Corrosion in Through-Hull Fittings and seacock valves in yachts and boats

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Fortunately, incidents of sudden ingress of seawater into pleasure boats and Yachts are not common events. However, when they happen, in most cases, it is either dangerous, if it happens at sea, or a financial catastrophe, when it happens in the harbour when no one is on board and the boat sinks. - For those reasons, hull openings have always been areas of special attention and requirements.

Over the last several years an increasing number boat owners of especially modern boats have. experienced broken sea cock valves and through-hull fittings. Many boat-owners have been concerned about the durability of their boats' ageing through hull parts and valves in their boat.

In many cases, laboratory examination of failed brass metal parts show that the brass parts have been attacked deep into the metal by dezincification corrosion or has been broken by stress corrosion cracking. The two mentioned forms of corrosion are typical and in general found in brass metals, which represent a number of copper alloys based on mixtures of Copper and Zinc as the main alloying elements. Brass with more than 36 % Zinc is widely used in low cost brass metals, generally used in household water and sanitary installations. These types of brass, typically named MS58 and CW617 and "marine-" or "sea-" brass, are not suitable for seawater applications.

The traditional copper alloy metals for seawater applications in ships and boats are gunmetal bronze and tin bronze. These cast copper alloys are based on copper and tin with the addition of smaller amounts of zinc and lead. Tin bronze and gunmetal are fully resistant against the two forms of corrosion mentioned for brass alloys.

It is another important advantage with bronze alloys that even to a non-expert it is easy to visually distinguish the colour difference of the two groups of copper metals. Brass is yellow, whereas bronze and gunmetal are more copper red as shown in figure 2 below.

The cheap and widely used type of brass alloy is the high zinc type CuZn40Pb2, free cutting brass. This material is a low cost material, easy to machine. However, this material is not corrosion resistant in seawater. Seawater corrosion resistant brass alloys do exist, but it is not possible to visually detect or identify the difference between the good and the poor alloys, without a chemical analysis or a material certificate. Both are costly and in most cases not available. Risk of stress corrosion cracking from ammonia is another possible problem with brass alloys. Under the right humidity conditions even traces of ammonia may cause cracking failure in mechanically stressed brass parts. In most cases "No leak before failure" applies.

Today, new seacock valves and through-hull fittings are specified in two International standards ISO 9093-1 for Seacocks and through hull fittings of metallic materials and ISO 9093-2 for Seacocks and through hull fittings of non-metallic i.e. plastics materials.

ISO 9093-1 specifies *"Materials used shall be corrosion-resistant or shall have protection against corrosion".* Unfortunately, the text is not sufficiently specific in its requirements. Only material experts know that only bronze and gun metals among the most common copper based alloys will fulfil the requirements.

Bronze, Gunmetal or Brass

For many years, the mostly used gunmetal alloy has been the type 85-5-5-5 cast gunmetal, which in the present European Standard EN 1982 is denominated CC491 or CuSn5Zn5Pb5. For valve shafts in seawater valves there are special types of brass with as high copper content and additions of arsenic that will prevent dezincification corrosion.

Many seacock valves are marked with the alloy material. It may be MS58 or CW617, as shown in figure 7. In old valves it might be the manufacturer's own material designation. With no marking to identify the alloy, the boat owner will have difficulties. For new parts it is important to check the marking so that the boat owner is not just replacing the old ones with new parts made from a poor brass material.

Today it is possible with most boat equipment suppliers and shops in Denmark to find both bronze/gunmetal through-hull fittings and ball valve seacocks. In most places, they are placed just next to the equivalent and cheaper brass valves. The bronze and gunmetal parts are more expensive than brass parts, which one may call "cheap brass".

It is relatively easy to visually determine, whether the hull fitting or seacock valve is made of brass or gunmetal/bronze. Brass is visibly more yellow, like a Danish 10-20 DKK or a Euro coin. Gunmetal and tin bronze are more reddish in colour. If the surface is tarnished, it is necessary to grind the surface clean and compare the colour with reference samples, if in doubt.

The mentioned coins are made of aluminium bronze. This is a high strength alloy. This group of materials are not recommended in boat hull fittings and valves as not all aluminium bronze alloys are corrosion resistant in seawater and they may suffer from severe de-alumination, which is yet another form of selective of corrosion.

Special types of brass are not attacked by dezincification or selective corrosion. These brass alloys have less than 36 % zinc and have added a small amount of Arsenic. The practical problem is to distinguish between the various types of brass alloys. It is not possible to identify the type and composition of a fitting or valve without an expensive laboratory chemical analysis or other destructive tests.

Determination of dezincification attacks of old brass hull fittings may often be discovered by scratching or grinding the metal surface from the outer seawater side. If the colour in a surface layer is more reddish and softer than found further down into the material or even red as copper, it is a clear sign of dezincification attacks. In such a situation, it is recommended the hull fitting and valve be replaced.

However, dezincification corrosion is not the only problem that makes brass hull fittings and sea cock valves unsuitable, even if the brass should be dezincification resistant. Stress corrosion cracking is a potential problem, which may attack all types of brass. Stress corrosion cracking occurs as cracks formed by a combination of mechanical stresses and the effect from moisture and ammonia. Under the right conditions, a cleaning detergent with ammonia, as found in many household cleaning aids, may provoke the stress corrosion cracking process.

It is the general recommendation to avoid using brass hull fittings and valves unless they are properly declared and documented to be a proper seawater resistant type of alloy.

Stainless steel

Stainless steel is an alternative, which many suppliers and shops also offer for through-hull fittings and ball valves are stainless steel. Within the field of stainless steel, there are several types. Today most boat owners know that best available quality is molybdenum alloyed acid prof stainless steel, also commonly denominated AISI 316. This material is widely used for all stainless parts above the waterline. The material surface is here kept clean from salt by the frequent raining of fresh water and drying.

In ocean seawater acid proof stainless steel AISI 316 has only limited corrosion resistance. The corrosion properties of stainless steel AISI 316 in seawater depends of the water temperature and the salinity of the water. This means that it might work in the northern Norway, Sweden and Finland where the water temperature is below 10 C° all year and the salinity in the upper Botnian bay is below 1%. In tropical and subtropical seawater, the conditions are the opposite with water temperatures varying between 20-30 C° and a salinity level of 3,5%. Corrosion attacks in the

form of crevice corrosion will be initiated after an incubation period of 3-6 months. In Danish sea environments, the incubation period may last a few years before crevice corrosion attacks starts. The crevice corrosion attacks will be visible as rusty red stripes going from the space between the external fitting flange and the glass fibre hull. This is a characteristic sign of active crevice corrosion in the joint. Over time, it will lead to a leak. However, this is more seldom than a slowly seeping leak.

Plastic compound
Non-metallic through hull fittings and sea cocks also comprise an alternative which is standardised in EN 9093-2. These fittings and valves are made of plastics, which are not directly exposed to corrosion. Through-hull fittings and seacock valves are produced from different materials e.g. Nylon, Deldrine, PVC or fibre reinforced plastics. At high stress levels, some materials may suffer from stress induced cracking if tightened too hard. For the safety of the consumer and boat owner, the standard defines a number of requirements that have to be fulfilled.

In order to ensure that you are buying through-hull fittings and sea cock valve parts of a good quality, it is important that each part is marked or followed by an attached label containing the following information as specified in the two EN 9093 standards:

- ✓ The name of the manufacturer
- ✓ Declaration of the fitting must be in accordance with EN9093-2
- ✓ The materials of all the fitting parts
- ✓ Size and type of tread
- ✓ Nominal bore diameter
- ✓ Installation requirements including bedding compounds
- ✓ Maximum torque for tightening during installation
- ✓ Maintenance and replacement requirement

Parts, which are not properly declared, are in principle non-specific "No-name parts" which should not be used for underwater parts.

Maintenance
In existing vessels, owners should consider replacing hull fittings and sea cock valves if they are made of brass. Old brass gate valves may fail without "leak before failure" as shown in the example in figure 8. Until then, as a minimum, every year before launching the boat in the spring, and in the middle of the summer you should:

- ✓ Check for signs of leaks at all the through-hull fittings and sea cock valves
- ✓ Pull hard in all hose nozzles, valve handles, tubes etc. Even if only one of these cannot withstand this inspection they should all be replaced before the vessel is launched into the water.
- ✓ Check that all valves can be operated easily by opening and closing them several times. If a valve starts to become tight to operate it is due time for replacement.

Several of the available new ball valves in the marine shops, which are intended used as sea cock valves, look correct with a bronze/gunmetal house/body in the correct reddish colour. However, you cannot be sure, unfortunately. At the market you may find e.g. Italian valves (labelled "ITALY" in the galvanised handle) with a shaft made from the poorest type of free cutting brass. Such valves will only last a couple of years, as the valve shaft will start corroding and start seizing due to dezincification. In the end it will become stuck and break, at which point you will have to pull the lever hard.

The present standard for through-hull fittings Seacocks ISO 9093-1 is being revised. It is the hope that the section covering the materials requirements will be improved and become more specific.

Overview of mostly used materials for through-hull fittings and sea cock valves

Popular name	EN material mark	Composition	Properties in seawater
Gunmetal / tin bronze Danish RG5	CC 491 CuSn5Zn5Pb5	85%Cu, 5%Sn, 5%Zn, 5%Pb	Corrosion resistant material for cast parts
Tin Bronze Danish RG10	CC480 CuSn10	90%Cu, 10%Sn,	Corrosion resistant material for cast parts
Admiralty brass	CW 706 CuZn30Sn1As	70%Cu, 30%Zn, Sn	Corrosion resistant material for valve shafts and tubes. Low risk of stress corrosion cracking
Brass, Ms58 Sea metal Marine brass Naval brass	CW 617N CuZn40Pb2 CW 612N CuZn39Pb2	58-59%Cu, 39-40%Zn, 1-2%Pb	Not corrosion resistant. Becomes attacked by dezincification and sensitive to stress corrosion cracking.
Dezincification resistant brass/ Special brass	CW 602N CuZn36Pb2As	62%Cu, 36%Zn, 2%Pb, As.	Some corrosion resistance in seawater. Resistant to dezincification. Low risk of stress corrosion cracking. Material for valve shaft
Stainless steel 18/8 AISI 304	W.st. 1.4303 X5CrNi18-9	18%Cr, 8%Ni	No corrosion resistance even in cold and brackish seawater. Attacked by pitting and crevice corrosion after a short time in seawater.
Acid resistant stainless steel AISI 316	W.st. 1.4401 X5CrNiMo17-12-2	17%Cr, 11%Ni, 2,5% Mo	Partly corrosion resistant - only in cold and brackish seawater. Attacked by pitting and crevice corrosion after some years of exposure in seawater
High alloyed stainless steel 254 SMO	W.st. 1.4547 X5CrNiMo20-18-7	20%Cr, 18%Ni, 7%Mo, 1-2%Cu	Good corrosion resistance in seawater. Seldom attacks of pitting and crevice corrosion. Expensive alloy.

As always, the final question is: *"Do I have to change my through hull fittings and sea cocks"?* --"*They look all right to me and work properly"*.

To give the correct answer the boat owner and skipper must first consider the following question: *How do you weight the risk of failure and possible sinking of your boat versus the cost and work of replacing the through-hull fittings located under the water line with new made of approved gunmetal, bronze or plastic fittings complying the ISO standards?*

When you have this answer the answer of the first question becomes easy.

Figure 1 Hull fitting for cooling water, made of brass, broken in the thread inside the boat. Possibly due to ammonia stress corrosion.

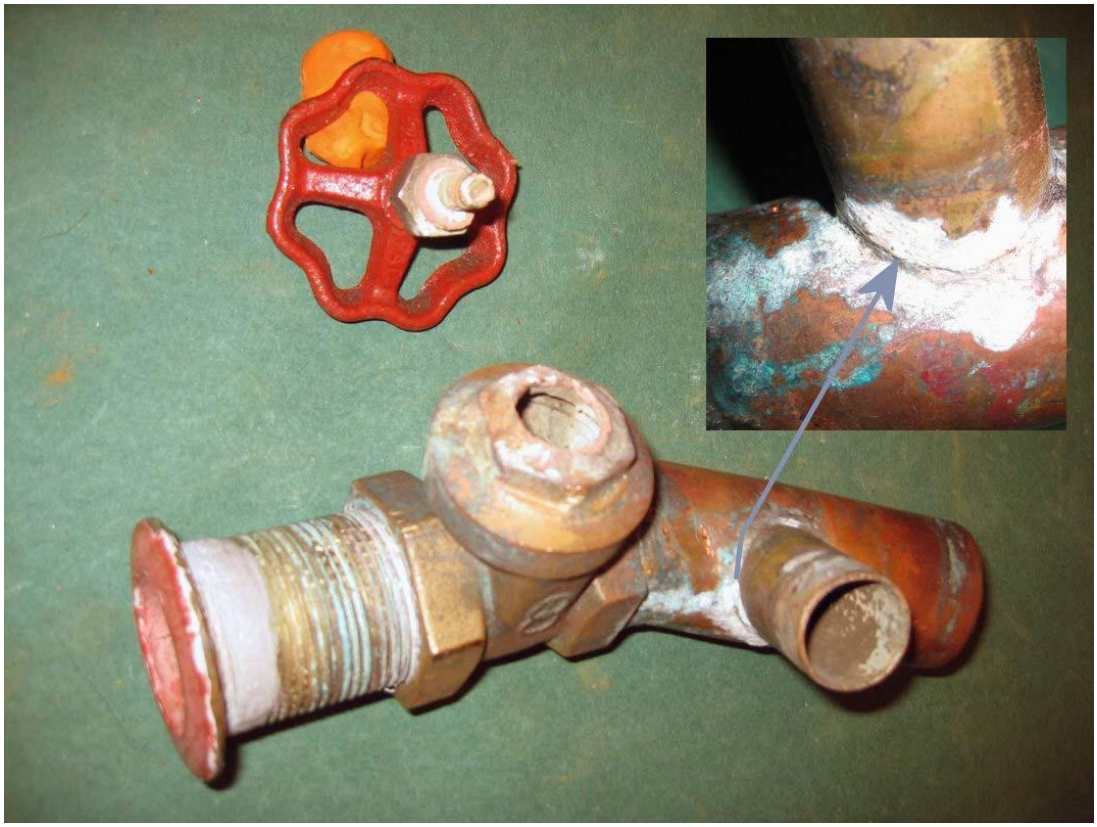

Figure 2 Dezincification and broken gate sea cock valve. The cover has broken off causing a major leak and major ingress of seawater into the boat.

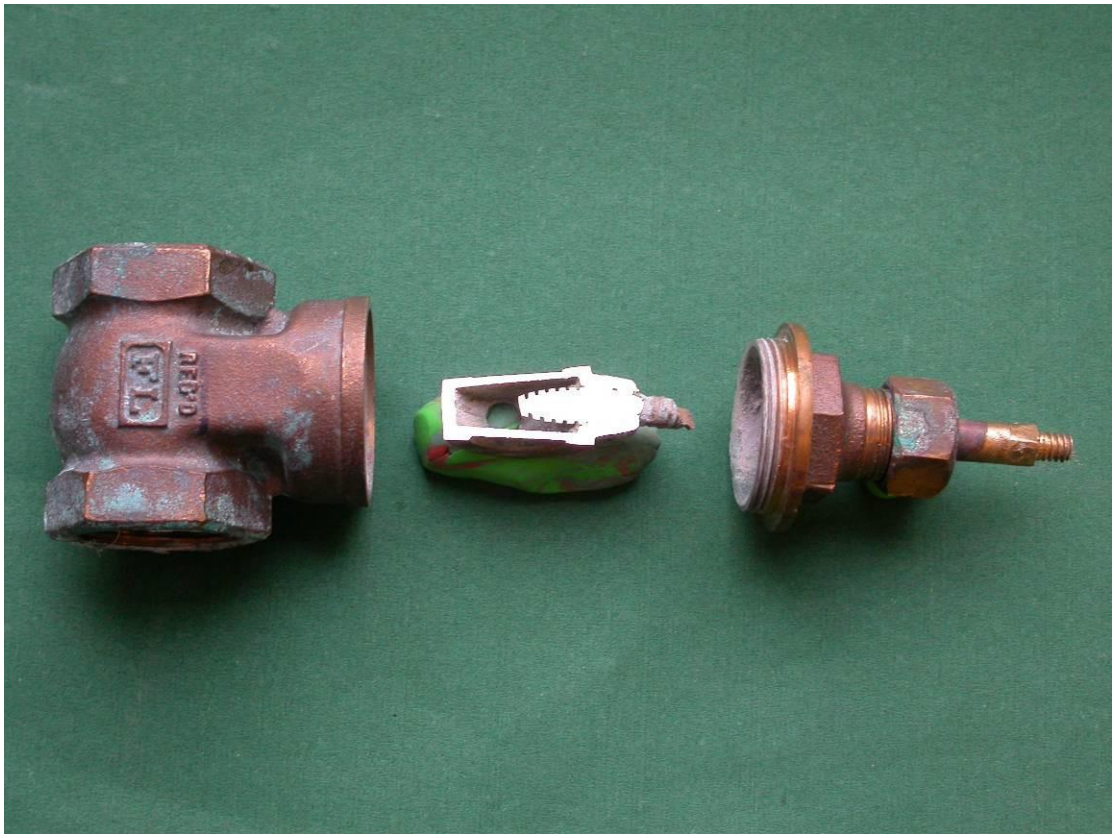

Figure 3 Old gate sea cock valve made from gun metal housing and stem. The brass spindle is attacked by dezincification corrosion and has jammed and finally broken.

Figure 4 The broken spindle in the stem. The colour difference between the light yellow brass and the red-yellow bronze is obvious here. The brass metal is attacked by dezincification corrosion causing the spindle to jam and break.

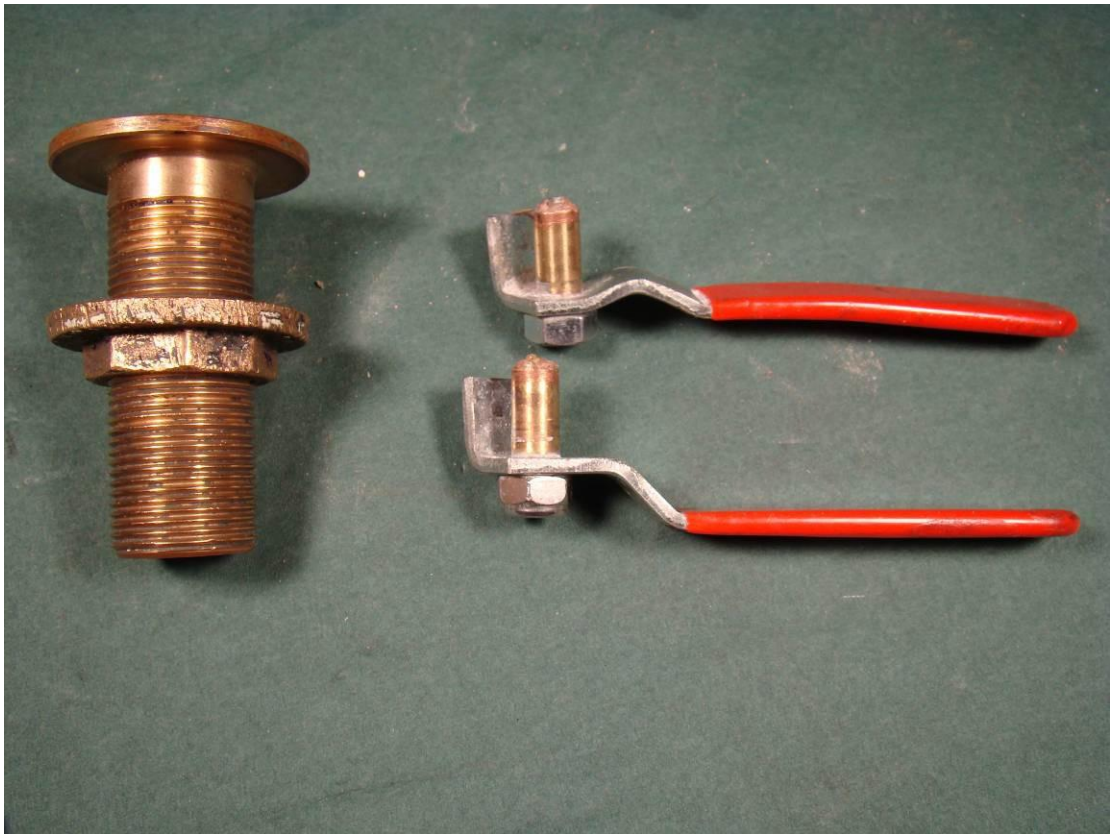

Figure 5 Replaced intact bronze hull fitting and two valve handles with broken brass shaft from ”new” bronze ball valves. The shafts are made of non-dezincification resistant brass. The handle is marked ”ITALY”.

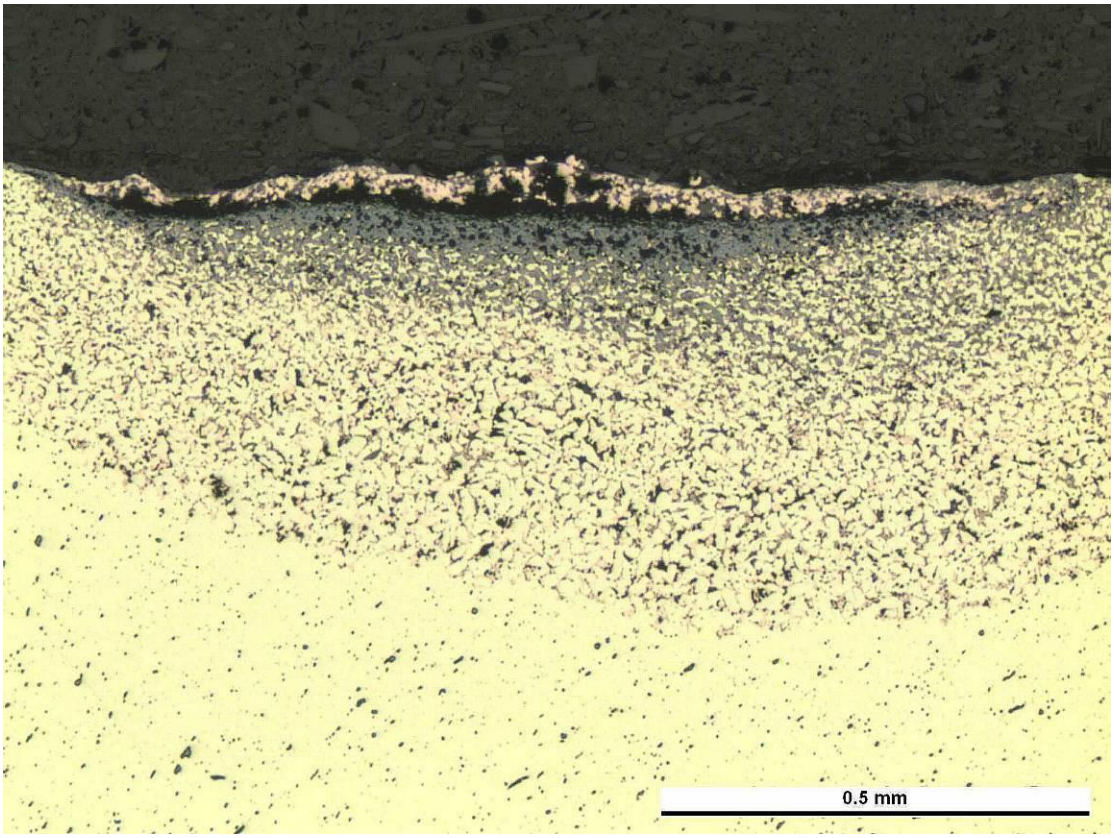

Figure 6 Attacks of selective corrosion seen as dezincification in the brass microstructure. This attack is still only 0.5 mm, but continues until the fitting will leak or break.

Figure 7 Brass alloy MS58 ball valve. The valve is Nickel coated on the outer side. The internal parts are attacked by dezincification corrosion. The material is intended for fresh water not seawater. MS58 is an old Danish material designation for CW617

Figure 8 Brass alloy ball valve marked with CW617. The valve is Nickel coated on the outer side. Possibly, the internal parts are attacked by dezincification corrosion. The material is intended for fresh water not seawater.

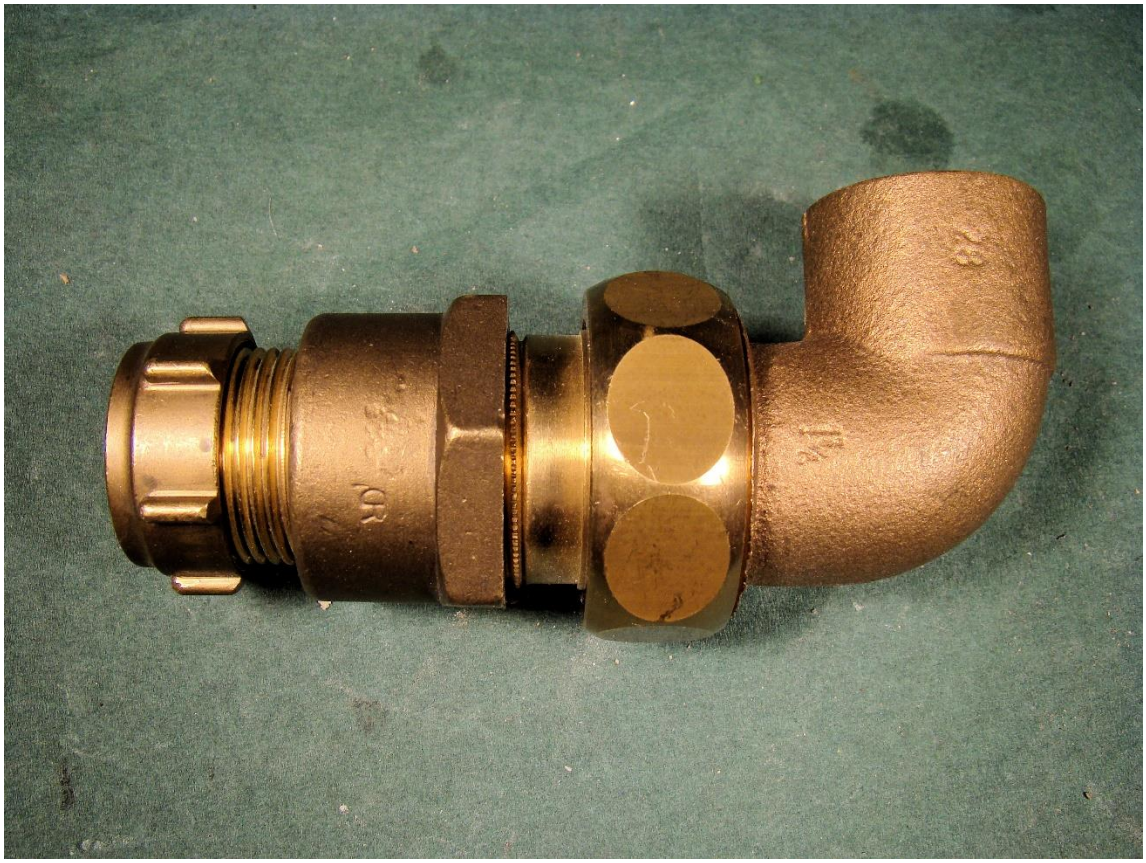

Figure 9 Combination of yellow brass fittings and reddish gunmetal bronze pipe-bend
Note the colour difference.

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