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# Modern Dispense Systems and Coated Brass Equipment – is this up to date? Results of an Investigation

For more than ten years different committees and boards have been discussing the very controversial usage of coated brass equipment in beer dispensing systems. For many years now, the use of those components has been forbidden or recommended not to be used in many countries [1, 2]. However, they are still being used in Germany today. The repeated efforts and recommendations of the “Arbeitskreis Getränkeschankanlagen des Deutschen Brauer-Bundes” to use solely equipment made of stainless steel have not yet penetrated into the awareness of all responsible persons in breweries as well as at suppliers [3]. Due to the fact that no scientific data is available, scientific proof became a necessity. Several investigations were carried out to determine the amount of lead released from coated brass equipment which came into contact with beer. This was done to investigate whether the usage of these components would affect the quality of draught beer or not. After a preliminary screening, two systematic test cycles under realistic conditions were completed to figure out the impact of coated brass hose nozzles and beer taps had on the quality of the beer which consumers are served by means of restaurants and pubs. The release of lead and other elements (element spectrum according to PV AAS030) was measured as well as the surface condition after a certain time of usage. Additionally a general material analysis was done by the German Bundesanstalt für Materialprüfung, BAM, in Berlin. As a result of these investigations it was shown that the measured lead contents (around 0,2 mg/l) are debatable but, because of missing legal basis, not enough to convince experts to a common action. From the investigations another definite result was consequent: The main aspect for a prohibition of coated brass dispensing equipment is the delamination of the coating, and the corrosion after the delamination.

Descriptors: Dispense equipment, coated brass, tap, nozzle, lead, delamination, surface condition

## 1 Introduction

In the whole food industry coated brass equipment is usually no longer in use, for which diverse reasons exist. The most important reason is the release of lead which is enriched in the foodstuffs and thus biologically accumulated in the human body. Due to good grindability brass with contents between 2.5 % to 3.5 % lead is conventionally used, which holds up the biggest share in production. Unfortunately coated brass devices are being used to mount dispensing systems in Germany. In order to avoid an unintended crossover or accumulation and to prevent the migration of lead and other elements, brass equipment is normally nickel-base coated.

Technically a clear distinction between chemical precipitation (nickel coating) and electro deposition (galvanization) is drawn, but due

to the fact that electro deposition is much cheaper than the former procedure, the latter is often preferred.

International and national (German) regulations and recommendations place certain requirements on materials which come into contact with foodstuff [1, 4–7]. At this point it should be stated that in Germany beer is legally recognized to be equivalent to foodstuff. The DIN 6650-2, which defines requirements for dispensing equipment materials, refers to those regulations [8].

A few years ago, investigations were conducted on water-taps, coffee-makers and other household and gastronomy equipment [9]. The results have shown the necessity to replace coated brass materials with plastics or stainless steel [1, 10]. The main topic in these reports was lead release, which is even higher at low pH values [1, 11]. The Federal Environment Agency (UBA, Umweltbundesamt) of Germany, made a recommendation to replace all water pipes made of lead [12]. Indeed the recommendation was made primarily for pregnant women or teenagers, but the health hazards of lead are well known to all. In another paper the UBA points out [13] that even brass components can contain small amounts of lead. It was also indicated that these components contain nickel and approximately 1/6 of the German population is allergic to nickel.

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According to these previous examinations on water-taps and coffee-makers, in this work first results were presented for coated brass equipment used in beer dispensing systems. These findings showed that lead concentrations (0,1 mg/l and more) are not hypercritical but there is a need for action. From the presented results one can clearly derive that galvanized coated brass equipment should be no longer used in dispensing systems and must be substituted step by step with stainless-steel equipment.

Dispense equipment made with a coated brass does not comply at all with the mentioned regulations and is still in use to mount dispensing systems. The big question is why? On the one hand legal regulations are available as mentioned, but are not sufficient for brass-banning so far. On the other hand a small price advantage exists in comparison to stainless steel. And as a third argument there is the humans psychology of traditional, authentic beer when draughted with bras equipment.

Another big problem which is responsible for the rejection of brass in the food industry arises regarding the insufficient coating, as mentioned above, and thus causing easier delamination of the coating. The investigations as well as the knowledge gained from experience in handling dispensing equipment have clearly shown that this present type of lamination is not adequate in combination with beer, mainly because of high flow rates and changing pH-values (acid beverage, caustig cleaning agent).

The main objective of this work was to prove from the scientific and industrial point of view that the coated brass components used are not appropriate for usage with beer. After pre-investigations the Chair of Process Engineering of the Technische Universität München initiated in cooperation with the Berufsgenossenschaft Nahrungsmittel und Gastgewerbe (BGN), Mannheim, an intensive methodical long-term analysis of hose nozzles and beer taps. The aim was to find out the amount of lead in beer, which was released after a defined time of contact. Additionally the inner surface, the quality of the coating and the condition of the coated brass devices used were also analyzed.

Results of these investigations were published partially in a Brauwelt paper [14] and in an EBC poster [15]. In this paper results are more deeply reported and debated again with new legal issues.

## 2 Materials and methods

### Test setup

The investigations were held with two components – hose nozzles and beer taps.

In the trials with hose nozzles, the test setup was prepared as shown in figure 1. In the complete setup, these 4 parts were the only ones made of brass with nickel coating. The coupler was made of stainless steel as well as the ball valve; the feed line and the tap were made of plastic. This setup ensured that the lead concentration measured was activated from the coated brass hose nozzles. The other materials are known as lead-free materials. In addition to the samples in the feed lines, samples were taken directly from the keg engaged as zero-value in order to detect possible lead concentrations already found in the beer.



Fig. 1 Test setup for the hose nozzle testing. The circles show the places where the coated brass nozzles were used. On the right picture a double threaded piece is shown [14, 15]

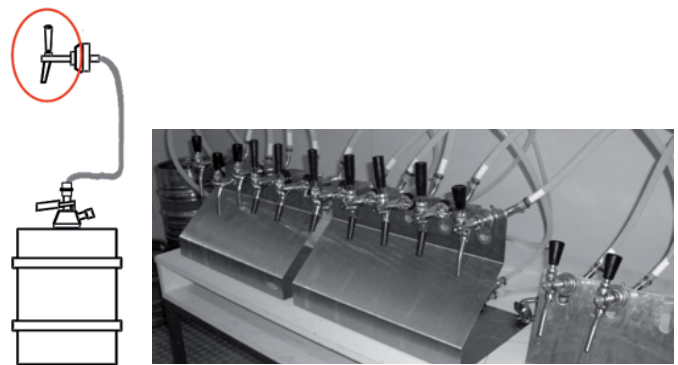


Fig. 2 Test setup for the tap testing, the beer taps used are seen in the right image [15]

The beer lines had a length of 2 m and a diameter of 10 mm additionally the filling volume was approx. 175 ml. In the middle of the line, a double threaded piece, made of PTFE, was used. Every type of hose nozzle was tested in three different lines (three lines at a time representing a test set-up with identical nozzles to meet statistical requirements) thus the complete testing setup consisted of 9 lines. Regarding the hose nozzles three different types were assigned: brand new (named "N"), brand new and damaged on purpose (named "Z") and already used (named "A"). The new hose nozzles were bought from a supply shop, the previously used nozzles had been in use at the institute for a period of two years. At this point it has to be stated, that in regards to the results of the BAM (cp. results below), hose nozzles from just one manufacturer were mounted in the test setup.

For the testing of the taps, a similar test setup was applied (comp Fig. 2). Instead of the coated brass hose nozzles, nozzles made of stainless steel were used. The keg couplers were also made of stainless steel. The double threaded piece was not used, because the testing focus was on the taps. Four different taps were bought, with 3 taps of each type. The whole test setup in this case showed 12 lines. Due to data privacy, the names of the four different manufacturers are not indicated. The taps were named with V1–V4. Tap 1 and 4 were free flow taps, 2 and 3 were compensation taps.

### Release of lead

In order to release the lead from the components the beer line was filled with beer (Weihenstephaner Original, pH: ~4,4) for

6 days with a replenishment every second day. The 7th day was the day of cleaning. On this day the complete system was filled with a caustic cleaning agent for 6 hours. This simulated 12 cleaning cycles of regular use with the dispense system. After the cleaning, the lines were refilled with beer. The sampling was carried out after an incubation time of 18 hours. The tests were held for 8 weeks with a weekly cleaning treatment for 6 hours in order to simulate forced aging.

### Sampling

The samples were taken every 7th day as described above. The samples were taken from the tap and put into a sampling bottle. In these bottles, concentrated nitric acid was prepared as groundwork for the analysis and to avoid foaming during the tapping.

### Analysis methods of metal release

During the testing period the metals released from the components into the beer were analyzed. The analyses were done at the Forschungszentrum Weihenstephan für Brau- und Lebensmittelqualität (BLQ). The metals were analyzed (copper, zinc, aluminum, et al) in accordance with PV AAS030 by BLQ. The lead was measured in accordance with DIN 38406-6.

Analysis of the inner surface, the quality of the coating and the condition of the coated brass equipment used

In addition to the analysis of the released metals, samples of the brand new components were sent to the Bundesanstalt für Materialforschung (BAM), Berlin. They analyzed the inner surface, the quality of the coating and the composition of the existing elements in the brass. A special emphasis of these analyses was focused on damages in the inner surface and the gauge of the coating. For these analyses, the components were moulded in plastic and cut in to pieces. These areas were analyzed with light microscopy (inner surface) and SEM/EDX (metal alloy). SEM/EDX is a well known combined analysis method of Scanning-electron-microscopy and energy dispersive X-ray.

## 3 Results and discussion

### Hose nozzle testing results

Figure 3 shows the released concentration of lead during the incubation time. It can be seen that the amounts are rather different in the 9 lines. The zero-value indicates the measurement resolution, which is equivalent to non-lead beer which was originally used.

Investigations of the beer in relevance to other metals and substances induced showed no elevated levels.

Figure 4 shows an example of the areas of lead clusters in the cutting area of one of the investigated hose nozzles. It is obvious that the elements are distributed very inhomogeneously. These results were shown in all cases of the analyzed hose nozzles.

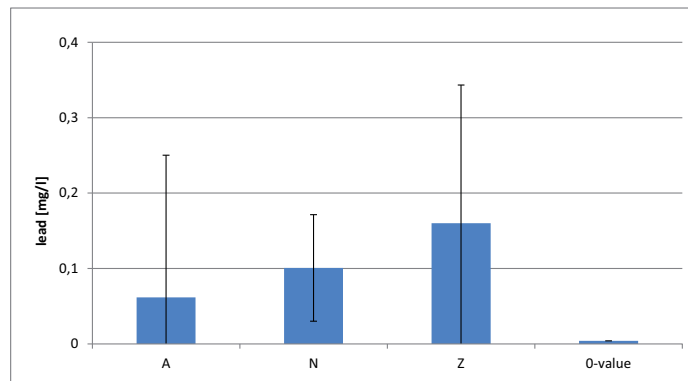


Fig. 3 Lead contents in the beer after the incubation time of 18 hours, dissolved from the hose nozzles

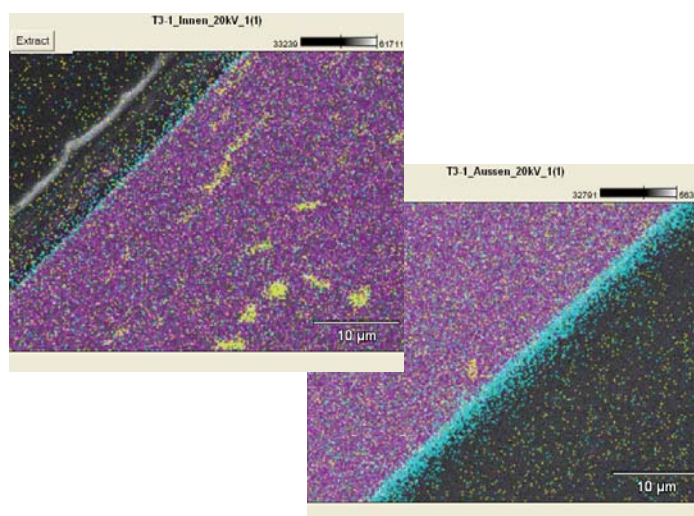


Fig. 4 SEM/EDX picture of a hose nozzle; the white dots indicate the lead clusters in the metal alloy

The SEM/EDX images show more results. Besides that the quality of brass was insufficient, also the condition of the inner surface was very poor. As the experts of the BAM explained, pores (open, not permeable pores) are partially necessary to avoid stress concentration on the surface. Especially in the use with foodstuff, a protective layer must be placed between the surface layer and the brass. Amazingly, none of the nozzles had shown such a protective layer.

For all four different manufactured hose nozzles, the investigation results from BAM showed that the coating varied in thickness, homogeneity, adhesion and also had scratches and cracks. Figure 5 shows examples of cracks and bad spots in the simple nickel coating of the inner surface. An unexpected result was that in two cases out of the three investigated inner layer coating was inhomogeneous and in most cases was thinner than 3 µm or even not detectable at all. Furthermore, poor adhesion of the coating was detected as mentioned in all hose nozzles as illustrated below.

For optical analysis, the hose nozzles, which were used for the trials in Weihenstephan, were sectioned in half after the tests. As figure 6 shows, the interior surface of the hose nozzle was damaged. It is clearly visible that the coating had peeled off from the brass.

During the test period, the beer sampled was also checked, beer analysis demonstrated that the detached coating, from the internal side of the hose nozzles, were able to pass into the glasses of beer as little metal chips.

### Hose nozzle testing discussion

During the whole testing time, different lead concentrations were observed in various beer lines. The large confidence intervals showed that the high inhomogeneity of release exhibits and therefore a systematic lead release could not be justified at the first moment. These deviations of lead concentration can be explained with the lead clusters detected in the brass. The SEM/EDX pictures of all the examined hose nozzles, provided by the BAM, show this inhomogeneity very clearly. It can be assumed that due to the random distribution of the lead clusters, a random and partial lead release from the alloy occurs. Another necessary condition is the direct contact of the brass with the beer itself, which is only possible if the applied coating has defects, cracks or in the worst case, does not exist any more.

Figure 3 shows an example of one of the analysis results. These results show high amounts of lead in the beer, which tends to come from the surface damaged nozzles. It was also seen that beer from the lines with new nozzles partially delivered higher lead concentrations than the used ones. This is surprising because of the fact that the used nozzles had no protective coating left on the internal side. This situation can be explained due to the inhomogeneous distribution of the lead clusters in the alloy. Depending on the area of such spots and on the right electrochemical preconditions, the elution happens very randomly and more or less intensively. Statistically, there is no difference between new and used nozzles which means that the coating is inefficient and useless against lead release.

### Beer tap testing results

Tap testing exhibited similar results as those of the hose nozzle. However, the conditions on the inner surface were even worse than those conditions in the hose nozzles. In three cases out of four the coating was too thin, inhomogeneous with cracks and other defects. Figure 7 shows the lead content in the analyzed beer samples: The huge confidence intervals can lead one to the conclusion that the lead in the alloy, which is used for the beer taps, is distributed as random as in the hose nozzles. The white dots in Figure 8 prove this argument, again, it is obvious that the lead is distributed in clusters.

The investigations of the beer in these trials also showed no elevated levels of other metals and substances induced.

As already seen in the investigations of the nozzles, the quality of the coating is not sufficient for usage with beer. Usually the internal surface should be made of chrome (BAM information), but with the taps investigated, their surfaces were coated with nickel. Most of the internal tap surfaces had defects, insufficient gauge or were imperfect (cp. Fig. 9). Because of an insufficient adhesion of the coating, a delamination was already expected to occur by the BAM experts. The delamination was also observed in reality (cp. Fig. 10).

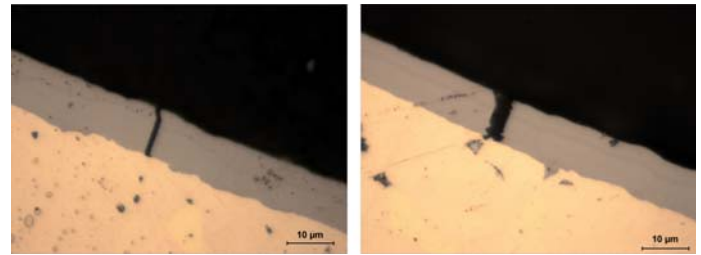


Fig. 5 Light microscope (OM, optical microscopy) picture of a hose nozzle, showing the quality of the coating. The arrows show cracks in the coatings which indicates insufficient and incomplete galvanization [14]



Fig. 6 Picture of a used hose nozzle sliced in half. The arrow refers to the areas where the coating is detached after the trials [14, 15]

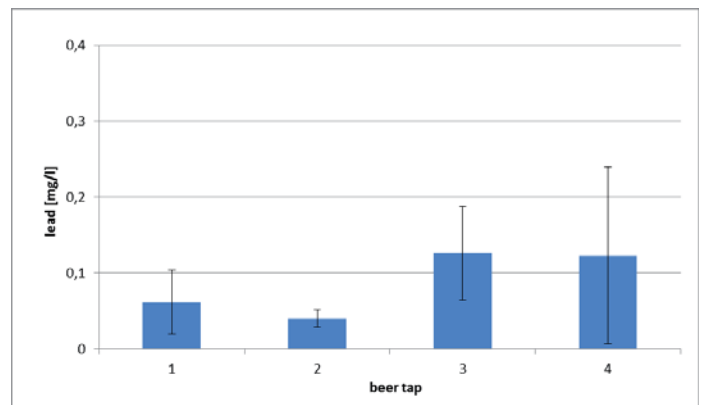


Fig. 7 Lead contents in the beer after incubation time of 18 hours, dissolved from the beer taps

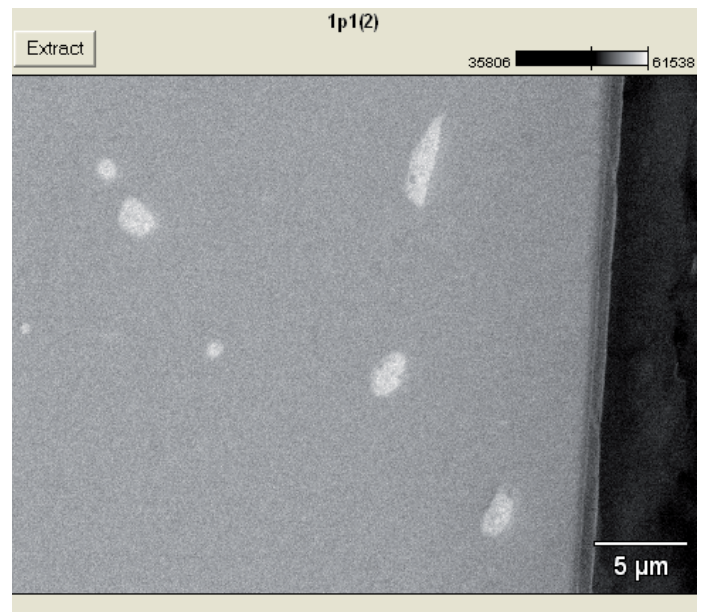
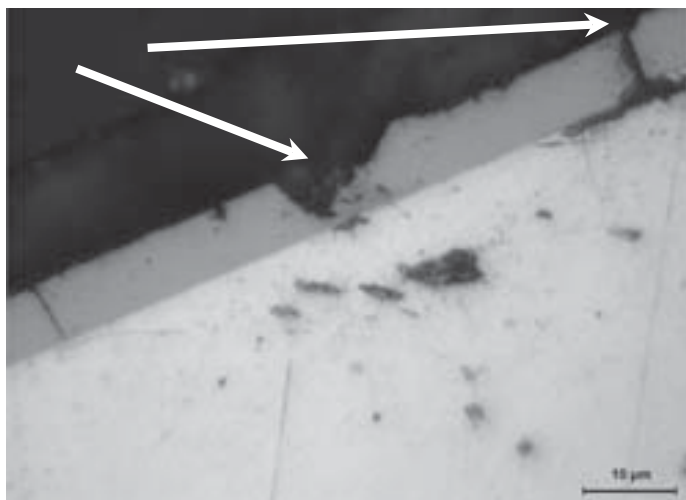


Fig. 8 Lead clusters in the alloy of tap no. 1 (detail of cutting area)



**Fig. 9** An example of the surface defect in a beer tap used for the trials/OM (optical microscopy)



**Fig. 10** Delamination of the internal nickel coating [15]

Another big problem, especially after the delamination, is the potential of surface oxidation. Figure 11 and figure 12 show examples of the taps where the components corroded to a very large extent during the testing period. In some cases the coating was completely detached from the inner surface such that; the internal side unveiled pure brass (cp. Fig. 12 at the bottom right).

### Beer taps testing discussion

The results of the hose nozzle testing were confirmed with the beer tap testing. The results have shown the same behavior in lead release and delamination of the coating. The reports of the BAM have shown that the quality of the coatings on the internal surface of the taps was absolutely insufficient for usage with beer.

Besides deep health risk, also sensorial influences are expected in the taste of the product not to mention law violation [4]. As a third risk, there is greater potential for microbiological infections through biofilms accumulations. Due to this fact, the German

UBA recommends a replacement of coated brass components for water [13] were similar effects of corrosion and taste changes were observed. The same must be recommended for beer lines if coated brass components are still to be part of the equipment.

### General discussion

One part of these investigations (nozzle investigations) was already published in a BRAUWELT paper [14]. As the discussion afterwards was very intensive, the second testing with the beer taps was done. First results of these trials were shown in a poster at the EBC 2009 in Hamburg [15]. As a consequence of these, new aspects and discussions on the use of brass components were held which are presented in this publication.

For a general assessment of the release experiments, it would be helpful if the limits of lead in beer could be based on the prescribed limits of lead in drinking water. This value is currently at 0.025 mg/l, starting on 01.12.2013 it will be even only 0.010 mg/l [13]. However this is not entirely trivial from the legal side, since water is a staple food, but beer is not a staple food [16]. But as Rapp announced furthermore, the European regulation (EC) No 1935/2005 [4] and the German LFGB [5] give clear guidelines with which requirements are placed on materials that come into contact with foodstuff. Considering this legal situation food inspectors have no possibility to enforce the replacement of coated brass equipment. Besides that, the U.S. FDA requires to the non-usage of brass equipment for foodstuff with a pH lower than 6 [1], which is satisfied in any beer (pH: ~3,8-4,4) and almost all beverages (e.g. pH of soft drinks: ~2,1-3,6).

As a result of the examination one can recognize that lead release is not the only problem with coated brass components. The other aspect is the coating delamination and the corrosion. If food inspectors observe this fact, then legal consequences are easily possible [17]. More punitive measures are in preparation, this is based on regulations requiring that no alterations in foodstuff properties is allowed during distribution to the consumer.

## 4 Conclusion/Summary

The testing of the hose nozzles and of the beer taps has shown that coated brass is not a suitable material used to construct equipment for dispensing systems.

Although, lead is released from the alloy but from the legal point of view, the amounts are too small, thus it is not possible to forbid those components based on this part of the investigation. Only detected allergic reactions caused by the release of e.g. nickel could probably lead to restrictions being placed. But this was not part of this investigation. Regarding the reported results it cannot be assumed, that no further actions are required.

Additionally the investigations have shown that the coating, which should protect the body material of the components made from brass against corrosion and release, was not sufficient in most of the samples analyzed. The consequence was delamination of the coating. On this point, food inspectors can intervene and forbid very easily the use of those components because of violation of laws.



Fig. 11 Massive corrosion of the components

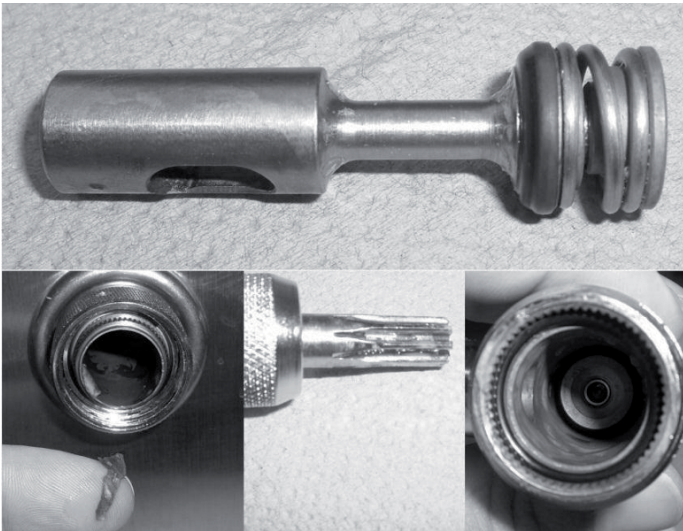


Fig. 12 Massive corrosion of the components [15]

As a consequence of these investigations, the German SK-Sign, used as a certificate for dispensing equipment quality is no longer given to components with direct contact between coated brass surfaces and foodstuff [18]. Bavarian food inspectors are now also educated and vigilant to observe coated brass components much more intensively. The legal basis for this is – according to German food inspectors – the *Bedarfsgegenständeverordnung* (*BedGgStV*) [17].

In conclusion to the investigations it can be said that coated brass equipment is not suitable for use in dispensing systems. Although there are no large health risks due to the amount of lead in the beer, nevertheless the delamination and the corrosion of the materials provide enough reasons to prohibit the use of such coated brass components. In other words: From the present results one can derive that galvanized coated brass equipment should no longer be used in dispensing systems and has to be substituted stepwise with stainless-steel equipment.

Finally, it should be noted that the corrosion of materials that come in contact with foodstuffs, are revolting. This provides strong grounds for food inspectors to penalize the usage of such equipment.

After concluding these investigations, the aim of the leading food law experts for the whole Federal Republic of Germany should be the prohibition of all coated brass components in beverage dispense systems.

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