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The European
Stainless Steel
Development Association

"Press-fit" fitting systems and stainless steel

Materials and Applications Series, Volume 19

Euro Inox

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- national stainless steel development associations;
- development associations of the alloying element industries.

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Cover photos
Cover photos: Geberit, Jona (CH), left
Nussbaum, Olten (CH), right

Contents

1 Introduction

The “press-fit” fitting technique ideally meets a number of key requirements for tube systems conveying drinking water, process water, other liquids or gases: ease and speed of installation, combined with long-term reliable service. Potable water requires the utmost neutrality of the material to ensure public health and that neither the colour nor the taste of the water is changed. For process liquids, the potential corrosive influence of the product has to be taken into account. For gaseous media, gas tightness can be safety-critical.

Mechanical fitting systems are available for a number of metallic materials. However, the outstanding formability of stainless steels and their proven neutrality make the “press-fit” fitting system, on the one hand, and stainless steel, on the other, a “dream team”. While this constellation is best known for its use in domestic plumbing, its potential areas of application are much wider and include process water, petroleum products and gas.

The present publication outlines

- the main technical properties of stainless steel “press-fit” connections
- its competitive position in the context of alternative solutions
- typical areas of application
- aspects of design and installation that are specific to stainless steel.

The stainless steel “press-fit” fitting system combines ease of installation with the proven neutrality of stainless steel. Photo: Chibro, Montano Lucino, CO (I)

At a glance:

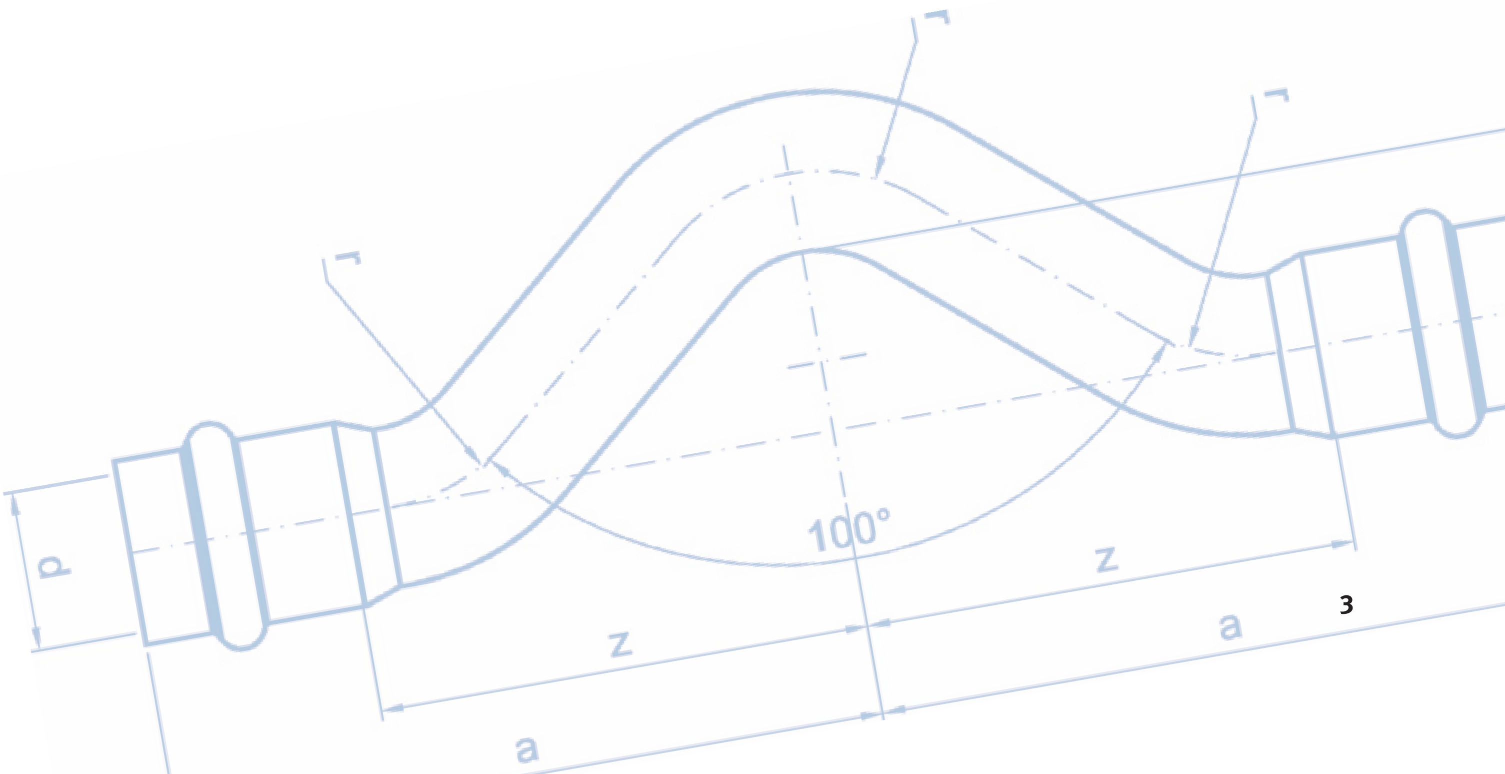
Why stainless steel?

- Corrosion resistant to any allowable European drinking water composition without restrictions
- Corrosion resistant to other fluids including many types of process water, mineral oil products and gaseous fuels
- Corrosion resistant outer surface for use in aggressive atmosphere (breweries, dairy production...)
- High resistance against erosion corrosion
- Visually attractive – contributes to a visual impression of cleanliness
- Lower thermal expansion than most alternative materials
- Exceptionally durable
- Proven hygienic properties, right from the start
- No ageing; insensitive to UV radiation when exposed to daylight
- Also available as flexible composite tubes with a stainless steel inner lining

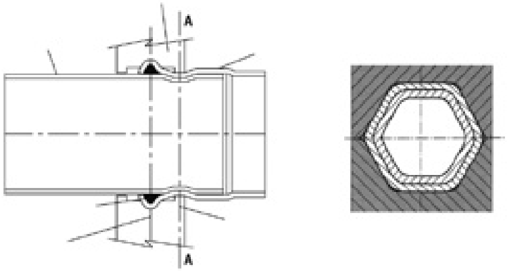
Why press-fit fittings?

- Exceptionally fast joining method
- Reach their full structural integrity immediately
- No heat input, no fire hazard
- Multi-purpose technique: one principle for the most diverse types of liquids and gases

Illustration: Sanha Kaimer, Essen (D)



2 The principle



The exact geometry of the section may vary from one system to another and also depending on the dimensions. Illustration: Raccorderie Metalliche, Campitello di Marcaria (MN), (I)

The term "press-fit" refers to a joining method for tube systems by means of fittings, which are mechanically pressed with specific tools. The pressing operation leads to a mechanical joint between the tube and the fitting. Hydraulic tightness is achieved by the O-ring-system.

Its high ductility is the reason why stainless steel is particularly suitable for this technique. The geometry of the fitting and the section of the compressed area vary from one manufacturer to another. Therefore, the (interchangeable) jaws of the power tools must be approved by the manufacturer of the fittings.

Additionally, an elastomer "O" ring is embedded in the fitting. Considerable research was carried out to identify and test polymers for these sealing components, which must provide a level of durability that is consistent with the useful life of the stainless steel. The "O" ring must be made of a material that is resistant to the media to be conveyed. For instance, different types of rings are used for water, petroleum products or natural gas. Some manufacturers use colour codes for different categories of seal rings to avoid errors. The manufacturers provide suitable product ranges for each of the various applications. Reassuring long-term experience has now been available for more than 40 years.

The press tool must match the geometry of the fitting. Photo: Sanha Kaimer, Essen (D)

Press tools are available in electro-hydraulic and electromechanical (including battery-powered) versions. Photo: Viega, Attendorn (D)

3 Comparison with alternative techniques

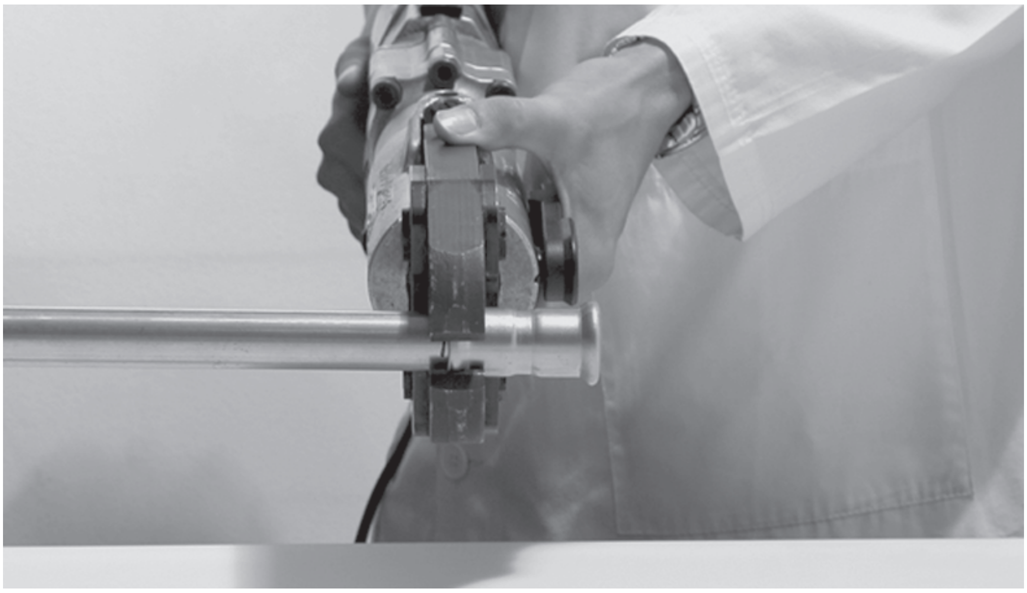
As a fully mechanical type of joints, press-fit connections are produced at ambient temperature and any fire risk is avoided. Photo: Geberit, Jona (CH)

In professional plumbing and heating installation practice, the brazing of copper has been a classic joining method. Its limitations include the use of open flames, which can involve fire risks, specifically in the renovation of buildings, where flammable materials may be close to the working area. The retrofitting of modern heating installations in listed buildings is a typical case. The selection and use of solder and appropriate flux are critically important. The joining process is relatively slow, requiring experience and skill. The joints are only mechanically sound when they have cooled off.

Plastic tubes are available as an alternative. The connections are adhesively bonded, which avoids the complexity and fire risks of the brazing process. Limitations for professional users lie in the fact that the adhesives need time to cure. It takes several hours before they are fully hardened and pressure tests can be executed. This can be a disadvantage in industrial environments, where downtime is an important cost element.

Press-fit connections for metallic materials are time-saving and safe:

- The operation is performed at ambient temperature. There is no risk of fire, even if the tube is laid close to (or even in) flammable materials, e.g. in historic buildings.
- The compression process is fast: it takes just a few moments. Depending on the tube diameter, it can be as short as 3 seconds. Contractors report reductions of time-related installation cost between 25 % and 40 %. Studies point out that the cost benefit is particularly marked in large-diameter systems.
- The joints immediately reach their final mechanical stability.



Interchangeable jaws are available for the press tools. Photo: Eurotubi Europa, Nova Milanese, MB (I)

Although for metallic materials there are several types of mechanical connections, e.g. (threaded) compression fittings and push-in fittings, the press-fit type has become particularly successful. It is available in a dimension range from 15 mm to 108 mm. The technique is usually applied using electronically controlled power tools. The mechanised process produces connections of consistent, reproducible quality with just a minimum of physical effort. Battery-powered machines are also available, some of which may be as light as 2.5 kg. Special tools are needed; however, their cost is amortized quickly. For occasional users, machines are available for hire. The system manufacturers provide detailed information about the availability of suitable power tools.

A single system can be appropriate for multiple purposes: in breweries, for instance, designers discovered the practical and cost advantages of using just one type of installation system for two applications: compressed air in a packaging line, on the one hand, and process water, on the other.

In breweries and other food and drink processing facilities, most of the equipment is made of stainless steel. Designers, engineers and owners often prefer the tubing also to be in stainless for unity of appearance and perceived hygiene. Depending on system and diameter, operating pressures up to 120 bar and temperatures of more than 200 °C are possible.

4 Relevant material properties

The synergic effects of the material stainless steel and the press-fit principle result from some intrinsic characteristics of stainless steel: their alloying composition and their mechanical properties.

4.1 Self-passivation

The exceptionally high corrosion resistance of stainless steel is due to a so-called passive layer. It is only a few molecules thick, adheres firmly to the substrate and is fully transparent. Therefore, it is totally different in nature from applied metallic (galvanic) or organic (painted) layers, which are much thicker. The passive layer provides "self-repairing" characteristics to stainless steel. If it is accidentally removed, e.g. through damage or machining, it re-forms automatically in the presence of oxygen. This means that the corrosion resistance is an intrinsic property of stainless steel.

However, this passive layer can make soldering and brazing a challenge. Specifically, there is a risk of a corrosion form known as knife-line attack. This is why soldering in drinking water installation requires specific fluxes and solders and good craftsmanship. Depending on national regulations, it may be ruled out for potable water applications.

Welding, otherwise a preferred joining technique for stainless steel e.g. in industrial pipework, is uncommon in plumbing for two reasons. Firstly, under on-site conditions, the required weld quality cannot be guaranteed for the relatively small diameter tubes. Secondly, the post-weld surface treatment, which is needed to remove heat tint and ensure self-passivation, may be impractical. For this reason, stainless steel is usually used in combination with mechanical joining techniques, which avoid influences possibly impairing the material's self-passivation capacity.

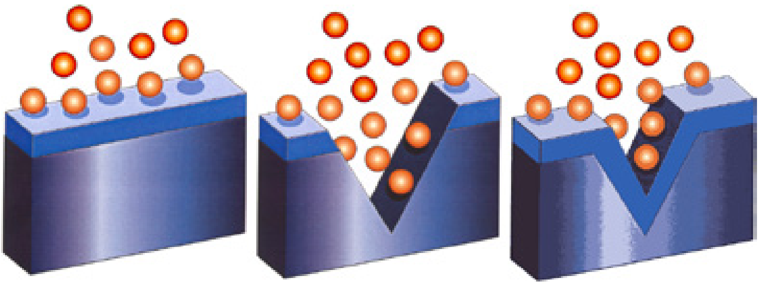
Elbow fitting are a time-saving alternative to bends. Photo: Sanha, Essen (D)

4.2 Work hardening

Stainless steel has high mechanical strength. Especially the chromium-nickel (-molybdenum) stainless steels known as austenitic grades (like grade EN 1.4404 / AISI 316L) show a forming behaviour which is characterised by marked work hardening properties. The mechanical strength of the material increases during the cold-forming process. Bending operations should therefore be reduced to a minimum. Although tube bending is possible and can be performed with usual tools (see chapter 6.2 below), elbow fittings are usually preferred for standard 45° or 90° bends. For other angles, flexible couplers can be a time-saving and easy solution.

The forming behaviour of the ferritic (chromium-molybdenum alloyed) grade EN 1.4521 / AISI 444 is similar to that of carbon steel; work hardening is not a factor that needs to be taken into account.

A self-repairing passive layer is the reason for both the high corrosion-resistance and the neutrality of the material stainless steel.



5 Applications

Stainless steel "press-fit" fitting systems can be used in a wide range of applications for liquid and gaseous media as well as vacuum.

5.1 Plumbing

Stainless steel is the only metallic material, which can be used for any drinking water composition allowed under the European Drinking Water Directive. Especially in regions with soft water, other metallic materials may develop corrosion and have their limitations. No such restriction exists for stainless steel.

Stainless steel is also exceptionally resistant to erosion corrosion, even at water flow rates over 30 m/s. Changes of cross-section, sharp changes in direction and turbulence downstream of pumps and valves normally do not cause noticeable erosion phenomena in stainless steel.

Scotland is a case in point: water is both soft and high in sediments. This is one of the reasons why stainless steel has become a preferred option, including in hospitals. Stainless steel tubes are rigid. Only a minimal number of fasteners is needed, which speeds up installation.

As stainless steel is not flammable, fire protection requirements are lower than for organic materials. In case of fire, plastics may burn, char, distort or even melt. Where the tubes penetrate walls or ceilings, smoke must be prevented from spreading into adjacent fire zones. Therefore, plastic piping often requires special fire protection collars for wall penetrations. In the case of fire, they expand and seal the gap, which the burnt, distorted or melted plastic pipe exposes. The special sealing compounds are a noticeable cost factor. In the case of metallic materials like stainless steel, such collars become redundant.

Besides residential and office buildings, industrial tubing is a common field of application. Especially in maintenance and refurbishing work, the "press-fit" fitting system has been successful because keeping downtime low is a priority.

In the food industry, clean rooms, pharmaceutical factories and others, high visual and hygienic requirements also apply to the (often exposed) external surface of water distribution systems. In many cases, the indoor atmosphere is corrosive so installation materials must also have a high level of corrosion resistance at the outer surface. In environments, in which worktops and cabinets, machines and ducts, tanks and reactors are made of stainless steel, it is often preferred also to use the same material in tubes for drinking water, other liquids or gases.

5.1.1 Vertical distribution

In multi-storey buildings, the vertical distribution lines are the backbone of the plumbing system. Their diameter increases with the number of storeys that shall be served. “Press-fit” fittings and tubes are available in dimensions of up to 108 mm. While plumbing installations on individual floors may be modernized several times during the useful life of a building, the vertical lines usually remain unchanged. Durability requirements are therefore particularly high. The possibility to leave the vertical distribution as it is makes a significant contribution to a favourable life cycle cost balance.

5.1.2 Horizontal distribution

For horizontal distribution within the floors, flexible tubes are often preferred over rigid ones. The reason is their ease of installation, especially of bending. In this context, some discussion about the potential health implications of plumbing materials is relevant. Some materials are known to release significant amounts of metallic ions, especially when new. Others are suspected of setting free organic compounds whose effect on human health and especially the hormone

system is not yet fully understood. In terms of inertness, stainless steel, which is also the most frequently used material in food processing plant, has an excellent reputation.

The use of stainless steel in contact with the fluid, on the one hand, and bendable tube material, on the other, are by no means mutually exclusive. Composite tubes are available, which have an extremely thin inner tube of stainless steel as the inner (water-contact) surface, and an outer layer of a polymer, which provides the necessary pressure resistance and mechanical protection. The high levels of ductility, which are characteristic of austenitic stainless steels, make these bendable composite tubes possible. They bring together the best of two worlds: the hygienic properties of stainless steel, on the one hand, and the ease of installation of bendable installation material, on the other. These flexible tubes, available in smaller diameters, can be joined by press-fitting technology in exactly the same way as massive metallic tubes.

Stainless steel tubes for press-fit connections are commonly available up to a diameter of 108 mm, e.g. for vertical distribution. Photo: Geberit, Jona (CH)

Flexible tube has a tight inner layer of a thin stainless steel tube and an outer layer consisting of a polymer. It combines the proven neutrality of stainless steel in contact with drinking water and the flexibility of plastic tube. Photos: Geberit, Jona (CH)

Flexible stainless steel-lined tube is available in lengths of up to 100 metres. It can be bent by hand at radii down to 5 times its diameter (5 D) without any relevant change of the inner section. Using suitable tools, a bending radius of 1.5 D can be achieved.

5.1.3 Grades of stainless steel for plumbing

The choice of grades depends on the composition of the liquids. In the case of potable water, the water chemistry and potential national specifications have to be taken into account. Most commonly, molybdenum-containing stainless steels are specified. Molybdenum enhances the basic corrosion resistance of stainless steel considerably. This element is present in both the (chromium-nickel-molybdenum alloyed) austenitic grade EN 1.4401 / 1.4404 (AISI 316/316L) and the more recently introduced (chromium-molybdenum alloyed) ferritic grade EN 1.4521 (AISI 444). Depending on national regulations and water compositions, grade EN 1.4301 (AISI 304) can also be used for cold water containing up to 200 mg/l chloride in some EU countries.

Both the inner and outer surface of welded tube for drinking water installation must meet special quality requirement. Photo: Viega, Attendorn (D)

The alloys may be specified in national standards. The basic corrosion resistance is also determined by the need to withstand the sanitizing procedures, including those in hotels, hospitals and other places where the occurrence of legionella is a possibility. Thermal disinfection has proved effective, as it is a method that can completely penetrate potential bio films and eliminate microorganisms to the very base of the deposit.

5.1.4 Tube for contact with drinking water

Tubes for drinking water installations are produced by forming stainless steel strip and joining it by a longitudinal weld. The corrosion resistance of the material in the welded seam should be virtually the same as in the base metal. The welding techniques and post-welding treatment processes applied ensure that the internal and external surfaces of the tube are smooth and free of heat tint (including the welded zone).

The hygienic requirements make tube for plumbing systems different from structural tube used, for instance, in handrails, for which visual appearance is more important. Austenitic stainless steels are known for their excellent weldability. In the case of the ferritic grade 1.4521, the alloy is stabilized using titanium or niobium to ensure that corrosion resistance is maintained in the weld and the heat affected zone.

5.1.5 Mixed-material plumbing installations

New installations are not always island solutions. Often, they have to be connected to pre-existing systems, which are mostly metallic. In this case, the question of galvanic compatibility has to be addressed.

Metallic materials can be ranked in the order of their electrochemical potential, which is indicative of their respective tendency to oxidise. Zinc, for instance, is low on this scale and oxidises quite easily. Stainless steel is much higher on this scale and is, in many environments, resistant to oxidation.

When two metallic materials with significantly different electrochemical potentials come into electrically conductive contact with one another and an electrolyte is present, electrons flow from the less noble towards the more noble material. This is the principle of a battery. It implies, however, that the less noble one of the partner metals is consumed.

The effect of galvanic corrosion can also be used for corrosion protection. In the case of galvanised steel, a layer of a less noble material – zinc – is applied. As corrosion preferentially attacks the less noble metal, it consumes the zinc and spares the steel. Over time, however, the protective zinc layer diminishes in thickness and finally disappears. Therefore, it must either be made thick enough to survive the specified design life, or it needs to be maintained and renewed. However, where the metallic coating is removed, e.g. through cutting operations or accidental damage, the corrosion protection is weakened locally.

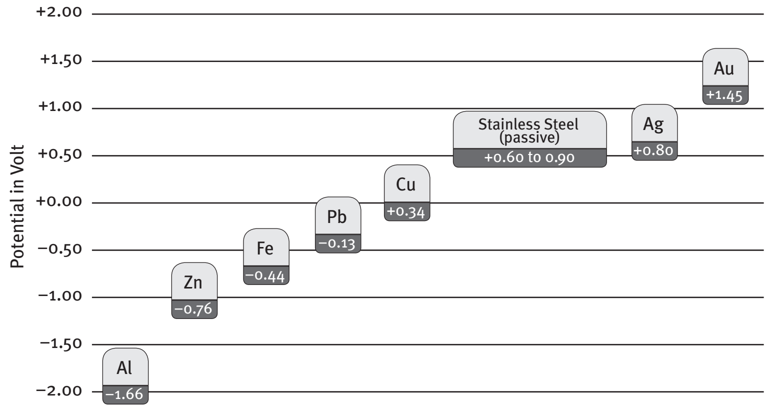


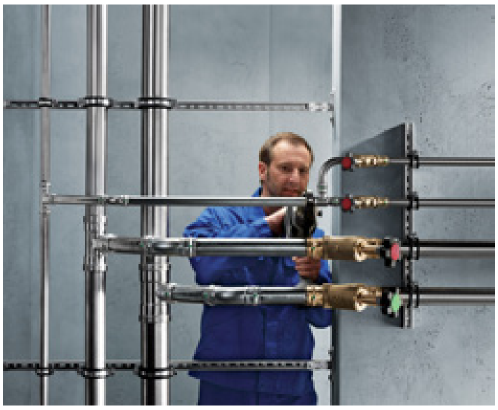
Figure 1: Normal potentials of stainless and other metals or metallic alloys compared to a hydrogen electrode

In hot water boilers, enamelled steel tanks are usually protected by a magnesium electrode. As can be seen from Figure 1, magnesium, too, is at the low end of the above-mentioned scale. It is consumed for the sake of protecting the steel. However, sacrificial anodes need to be monitored and replaced at regular intervals.

Stainless steel, in terms of electrochemical potential, is rather high in rank. This means that it does not easily corrode. For this reason, there is no need for any protective layer. However, if in contact with other, less noble metallic materials, it can make the partner metal corrode. The stainless steel, of course, remains unaffected. Methods of risk evaluation and simple preventive measures are described in the Euro Inox publication *Stainless Steel in Contact with Other Metallic Materials*[1].

[1] The flow direction is only of importance for combinations of galvanized or unalloyed steel on the one hand with copper or copper alloys on the other. Due to cementation of copper ions on the steel surface, copper induced pitting corrosion may occur on the latter. In the case of combinations of stainless steel and galvanized steel, this, "flow rule" does not apply.

Mixed-material installations, e.g. with gunmetal or other copper-containing alloys, are uncritical. Photo: Viega, Attendorn (D)



In mixed-metal plumbing systems, a non-conductive component should be placed between the different parts of the system to ensure electrical insulation. Even if the liquid is an electrolyte, the second prerequisite for galvanic corrosion, the electrically conductive contact between the metals, is not met and no galvanic corrosion can take place[2].

If the total surface of the less noble part is much larger than that of the noble parts, the risk of galvanic corrosion decreases and can become negligible.

Many years of practical experience show that galvanic corrosion in mixed drinking water installations is not a problem if these basic principles are taken into consideration. Where the partner metal is copper, no risks are to be expected, because copper and stainless steel have similar electrochemical potentials.

It is also usual to use gunmetal – a copper alloy – for the fittings, which have also provided excellent service. For instance, when joining stainless steel to galvanised steel, the use of adaptors has been recommended, which shall be made from a copper alloy and whose length shall at least be the same as the diameter of the component.

In heating systems, galvanic reactions are not to be expected, because the high temperature removes most of the oxygen from the water, which is then circulated in a closed system.

5.2 Heating

In the retrofitting of heating installation in listed buildings, stainless steel tube systems are used to their maximum advantage. In buildings, which are supposed to last for future generations, durability is an important criterion of choice. In contrast to plumbing, the installation of a heating system typically concerns all rooms of a building. The advantage of a “cold” method of joining, which avoids fire hazards, is particularly obvious for buildings involving wooden structures, flooring or wall cladding.

[2] When insulating one part of a metallic plumbing system from another, both need to be earthed to avoid electrical shock upon touching. If earthing of the truncated section is not possible, the use of brass instead of polymer couplers between the carbon steel and the stainless steel part of the system is an option. The galvanic compatibility of brass is good in contact with stainless steel and acceptable in contact with hot dip galvanized carbon steel. While the electrical conductivity is high enough to neutralize any potential differences appear between carbon and stainless steel, the gradual transition in electrochemical potential significantly reduces the risk of galvanic reactions.

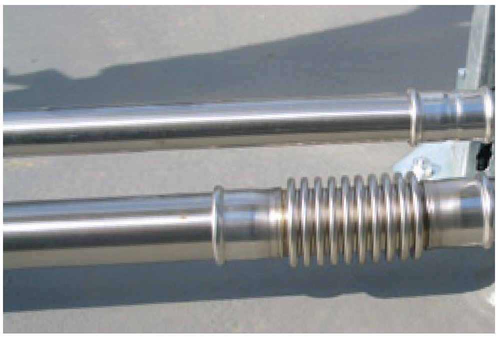
In the retrofitting of heating installations in listed buildings, the advantages of a cold process, which does not involve any fire hazards, are particularly appreciated. Photo: Geberit, Jona (CH)

In heating installations, the thermal expansion of the materials used is an important design criterion. In the case of stainless steel, it is about 10 to 20 times lower than those of plastics. Usual polymers used for heating and plumbing have typical thermal expansion values between $0.08 \cdot 10^{-6}$ K^{-1} and $0.18 \cdot 10^{-6}$ K^{-1}. The coefficient of thermal expansion indicates the number of millimetres per metre that the tube lengthens when its temperature goes up by one degree Centigrade. For example, in a 10 metre-long plastic tube, a temperature rise by 50 °C would cause an elongation of 40 mm to 90 mm. In the case of austenitic stainless steel grade EN 1.4404 (AISI 316L) with a thermal expansion of $0.0165 \cdot 10^{-6}$ K^{-1}, the elongation would be 8.25 mm. An equivalent tube of ferritic grade EN 1.4521 (AISI 444) and with a coefficient of thermal expansion of $0.0108 \cdot 10^{-6}$ K^{-1} would expand by 5.4 mm.

In the case of stainless steel, axial compensators are often sufficient and can be used as a space-saving alternative to expansion bends. A desirable side effect can be a better noise reduction. In other cases, the number of compensators or the size of the expansion bends can be reduced.

5.3 Solar panels

The connection of solar panels is usually exposed to external atmosphere, which makes an intrinsically corrosion resistant material like stainless steel a good choice. The primary water circuit normally contains a mixture of water and glycol. The temperature range varies from –20 °C to +220 °C to take into consideration a safety margin for the case of overheating.



Solar hot water panels are among the applications where both external corrosive stress and pressure resistance in case of overheating have to be taken into account. Photos: Filtube, Barcelona (E)

Stainless steel press-fit fitting solutions have also successfully been used for the fire extinguishing system of ships, where they withstand the chloride-containing atmospheric conditions at sea. Photo: Geberit, Jona (CH)

5.4 Process water and chilled water

Drinking water is not the only product that stainless steel piping in conjunction with the "press-fit" fitting technique is used for. It is also applied for process water, chilled water, mineral oil products or oil-containing liquids. Grade EN 1.4401 (AISI 316L) is a common material. The fabricator should be consulted to find out about the suitable "O" rings for the respective fluid.

Chilled water can contain up to 50 % of glycol. De-ionised water tends to pick up ions from contact materials and dissolve metals that they come in contact with. In softened water, sodium ions have been substituted for the original calcium and magnesium ions. Stainless steel has successfully been used in de-ionised, softened or other types of conditioned waters.

5.5 Fire extinguishing systems

Stainless steel press fitting systems are a common option for fire extinguishing systems. They have been used successfully where there is only limited space, speed of installation is important and corrosion resistance to marine atmosphere must be ensured. Cruise ships are a case in point.

5.6 Drainage

Some producers provide interfaces with floor drainage systems so the entire pipe work is in stainless steel throughout.

Stainless steel installations are also found in road tunnels, where exhaust gases and de-icing salt make the environment exceptionally corrosive. Photos: Nussbaum, Olten (CH)

5.7 Mineral oil products and chemicals

Stainless steel systems are used successfully for diesel fuel, heating fuel, engine oils and lubricants. The system manufacturer will advise users on the grades of stainless steel and the type of "O" rings which have been tested and approved for the respective application. Other tested and approved media include urea solutions, ethanol, methanol, glycerin triacetate, sodium hydroxide and acetone.

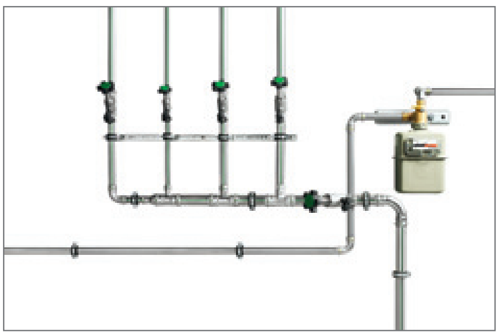
Stainless steel press-fit fitting systems are also suitable for a wide range of chemical products. Photo: Raccorderie Metalliche, Campitello di Marcaria, MN (I)

5.8 Gaseous fuels

Stainless steel has been used successfully for both natural gas and liquid gas (propane, butane, methane). Piped natural gas is a preferred source of heating energy in many European countries. In most of them, gas tubes are usually made from metals. Gas is expected to develop further in future because of its environmental properties: it is virtually free of sulphur and does not lead to the formation of particles. Besides its established uses in domestic heating and cooking, gas operated models are also available for dishwashers and tumble dryers.

In rural areas, where there is no connection to the gas grid, liquid gas is a common option, for instance on farms. Gas ducts passing through agricultural buildings can be exposed to corrosive atmospheres, e.g. in cowsheds, making stainless steel a most suitable option. External corrosion protection is only required in chloride-containing atmospheres.

Stainless steel also meets the high thermal stability requirements for gas-conveying installations: in case of fire, the material must withstand a temperature of 650 °C for a minimum duration of 30 min to avoid the leakage of natural gas, whose ignition temperature in air is about 640 °C.



Stainless steel press fitting systems are equally suited to gases. Photo: Viega, Attendorf (D)

5.9 Compressed air

The application for compressed air is proof of the tightness and mechanical performance of stainless steel "press-fit" fitting systems. It has to be borne in mind that compressed air typically contains finely distributed oil, which will deposit on the tube and the fittings. Care has to be taken to consult the manufacturer for the selection of suitable "O" rings because not all polymers are oil-resistant.

5.10 Other gases

The stainless steel systems mentioned above may also be approved for other types of gas, e.g. acetylene, argon, nitrogen, hydrogen, carbon monoxide and carbon dioxide. They have also been applied to gas mixtures like forming gas (80 % Ar / 20 % CO_2) or Carbogen ($CO_2 + O_2$).

Cable protection is another application of press-fit joining systems.

5.11 Electrical installation

Stainless steel pipes are also used for cable protection. This high-end option is specifically specified where cables are safety-critical, e.g. in underground stations, or where they shall be made more acceptable visually.

6 General recommendations for installation

Details of best practice in design and installation are given by the manufacturers' technical handbooks. They may vary from one application to another. However, the following advice should be observed for all uses of stainless steel piping systems.

6.1 Exposure to chlorides

If the systems are properly installed and operated and the manufacturers' instructions are taken into account, the stainless steels specified for plumbing applications are resistant to the levels of chloride within the Drinking Water Directive (up to 250 mg/l). This also applies to common disinfecting procedures involving (hydrogen peroxide [H_2O_2], or chlorine dioxide). For instance, disinfecting drinking water systems with a solution of 50 mg/l chlorine over 1–2 hours is a common disinfection procedure to prevent the proliferation of *legionella pneumophila*.

However, care has to be taken to avoid exposure of the external surface to uncontrolled sources of chlorides. Insulating tapes should be of the chloride-free type. Where, exceptionally, threaded connections are involved, usual chloride-free hemp is a suitable option.

In hospitals, plumbing systems must withstand common disinfection procedures. Photos: Nussbaum, Olten (CH)

Insulation materials and clamp inserts, which come into direct contact with stainless steel, must not release any chlorides. Photos: Filtube, Barcelona (E)

Materials for thermal insulation may also release chlorides. Most manufacturers accept a maximum level of 0.05 % of soluble chloride ions in insulation materials as a safe value. Felt should not be used as it absorbs humidity. Closed-cell foam products should be preferred. Vibration- and sound-dampening polymer inserts for pipe clamps should also be chloride-free.

Additional external corrosion protection may be required if the stainless steel pipes are exposed to chloride-containing atmospheric conditions. Certain industrial environments can contain high levels of chloride, e.g. paint shops, hot-dip galvanising plants etc.

Bleach is particularly aggressive for metallic material. Splashes or aerosols of chloride-containing cleansers should not come into contact with stainless steel. If the material has accidentally been exposed, it should be rinsed with liberal amounts of tap water to keep the contact as short as possible.

6.2 Cutting and bending

Stainless steel tube should only be cut using pipe cutters, fine-toothed metal saws (32 teeth per inch) or power saws. Because of the work hardening tendency, sawing should be performed at low pressure and moderate speed. Applying greater pressure and higher speed will favour work hardening and can make cutting unnecessarily difficult. The special set of tools should be reserved for stainless steel. It must not have been used on carbon steel before, because the stainless steel would become contaminated with carbon steel particles, which rust and may damage the passive layer of stainless steel. Angle grinders and flame cutters are unsuitable.

While for 45° and 90° bends, the use of appropriate fittings is usually the most obvious solution, there may be situations, in which other angles are required and the tube needs to be bent accordingly. In this case, pipe-benders can also be used for stainless steel. However, because of the higher mechanical strength of stainless steel compared with copper, the bending machine should be strong enough to bend at least the next size up of copper. For diameters above 28 mm, a ratchet or hydraulic machine is recommended. The bending radius should be at least 3.5 times the tube diameter. The material must not be heated as the heat treatment could negatively influence the mechanical and corrosion resistance properties.

Suitable tube cutter and bending tools are available to cut and form stainless steel plumbing tube. Photos: Ridge Tool Europe, Heverlee (B)

7 Summary

Stainless steel in combination with "press-fit" fitting systems is a technically proven, fast and economical solution for tubing. The applications include plumbing, heating and industrial applications for conveying liquids, steam, gas and vacuum. Its assets include speed of installation, versatility and durability. As a mechanical joining technique, which is applied at ambient temperature, fire hazards are avoided. Stainless steel installations using "press-fit" fittings have a high level of corrosion resistance on both the inner and outer surface and are visually attractive in visible applications.

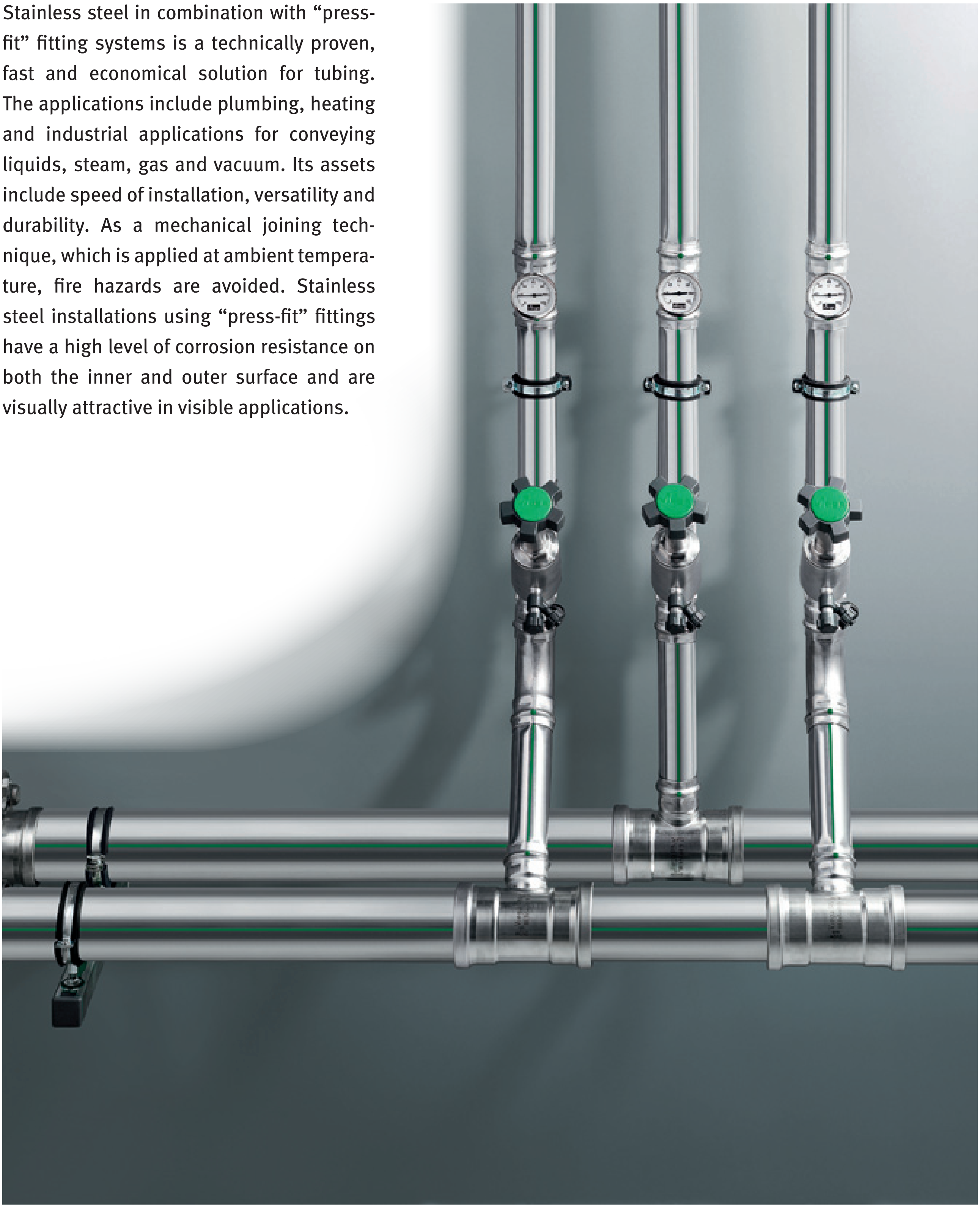


Photo: Viega, Attendorn (D)

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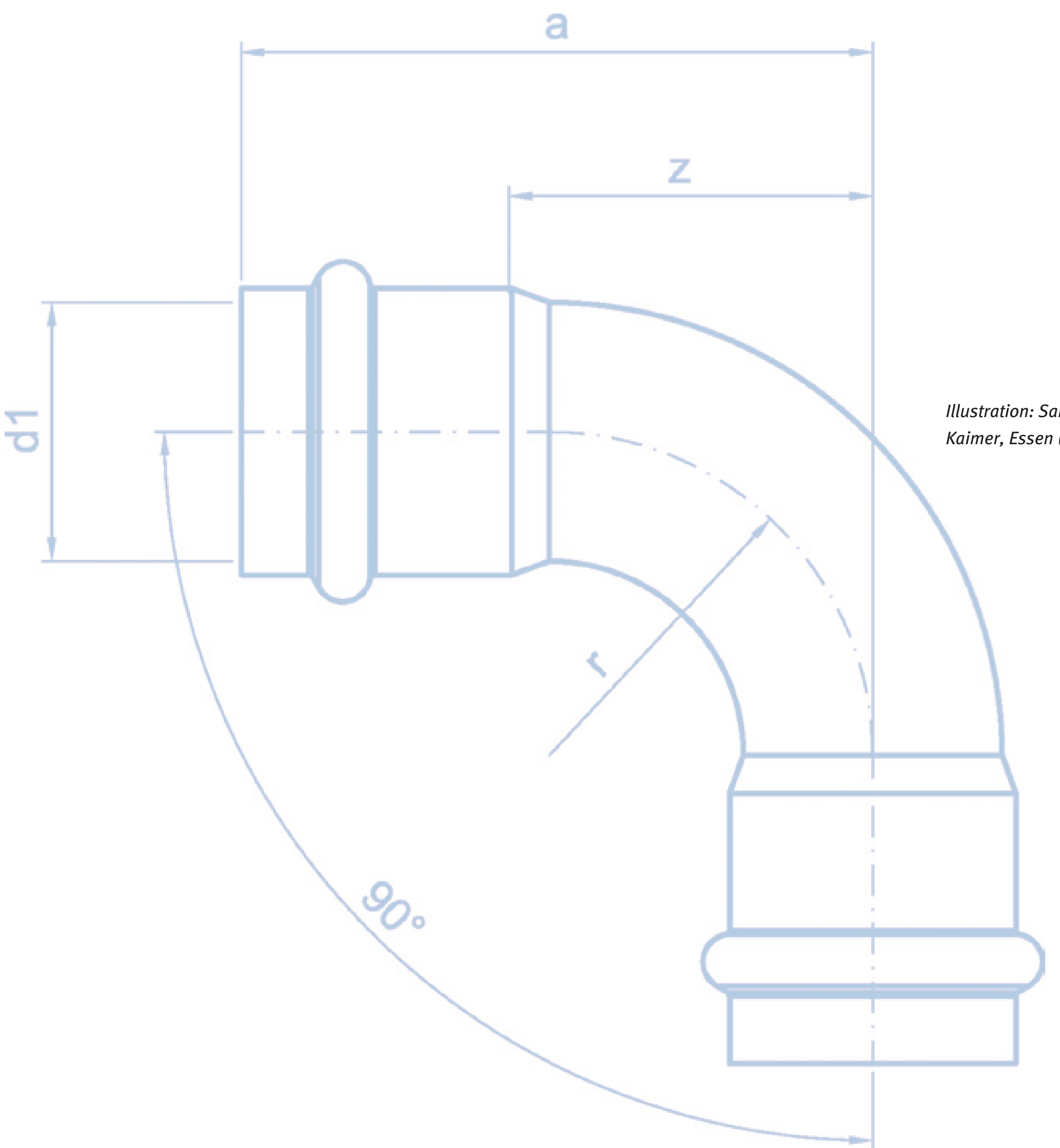

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