult to inspect and maintain the trap. Traps that are not easily accessible also risk being neglected or forgotten, which can lead to problems if the trap is not operating properly. Often, such traps in inaccessible locations can fail and be left unnoticed for many years.

If a ladder or some other means of access is permanently set in place, then even traps set in elevated locations can easily be inspected and maintained. If such a setup isn't feasible, then setting the trap in an easily accessible location is recommended, with the requirement that any horizontally-installed trap should be located as close to the vertical drop leg as possible. The trap inlet piping should then be well insulated to limit heat loss.

7.5.1. Setting Trap Close to Piping vs. Close to Ground



| | ADVANTAGE | DISADVANTAGE |
|-----------------|-------------------------------------|---|
| Close to Piping | Less heat is lost through radiation | More difficult to inspect and maintain traps, which might lead to circumstances where a failed trap is simply forgotten. |
| Close to Ground | Easier to maintain and repair | More heat loss through radiation because the longer downpipe acts as a smaller bore extension of the steam line. (Insulation can help reduce heat loss significantly in cases where trap operation is not negatively affected by insulation.) |

Additional Note

When installing a steam trap on a steam main, TLV typically recommends the use of traps that discharge condensate continuously, such as the Free Float® type. Other trap types such as disc, bucket, or balanced pressure thermostatic can be used provided that the collecting leg is adequately sized to prevent back-up into the steam main. Bimetal traps are not recommended for use on steam mains due to the possibility of large back-up distances which could pool condensate in the steam main itself. This is an especially worrisome situation when the trap is located close to the steam main.

7.6. Trap Orientation: Vertical or Horizontal?

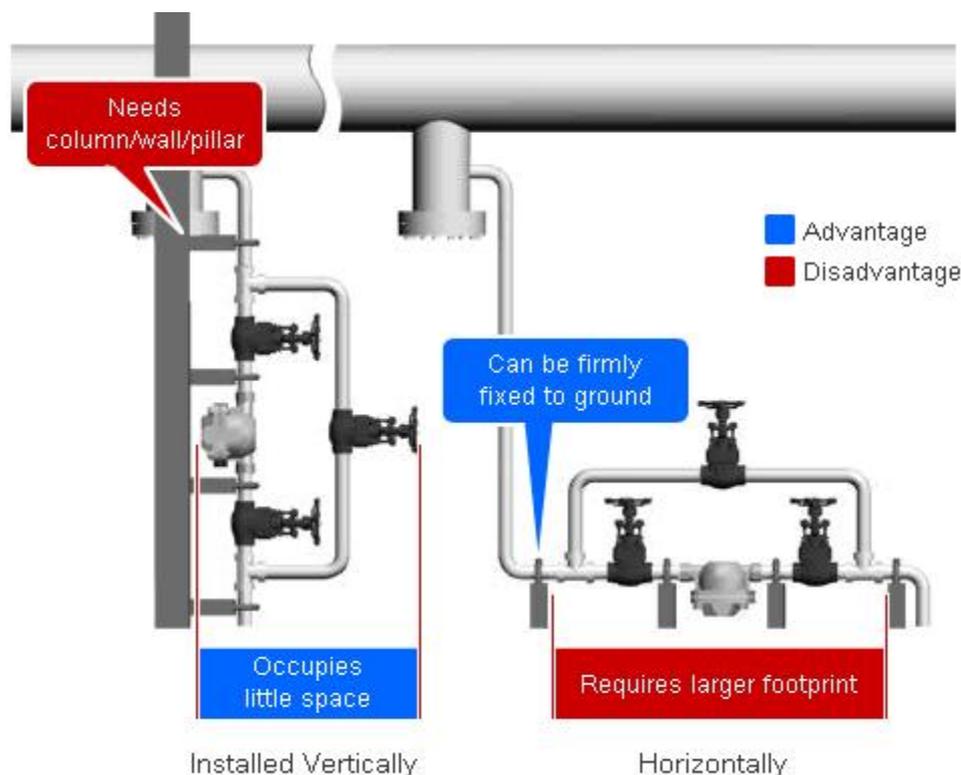
When draining condensate from an elevated steam main using a drip leg, if space is of concern, it is possible to install the trap directly on the vertical section of the trap inlet piping to save space. While the horizontal and vertical setups require virtually the same components, such as a bypass valve with manual valves set before and after the trap, setting the trap at ground level means that greater space is required to install all these components horizontally.

On the other hand, setting the trap on the vertical section of the trap inlet piping does require proper vertical support such as a pipe rack column or pillar for the trap and other piping. Also, if the trap is not firmly set on the ground, maintenance and repairs can also become more difficult to accomplish, so some method for anchoring to the ground or vertical support is still required.

Support is usually not a problem when setting the trap and piping closer to the ground, as the ground can provide support for the installation. Repairs and maintenance are also easier to accomplish because components are typically more easily accessible.

As each method has its pros and cons, it's important choose the most suitable setup for your particular location.

7.6.1. Setting Trap Vertically vs. Horizontally



| | ADVANTAGE | DISADVANTAGE |
|------------------------|--|--|
| Installed Vertically | Occupies little space. | Needs installation against a column/wall/pillar. Its position can make maintenance tasks more difficult. |
| Installed Horizontally | Can be firmly fixed to the floor/ground. | Requires a larger footprint added space. |

Additional Note

Furthermore, when selecting traps such as the Free Float® type for steam mains, it is important to realize that different models exist for horizontal and vertical piping installations.

7.7. Summary

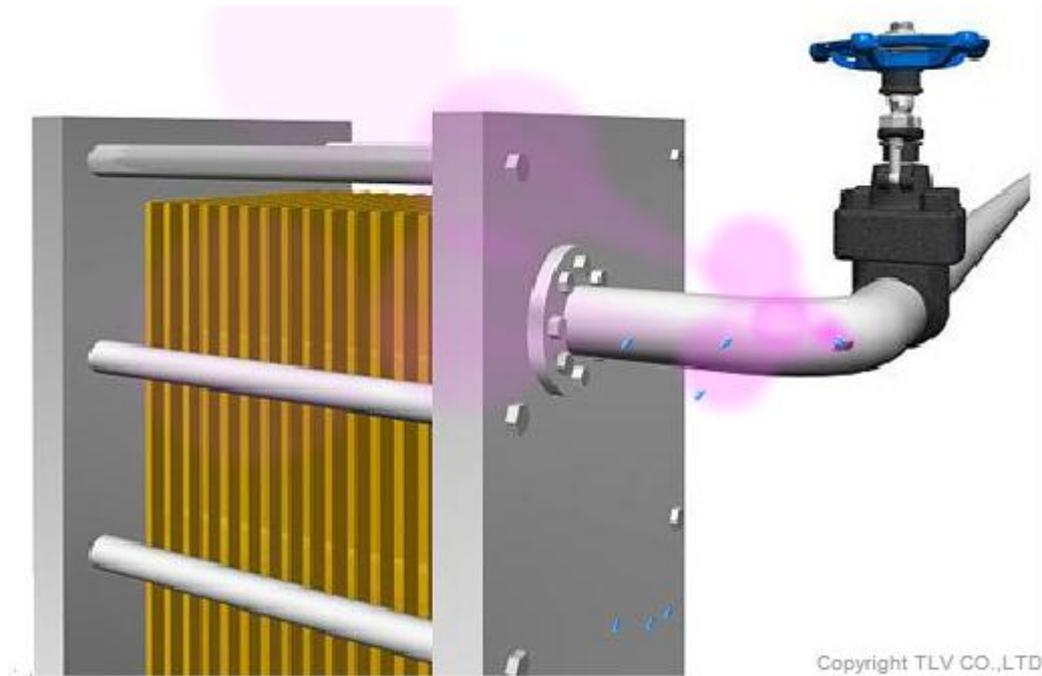
Installing a trap off a steam main isn't simply about trap selection. There are a number of other factors involved such as proximity to the steam main and space requirements. It is highly recommended to evaluate trap location and setup before purchasing traps to ensure the safe and efficient transport of steam to the location where it is needed. Proper setups should try to minimize steam loss while allowing for easy maintenance.

All these factors should be taken into account when deciding the trap setup that will provide the greatest benefits over the long term.

8. Erosion in Steam and Condensate Piping

Erosion is a physical process that refers to the gradual wearing away of a solid through abrasion. This article will focus on erosion in steam and condensate piping, a common problem in steam plants wherein sections of piping are eroded away causing significant steam leakage.

Steam Leak Caused by Pipe Erosion



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Erosion causes the thinning of the pipe wall that can eventually lead to holes in piping, causing live steam leaks that can be a serious safety hazard.

8.1. What Causes Erosion?

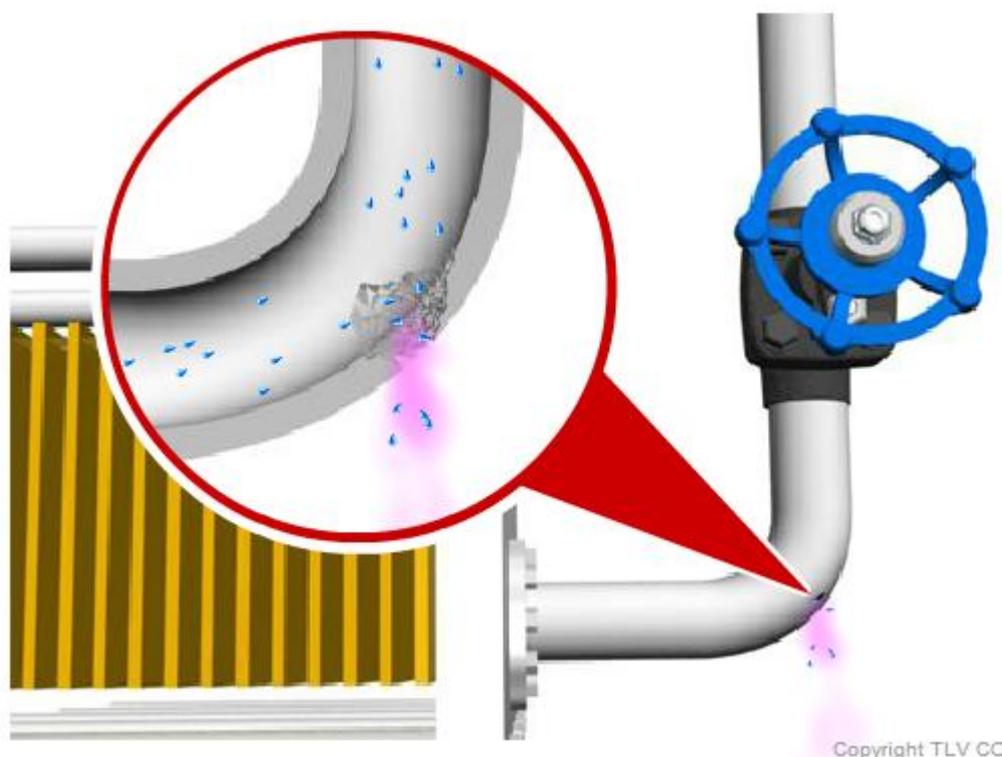
Water both entrained in steam flow and also as non-discharged condensate traveling at high speeds in piping is the source of most erosion. By repeatedly impacting piping at bends, the water can cause the gradual thinning of the pipe wall due to its mass and high velocity of impact, similar to what occurs in industrial water jet cutting. This type of erosion - caused by water droplets - is typically known as Liquid Droplet Impingement (LDI) Erosion.

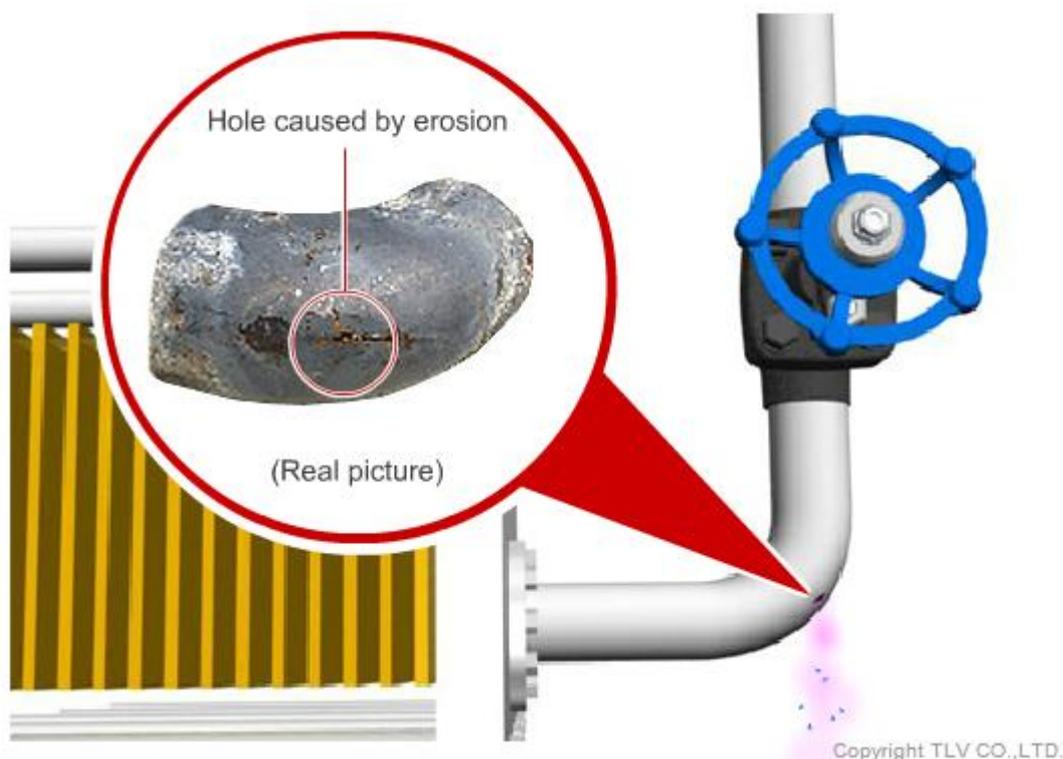
In many cases, but particularly with carbon steel piping, erosion can remove the protective inner piping surface treatment thereby speeding the electrochemical thinning of the pipe wall, a process known as corrosion. In fact, both erosion and corrosion typically work together to cause the thinning of the steam pipe inner wall.

8.2. Piping Damage Caused by Erosion

Resistance to erosion varies according to the material. For reasons related to cost and installation, carbon steel piping is typically used as standard practice in most steam distribution lines even though it isn't as resistant as stainless steel piping. Use of stainless steel piping is usually limited to pharmaceutical, biotech, clean steam, or other sterile applications.

8.2.1. Erosion Occurring in Piping





As liquid droplets hit the inner wall of the pipe, the wall slowly wears away.

Some surface treatments can offer carbon steel piping protections against corrosion, but these aren't as resistant as those for stainless steel. The treatments can temporarily protect the steel to slow down erosion and corrosion.

However, once thinning caused by erosion starts to occur, additional thinning of the pipe wall can occur even more rapidly. This is because the high velocity water not only physically breaks down the impacted region of the steel piping, but also accelerates corrosion by removing the surface treatments that protect the piping.

8.3. Other Types of Erosion in Steam and Condensate Piping

Erosion in steam and condensate piping is not limited to the above-mentioned erosion caused by liquid droplet impingement (LDI) or high velocity dis-entrained condensate.

Condensate recovery piping in particular can be susceptible to erosion from improperly handled flash steam that occurs in the discharge stream. Indeed, even though condensate piping is designed for condensate transport, the process of flash re-vaporization can result in an environment very similar to steam distribution piping containing a large volume of high velocity wet steam. This type of LDI erosion is often called "flashing erosion".

Flashing erosion can often be worsened by two related factors:

- Undersized condensate return lines that cause high flash steam velocity (water-cutting effect)
- Corrosive elements such as carbonic acid that can be associated with low temperature condensate

Additionally, "cavitation erosion" can occur from the sudden shock wave impacts caused by the implosion of small liquid-free zones within condensate. Cavitation erosion occurs because flash steam can occupy a very large volume, but then suddenly and rapidly condense after a portion of its heat is lost, having been transferred to the adjacent fluid or piping.

Due to specific volume differences between steam and condensate, the sudden condensation of flash steam can create a large void that is rapidly and often violently filled by adjacent condensate, thereby causing shock waves known as water hammer. The rapid collapse of the flash volume and associated shock caused by high velocity condensate filling the void can lead to significant piping erosion and damage.

8.4. Erosion Countermeasures

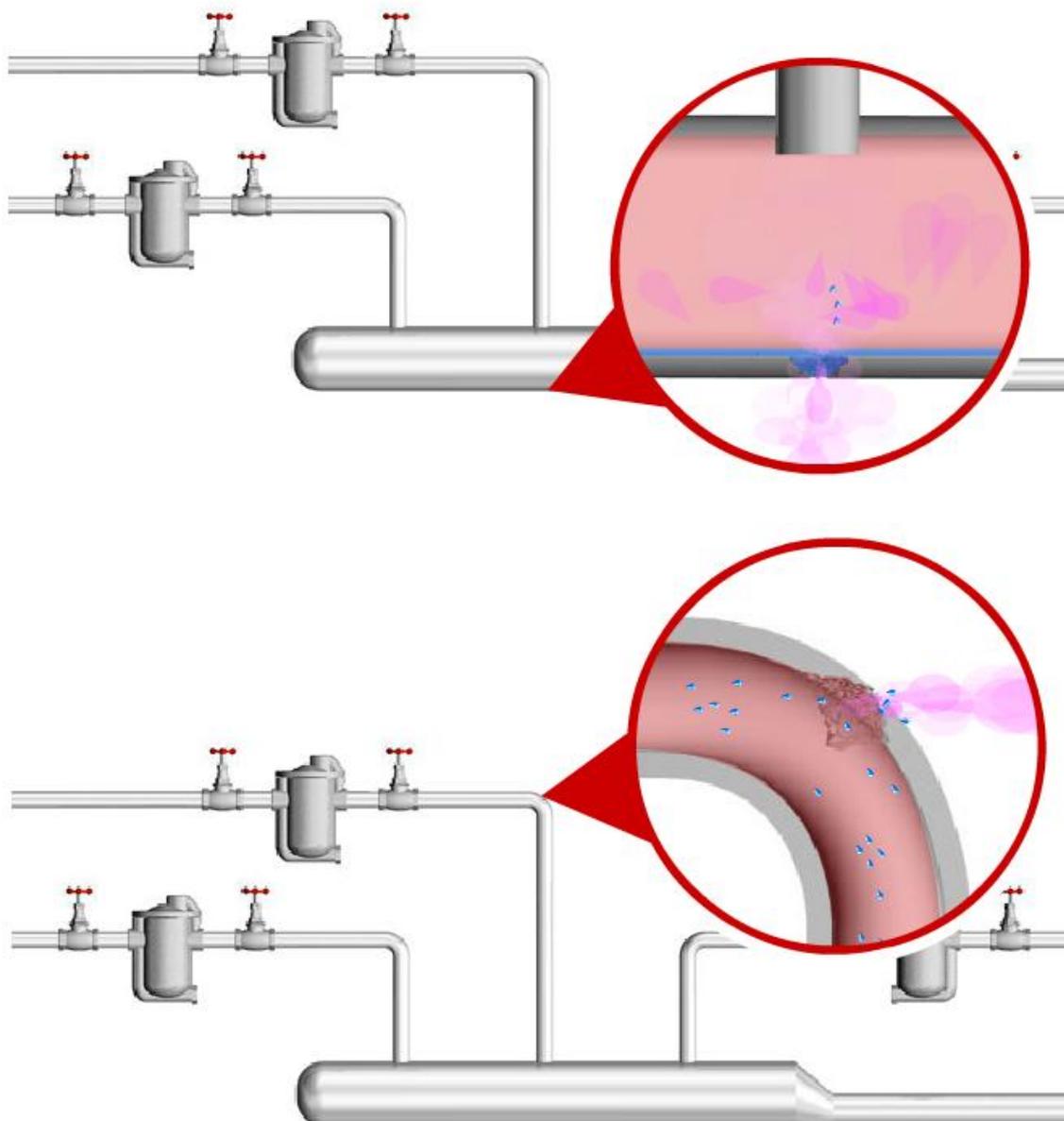
8.4.1. Countermeasures for Limiting Erosion in Condensate Recovery Piping

Limiting erosion in condensate recovery piping requires multiple design considerations. One crucial element is to size the condensate return pipe large enough to accommodate steam and condensate two-phase flow, as discussed here:

- [Condensate Recovery Piping](#)

Condensate recovery piping is typically designed using the average rate of condensate flow. However, if steam traps that operate intermittently are used, such as bucket, disc, piston, and thermostatic type traps, then the momentary discharge rate can be much greater than the calculated average. This can result in a much higher condensate flow velocity than anticipated, which may lead to greater erosion of the piping.

8.4.1.1. Erosion at Trap Outlet



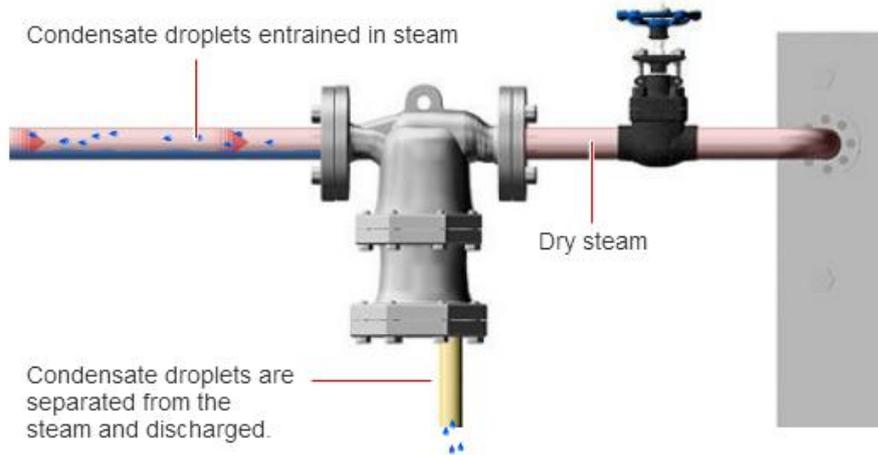
Traps that operate intermittently may lead to greater erosion of piping at the trap outlet.

In such cases, the options are to locate the trap further upstream and away from the direction change, eliminate direction changes where possible, over-size the discharge pipe if cost effective, or select a trap with a more continuous type discharge such as a Free Float® or float design.

8.4.2. Countermeasures for Limiting Erosion in Steam Distribution Piping

Preventing erosion in steam distribution piping is generally a simpler matter, and typically requires the removal of water droplets entrained within the steam. This involves the installation of a steam-condensate separator.

Steam Separator



Condensate entrained in steam is mechanically removed using a steam separator.

Although steam supplied through the boiler can have a high percent of dryness, all boilers without super heater sections still contain certain amounts of condensate entrained in the steam that is created. Condensate also forms from radiation heat loss throughout the distribution piping. For these reasons, it is critically important to both install traps at regular intervals and install separators that mechanically remove water droplets from steam in required areas.

9. Our Technologies for corrosives processes

GT-BLOC : round modular blocks heat exchanger

- Compactness
- Modular construction
- Fast assembly / disassembly
- Standardized spare parts
- Possibility to use corrosive media on both side with a protective coating / lining on shell side.
- Available in GT-KELITE(+) / GT-CARB+ / GT-FLON
- From 0.3 m² to 800 m².
- Monoblock or multiblocks configurations

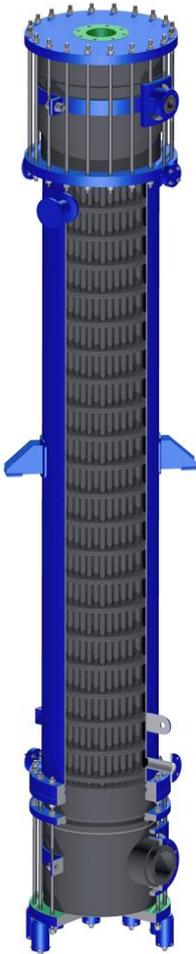
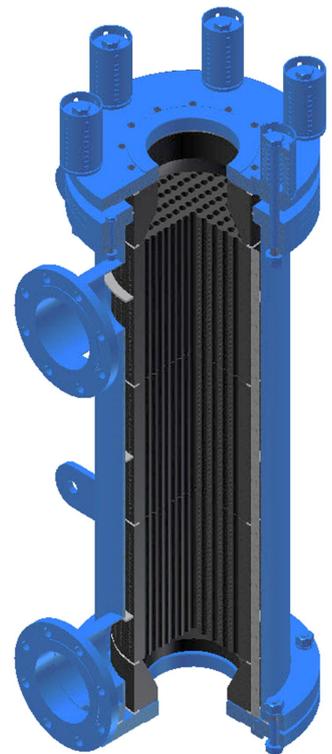
In standard

- SHOCK PROTECT[®]
- STABLE LOAD[®]

- STRESS FREE[®]
- FILT-IN[®]
- HAMMER PROOF[®]

Optional :

- C-HARD[®] erosion reinforcement



GT-TUBE : shell and graphite tubes heat exchanger

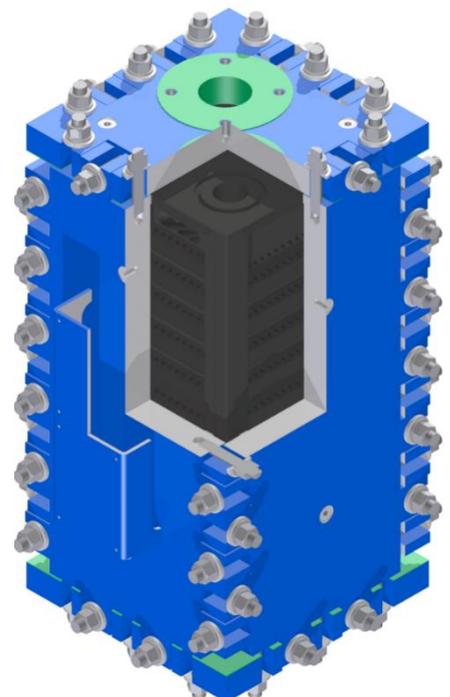
- High heat transfer area, heavy duty.
- High process / service section for big flow (15,000 m³ liq./h)
- Gaskets only at tubesheet and header location.
- Available in GT-KELITE (+)
- Gasketed baffle on service side for cooler
-

Optional :

- Falling film design
- C-HARD[®] erosion reinforcement
- Carbon fiber reinforcement for high vibrations and stress resistance

In standard

- SHOCK PROTECT[®]
- STABLE LOAD[®]
- STRESS FREE[®]
- FILT-IN[®]
- HAMMER PROOF[®]



GT-CUBIC : cubical block heat exchanger

- Possibility to use corrosive media on both sides (economizer)
- No gasket between 2 sides media (no contamination with gasket failure)
- Outstanding corrosion resistance (GT-KELITE(+)) / GT-CARB+ / GT-FLON)
- Monoblock or multiblocks configurations

In standard

- STRESS FREE[®]

Optional :

- HAMMER PROOF[®]

GT-DISC : disc and frame heat exchanger with slot or annular groove design

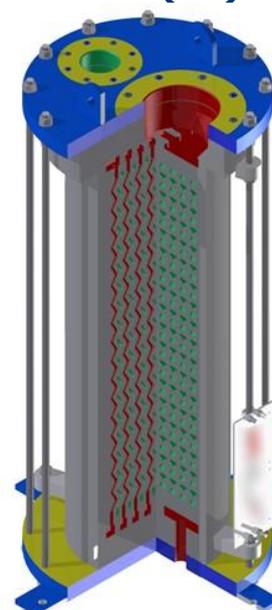
- Excellent heat transfer adapted to reactor condenser and subcooler
- Compactness
- Modular design with ability to reduce or extend capacity or footprint
- Fully dismantle without heavy components, easy cleaning
- Possibility to use corrosive media on both sides (economizer)
- Low pressure drop, free-flow
- Auto dry surface.
- Available in GT-KELITE+ / GT-CARB+ / GT-FLON
- From 0.5 m² to 50 m²
- Temperature up to 500 °C, pressure up to 10 barg
- High performance with viscous media

In standard

- STRESS FREE®

Optional :

- HAMMER PROOF®



GT-PLATE : plate and frame heat exchanger



- High performances
- Compactness
- Modular design with ability to reduce or extend capacity or footprint
- Possibility to use corrosive media on both sides (economizer)
- Available in GT-KELITE+ / GT-CARB+ / GT-FLON
- From 0.3 m² to 80 m²
- Temperature up to 300 °C, pressure up to 8 barg

In standard

- STRESS FREE®

Optional :

- HAMMER PROOF®
- FREE FLOW for dirty media

GT-TOWER : column, reactors & internals

- Column for distillation, stripping and absorption
- Distributor, trays, packing support grids, mist eliminator support, dip-pipe... for tantalum, graphite, fluoro lined and glass lined tower
- Available in GT-KELITE (+) / GT-CARB (+) / GT-FLON
- From 0.05 m³ to 5 m³
- Temperature up to 500 °C, pressure up to 10 barg incl. vacuum

In standard

- STABLE LOAD®
- STRESS FREE®

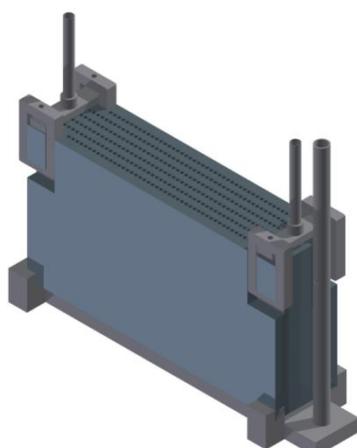
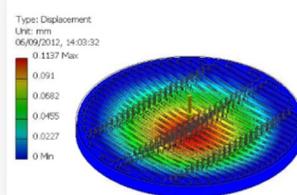
Optional :

- HAMMER PROOF®



Distributor in GT-KELITE for distillation column (MCA process)

Displacement



GT-BATH : immersed heater/cooler

- Equipment immersed in the process bath or tank
- No pump and circulation piping required
- Economical, easy adaptation for existing processes
- Outstanding corrosion resistance (GT-KELITE(+)) / GT-CARB+ / GT-FLON)
- Outperform immersed heater in Tantalum or PTFE pipe thanks to high turbulence conception
- Low footprint, light structure without steel parts



GT-FIN : gas heater/cooler

- Modular blocks with extended surface fins for gas cooling or heating
- Outstanding corrosion resistance (GT-KELITE(+)/ GT-CARB+ / GT-FLON / GT-OXY FLON)
- High flexibility of design
- Low footprint, light structure
- Custom design

GT-JET : ejector mixer and jet vacuum technologies

- Jet vacuum systems
- Ejector mixer for chemical reactions (gas/liquid, liquid/liquid)
- Outstanding corrosion resistance (GT-KELITE(+)/ GT-CARB+ / GT-FLON)
- Custom design



GT-CP : special equipment for chemical reactions

- Reactors with /without thermosyphon, agitation, cooling / heating functions
- Storage tank for hot media
- Custom design, lab scale
- Outstanding corrosion resistance (GT-KELITE(+)/ GT-CARB+ / GT-FLON / GT-OXYFLON)
- Up to 500°C and 10 barg



GT-PF : piping and fittings

- Straight pipe / Elbow / Tee / Cross
- Custom design even for lab size
- Outstanding corrosion resistance (GT-KELITE(+)/ GT-CARB+ / GT-FLON / GT-OXYFLON)
- Up to 500°C and 10 barg
- Custom design, lab scale



PROCESS SYSTEMS : chemical processes design



- Absorption HCl, HF for waste gas treatment and acid recycling.
- Mixing chemical products liquids/liquids, liquids/gases (static mixer, jet mixers, ultrasonic mixer)
- Chemicals reactions and heat control
- Acid concentration (sulfuric, hydrofluoric, phosphoric and hydrochloric acids)
- Acids dilutions



SAG-CORROTEC : heat exchangers in PVDF, ECTFE, ETFE

- Ideal for pharmaceutical, electronics (ultra-pure liquids), metal finishing and sea water processing industries
- Excellent resistance to thermal shock
- Not sticky material
- Temperature from -40°C to 160°C
- Shell and tubes heat exchangers
- Bayonet exchangers
- Immersion exchangers
- Shell in FRP, RTP, carbon steel or stainless steel



Services

- Start-up & Operating assistance
- Dedicated maintenance during lifetime of your units
- Quick support - Field Service – Spare-Parts availability
- Replacement, optimization and repair of your existing equipment without piping modification
- Expertise to remedy recurrent failure or lack of performances
- Corrosion tests
- Pilot equipment



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INNOVATIVE CHEMISTRY

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