

# 720 hrs salt spray corrosion resistance plating for RF connectors

White Paper



# Abstract

HUBER+SUHNER AG and Rosenberger Hochfrequenztechnik GmbH & Co. KG are leading suppliers of RF and optical connectivity components including but not limited to connectors, cables and assemblies for telecommunications, space & defence and test & measurement applications. Since material plating is a crucial parameter in defining performance of a RF connector, both companies have state of the art plating facilities and R&D capacity for new plating development. In order to provide the customers with detailed information about different platings and their performance regarding RF connectors, HUBER+SUHNER and Rosenberger have worked very closely together to create this white paper which can be used as a reference while evaluating different plating options. This white paper evaluates traditional state of the art platings as well a new proprietary plating, SURO720, developed in partnership by HUBER+SUHNER and Rosenberger.

To find out the performance of a variety of platings on RF connectors the study in this white paper evaluates corrosion resistance under a 720 hrs salt mist test. The test investigates performance qualities of five different platings including silver, white bronze, SURO720, tin-nickel and electroless nickel-phosphorus. Contact resistance, wear resistance, ductility, solderability and passive inter-modulation properties are investigated.

For contact resistance, silver platings showed the best results, followed by white bronze, SURO720 and tin-nickel platings. Electroless nickel-phosphorus plating demonstrated the highest contact resistance.

Regarding wear resistance, electroless nickel-phosphorus showed the best

results. Silver platings showed excessive wear and thus are not recommended for applications with a high number of mating cycles. As a disadvantage of its hardness and wear resistance, electroless nickel-phosphorus also shows an increased brittleness.

For soldering, silver, SURO720 and white bronze platings are the preferred options. Electroless nickel-phosphorus plating has a poor wettability under standard solder parameters and will presumably cause problems during soldering, especially for PIM sensitive applications. Tin-nickel plating can be soldered but requires very strict control during the plating process, part storage and soldering process. Therefore, tin-nickel is not an ideal plating for parts which need to be soldered.

With respect to corrosion, simulated by a 720 hrs salt mist test, silver platings with thiol-based anti-tarnish post-treatment and electroless nickel-phosphorus platings, show satisfying results. While electroless nickel-phosphorus platings perform better on visual corrosion, silver platings show virtually no deterioration of the contact resistance. Tin-nickel platings are affected by severe discoloration and show an increased contact resistance. Without direct contact to aluminium, standard white bronze plating shows visible corrosion while the new SURO720 plating shows almost no corrosion. Also, the contact resistance of SURO720 shows no significant change after the corrosion test. Therefore, SURO720 meets the most important requirements of RF connectors in terms of corrosion, solderability and electrical performance while retaining the significant cost advantage of conventional white bronze platings.

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# Introduction – platings

## Introduction

There is a strong trend in the mobile communications market for connectors with increased performance demands on platings, especially for corrosion resistance. Connectors used in outdoor applications, such as for remote radio heads and antennas, are exposed to extreme environmental conditions and have to withstand a wide temperature range from arctic winters to tropical heat. In addition, aggressive atmospheres in heavily polluted industrial and coastal areas attack the surface of these parts, threatening their functionality. Thus, these connectors require plating with exceptional corrosion resistance along with fulfilling stringent mechanical and electrical requirements. Currently many different types of platings are used in the design of RF connectors therefore a detailed comparison of advantages and disadvantages of different optional platings is needed to find out which provides optimum corrosion resistance. Thus, an extensive comparative study of the most popular RF connector plating has been performed by HUBER+SUHNER AG (H+S) and Rosenberger Hochfrequenztechnik GmbH & Co. KG (RT). Numerous tests have been conducted in order to compare various platings. External partners have been involved in this study to ensure the best expertise is used to effectively manage special test procedures and to guarantee a neutral ranking of the test results. The results of this extensive study presented in this white paper should serve as a guide for product designers to choose an appropriate plating for each specific application.

## Platings

The following platings are most common for outdoor RF connectors and have been investigated within the scope of this study. For all platings, the thickness was specified to be between 3 and 6 µm.

### Silver (Ag)

Silver plating is well-established and known for its outstanding electrical characteristics. As a noble metal, silver has an excellent corrosion resistance with a drawback that it can tarnish over time. However, surface discoloration, caused by  $H_2S$  in most cases does not affect the technical properties and can be minimized by appropriate anti-tarnish post-treatments. Silver plating offers excellent conductivity, solderability and PIM performance; therefore, it is used as the first choice of plating on centre contacts and outer contacts for RF connectors, such as 7/16, 4.3-10, 4.1-9.5 and NEX10. In some cases, it is also used as a surface/outer body plating for RF connectors and other components.

### White bronze (CuSnZn)

White bronze is a ternary alloy consisting of copper, tin and zinc. It is known under different trade names, e.g. SUCOPLATE (H+S) or Optalloy (RT). White bronze is a cost-efficient plating with

# Platings

improved wear resistance compared to silver platings. White bronze offers an excellent and cost-effective alternative for silver in terms of conductivity and PIM performance, therefore it is used as an economic choice for plating on bodies of RF connectors, such as 7/16, 4.3-10, 4.1-9.5 and NEX10.

## **SURO720**

HUBER+SUHNER and Rosenberger have jointly developed a new and improved version of white bronze plating for high corrosion resistant applications. This plating offers similar visual appearance, and electrical and mechanical properties like standard white bronze but with much better corrosion resistance. Therefore, the new SURO720 plating can replace all existing white bronze applications, while offering 720 hrs corrosion resistance and PIM stable solderability without any significant cost increase.

## **Tin-Nickel (SnNi)**

Due to resistance to corrosion, tin-nickel platings, available in the market under different brand names, have been recently introduced as a possible choice for RF connector platings. Tin-nickel plating was already developed in the 1950s but has not yet gained acceptance in the commercial RF connector market. This binary alloy consists of approximately 65 wt% Sn and 35 wt% Ni. Despite its nickel content, the intermetallic compound is non-magnetic. The use of tin-nickel plating requires some caution as there are some versions commercially available which use chromium as a way to improve resistance to corrosion. Since chromium and especially hexavalent chromium is under strict regulations for commercial use, tin-nickel plating should always be verified for chromium.

## **Electroless nickel-phosphorus (NiP)**

Electroless nickel-phosphorus is among the most common electroless platings. For RF connector applications, the phosphorus content has to be > 10 % in order to achieve a non-magnetic plating. Electroless nickel-phosphorus with phosphorus content > 10 % is also called nickel high-phosphorus. Nickel high-phosphorus plating shows excellent corrosion and wear resistance, but the relatively high contact resistance could hamper the use of this plating for applications with high conductivity requirements.

## **Test results**

HUBER+SUHNER and Rosenberger did extensive testing on each of the above mentioned platings for different parameters which are critical for the performance of a RF connector. The results of these tests are summarized below.

# Contact resistance

Contact resistance is one of the most important parameters that can significantly influence the RF performance of a coaxial connector. Contact resistance depends not only on the plating but also on how the contacts are made between male and female connectors, i.e., whether it has a front/butting contact or radial contact by sliding/wiping motion.

For contacts with a wiping motion, the contact resistances are generally lower as the isolating oxide layers on the surface are partially destroyed due to wear, caused by the surface cleaning effect of the wiping motion. This is particularly valid for non-noble metals, and leads to an exposure of pristine metal that ensures a good electric contact. However, the wiping also causes wear of the plating. This surface cleaning effect, along with plating wear, is more effective if the applied contact force is higher. Satisfying contact resistance might only be achieved after repeated mating and removal of isolating layers. Therefore, two different experimental set-ups have been performed to simulate contacts without wipe (e.g. butting connectors) and with wipe (sliding/rub of surfaces).

## Contact resistance for non-wiping contacts

For contacts without wipe, silver has by far the lowest contact resistance, reaching values  $< 5 \text{ m}\Omega$  even under low normal forces.

SURO720 and white bronze platings show a moderate contact resistance, reaching  $< 100 \text{ m}\Omega$  with normal force of 1 N. The higher contact resistance can be attributed to the insulating oxide layer on the surface of the plating, which is insufficiently removed in the case of a contact without wiping motion.

Tin-nickel platings (ca.  $400 \text{ m}\Omega$  at 1 N contact force) and electroless nickel-phosphorus platings (ca.  $100 \text{ m}\Omega$  at 1 N contact force) have high contact resistance. Therefore, for applications sensitive to contact resistance, tin-nickel and nickel-phosphorus are not recommended for contacts without wipe.

# Contact resistance

## Contact resistance – butting contact

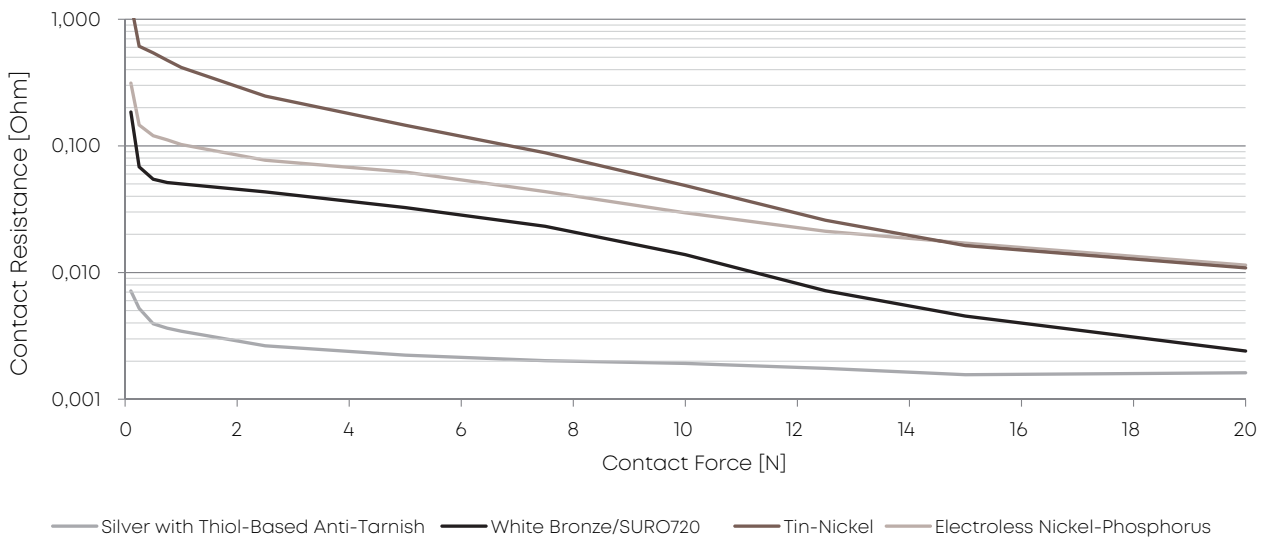


Figure 1 Contact resistance as a function of the contact force for contacts without wiping motion

## Contact resistance

Experiments were conducted with 3 mm wipe and contact forces of 1 N and 5 N. The tests show that the general succession of different plating materials is virtually unchanged.

Silver plating exhibits superior contact resistance values  $< 1 \text{ m}\Omega$ , even under low contact forces (1 N).

White bronze plating/SURO720 and tin-nickel plating have contact resistances in the range of  $15 \text{ m}\Omega$  and  $2\text{--}3 \text{ m}\Omega$  for contact forces of 1 N and 5 N, respectively.

For electroless nickel-phosphorus plating, the contact resistances are generally higher ( $60 \text{ m}\Omega$  and  $30 \text{ m}\Omega$  for contact forces of 1 N and 5 N, respectively). The impact of the oxide layer is more severe, resulting in a stronger variation of the contact resistance as a function of the number of mating cycles. Therefore, the application of electroless nickel-phosphorus plating is not recommended if a low and stable contact resistance is desired.

Tin-nickel plating shows better results than nickel-phosphorus but comparable to white bronze and SURO720.

# Contact resistance

## Contact resistance - contact with wiping motion

Contact resistance after 1 mating cycle, for 1 N and 5 N contact force

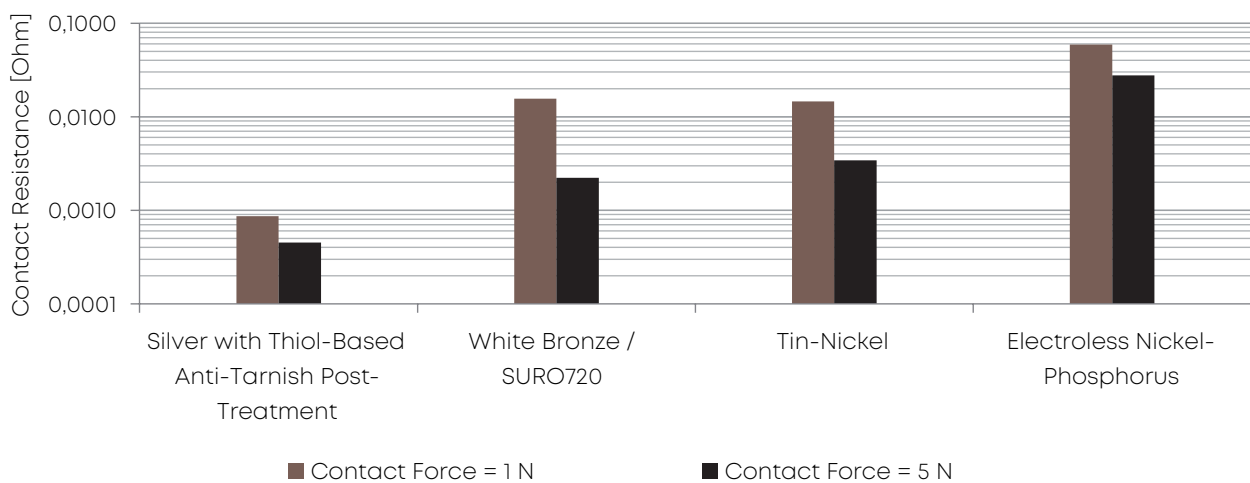


Figure 2 Contact resistance after one mating cycle for contacts with wiping motion

In summary, silver plating shows the best results concerning contact resistance and should be preferred if this parameter is of particular importance for a specific RF connector. White bronze, SURO720 and tin-nickel platings show satisfying results and meet most RF connector application requirements. Electroless nickel-phosphorus plating shows a high and unstable contact resistance and is therefore not recommended for applications which require a low and stable contact resistance.

Silver	White Bronze and SURO720	Tin-Nickel	Electroless Nickel-Phosphorus
++	+	+	-

Table 1 Rating of contact resistance of different platings



# Ductility – wear

## Ductility

If a plating is brittle, it can suffer damages by deformation or fracturing and can severely impact the overall performance of a RF connector. Thus, the ductility of the different plating was investigated by a three point bending flexural test. Most platings were still intact after this test and did not show significant damage or fissures. Also, tin-nickel plating, which is frequently considered as brittle, was just slightly affected. Only electroless nickel-phosphorus plating, which is known for its brittleness, showed severe damage, including detachment of the plating.

Silver	White Bronze and SURO720	Tin-Nickel	Electroless Nickel-Phosphorus
++	+	+	--

Table 2 Rating of ductility of different plating as determined from three point bending flexural test

## Wear

RF connectors are specified for numerous mating cycles, e.g., 7/16 and 4.3-10 are specified for 500 and 100 mating cycles, respectively. Therefore, wear of the plating becomes an important issue and has to be taken into account when making a selection of suitable platings for RF connectors. Wear of plating is a function of numerous parameters including the design of the connector. In particular, the normal force of the contact area and the wipe distance play an important role. However, the coefficient of friction (COF), frequently represented by  $\mu$ , is dependant on the contact material itself and is defined as the quotient of the force of friction between two bodies and the force pressing them together. Thus, a high COF leads to higher insertion forces for connectors and is frequently associated with increased wear. Particularly silver plating exhibits a high COF.

Results for wear were obtained from the same experiment that investigated the contact resistance with wiping motion. For each plating type, 10 and 25 mating cycles were conducted with 3 mm wipe distance and contact forces of 1 N and 5 N, respectively. Wear tracks were examined by optical microscopy.

# Wear

## **Wear resistance with 1 N contact force**

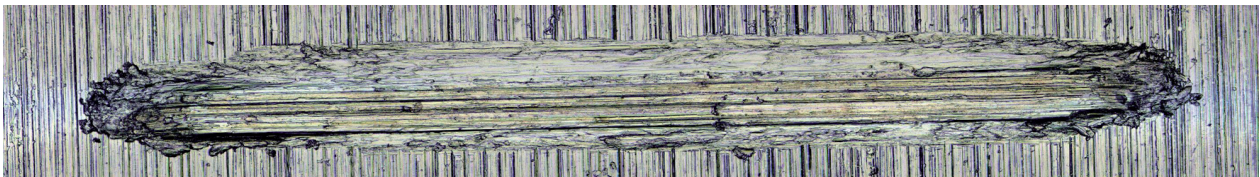
For 1 N contact force, most investigated platings were still intact after 25 mating cycles. Only silver plating was worn and the base material was exposed. This behaviour is a well-known problem of silver plating, as it is relatively soft, ductile and shows a high coefficient of friction (COF) in the range of  $> 1$ . However, certain anti-tarnish post treatments have a lubricating effect during the first 5-10 mating cycles, which reduces the wear of the plating.

## **Wear resistance with 5 N contact force**

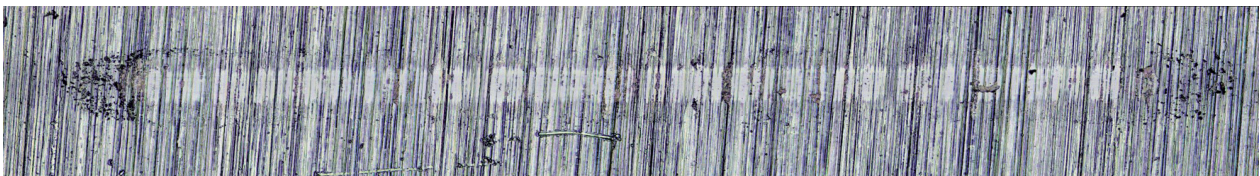
If the contact force increases, the wear of plating becomes a more serious problem. For a normal force of 5 N, all plating showed damages on the wear track or the rider after 25 mating cycles. Silver plating was worn after 10 to 15 mating cycles. The COF was around 1.2 and only when plated with anti-tarnish treatments did it show a lower COF between 0.2 to 1.0 during the first 10 mating cycles. White bronze plating and SURO720 showed moderate signs of damage, mainly on the rider (exposure of base material after 25 mating cycles). The COF increased from 0.2 to 0.4 after 25 mating cycles. Tin-nickel plating showed a relatively high COF ( $\sim 0.6$ ); exposure of base material occurred partially. The best results were obtained by electroless nickel-phosphorus plating, showing only very little deterioration and no base material exposure after 25 mating cycles.

# Wear

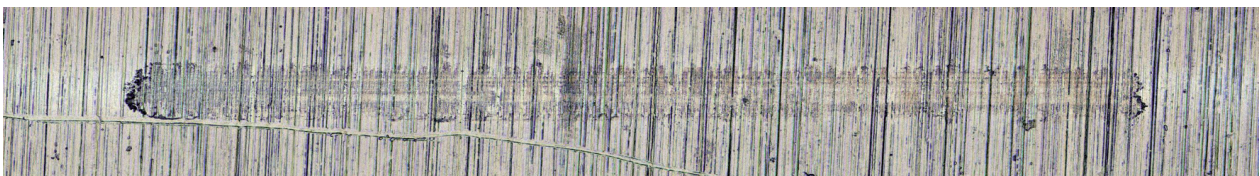
The figure below shows different platings after wear test:



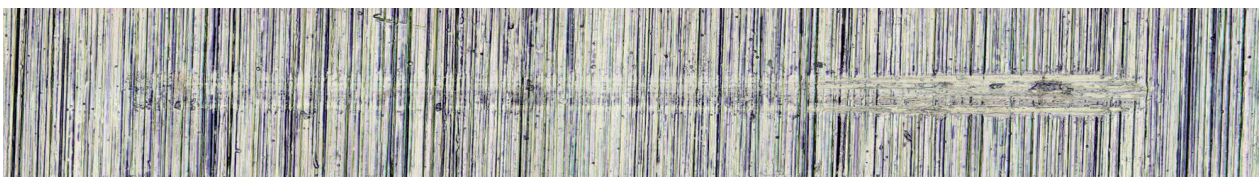
Silver with thiol-based anti-tarnish



SURO720



Tin-nickel



Electroless nickel-phosphorus

Figure 3 Wear tracks after 25 mating cycles (5 N normal force, 3 mm wipe)

Silver	White Bronze and SURO720	Tin-Nickel	Electroless Nickel-Phosphorus
--	-	-	+

Table 3 Rating concerning wear of different platings

# Solderability

## Solderability (wetting balance)

RF connectors used in cable assemblies are often soldered with cables, especially for PIM stable applications. Therefore, solderability is an important parameter which has been tested by means of wetting balance. A Sn96.5Ag3.8Cu0.7 solder (according to IPC J-STD-006/ISO 9453) has been used for this test. Solderability tests have been conducted on new plated samples as well as after storage of 10 days at 40 °C/95 % rh to simulate storing according to IEC 60068-2-78. Norm flux 1 (ROL0 according J-STD-004, 0.2%Cl) and norm flux 2 (ORL0 according J-STD-004, 0.5%Cl) have been used.

Silver, as a noble metal, shows expectedly the best results in this category. Even after simulated storing, the wettability is still excellent.

White bronze and SURO720 platings show good wettability results as well. For non-aged white bronze and SURO720 platings, the solderability is comparable to silver platings. After simulated storing, the wettability of white bronze platings decreases slightly but still provides good solderability to give required electrical and mechanical performance of a RF connector and assembly.

In contrast to these two platings, electroless nickel-phosphorus plating has a very poor solderability and cannot reach wettability requirements defined by the test protocol. Even by using the more aggressive norm flux 2 (0.5 % Cl), the wettability requirements were not reached. Tin-nickel plating is not solderable with standard soldering processes. The soldering of tin-nickel plating depends on three critical factors, i) quality of plating bath ii) duration of storage of parts before soldering and iii) type of flux used. The type of flux especially plays a big role in making tin-nickel solderable. In this test, tin-nickel could only be soldered by using a very aggressive flux and required extensive cleaning afterwards. Therefore, nickel-phosphorus and tin-nickel plating are not recommended for connectors which require cable soldering (approximately all of PIM sensitive cable assemblies) in a cost-efficient way.

Silver	White Bronze and SURO720	Tin-Nickel	Electroless Nickel-Phosphorus
++	++	-	--

Table 4 Solderability of different platings as determined by wetting balance

# Passive intermodulation

## Passive intermodulation (PIM)

For most applications in communications market, passive intermodulation (PIM) is a crucial performance criterion for RF connectors. In case of a substandard or magnetic plating, the signal through connector can be disturbed by undesired interference, e.g. generating harmonics or intermodulation. The presence of corrosion products or plating flitters can also be a potential cause for PIM. Nickel plating by itself is magnetic and cannot be used for PIM sensitive applications. However, when combined with phosphorus or tin in specific percentage, the plating becomes non-magnetic. All platings were tested for their magnetic behaviour via PIM set up using 7/16 connector and following values were obtained:

Plating	Initial PIM [dBc]
Silver (thiol-based anti-tarnish post-treatment)	-177.5
White bronze and SURO720	-177.6
Tin-nickel	-176.7
Electroless nickel-phosphorus	-178.3

Table 5 Results of PIM analysis

Silver	White Bronze and SURO720	Tin-Nickel	Electroless Nickel-Phosphorus
++	++	++	++

Table 6 Rating concerning passive intermodulation effects of different platings

# Corrosion

## 720 hrs salt mist test

The salt mist test is a popular method to evaluate the corrosion resistance of platings. There are, however, some doubts whether the results obtained from this test can be transferred to real corrosion situations. Nevertheless, the neutral salt mist test (according to ASTM B117) is a standard test method and has therefore been applied in this study to examine the corrosion behaviour of the investigated platings.

## Contact resistance after 720 hrs salt mist test

While applying the corrosion test results to RF connectors, it is very important to note that the electrical contact areas for most RF connectors, such as 7/16, 4.3-10 and NEX10 are almost always protected with a sealing in mated condition. Therefore, the effect of corrosion is not influencing the RF performance inside the connector instead it is just causing a visual damage on the outside surface. However, during this test, the contact resistance of various platings were measured even after the corrosion of surface. The contact resistances of various platings determined after the 720 hrs salt mist test are displayed below.

## 720 hrs salt mist test Contact resistance after first mating cycle, 5 N contact normal force

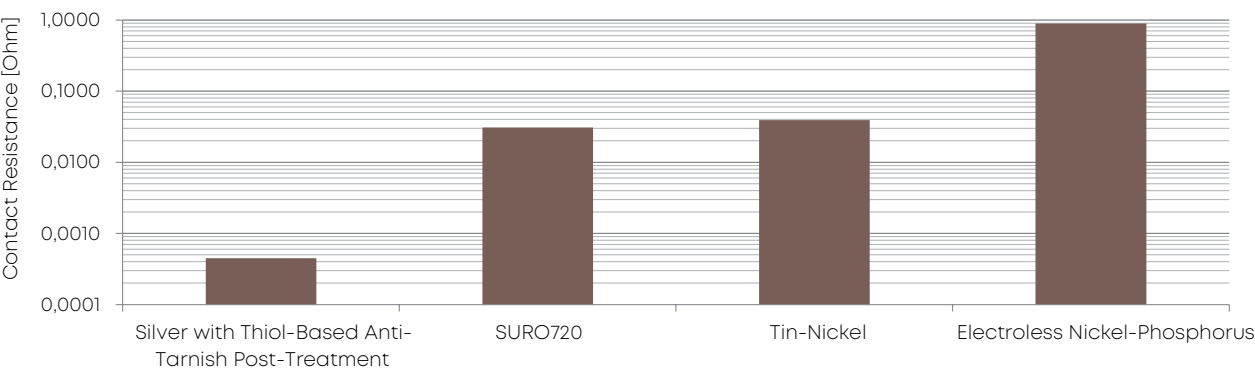


Figure 4 Contact resistance after 720 hrs salt mist test (after 1 mating cycle, 5 N contact force)

# Corrosion

Among all tested platings, samples with silver plating (with specific anti-tarnish post-treatment) show the best results. The contact resistance after corrosion remains basically unchanged when compared to original values before corrosion. White bronze plating, including the new SURO720 and tin-nickel plating did not establish a stable contact without wiping motion. For contacts with wiping motion, the contact resistance of these two plating types after several mating cycles is twice as high as before 720 hrs salt mist test, indicating a significant deterioration due to corrosion. Electroless nickel-phosphorus platings, which already showed a high contact resistance before the corrosion test, were also not able to establish a stable contact after salt mist test in the case of butting contacts. For contacts with wipe, the contact resistance after several mating cycles is 2–4 times as high as before 720 hrs salt mist test, indicating a severe deterioration although almost no corrosion is observed visually.

Silver	White Bronze and SURO720	Tin-Nickel	Electroless Nickel-Phosphorus
++	-	-	--

Table 7 Rating concerning contact resistance of different platings after 720 hrs salt mist test

## Visual evaluation of corrosion after 720 hrs salt mist test

For certain customers and applications, the visual impression of the plating after exposure to corrosive environment is of the most importance. Therefore, all plating discussed in this white paper were subjected to visual appearance standards. For the sake of reference, the standard white bronze plating, which is specified only till 48-96 hrs, was tested for performance under salt mist test up to 720 hrs and following results were obtained:



After 48 hrs



After 96 hrs



After 720 hrs

Figure 5 Standard white bronze (Trimetal) after 48, 96 and 720 hrs salt mist test.



# Corrosion

The results verify the expectations that the standard white bronze plating works well at least till 96 hrs. After this, the corrosion begins to damage the visual appearance and after 720 hrs, the visual appearance is severely influenced by corrosion.

The visual appearance of the other investigated platings after 720 hrs salt mist test is shown in figure 6.

Electroless nickel-phosphorus plating shows the best results with almost no signs of corrosion.

Silver plating with anti-tarnish post-treatments and the new SURO720 only show small corrosion spots. These small corrosion phenomena are regarded to have no significant impact on the function of the connector.

Tin-nickel platings, however, show distinct corrosion spots near edges or even large areas affected by severe corrosion. The function of the connector could be negatively influenced by the corroded areas.



Silver with thiol-based anti-tarnish



SURO720



Tin-nickel



Electroless nickel-phosphorus

Figure 6 Corrosion of samples after 720 hrs salt mist test.

Silver	White Bronze and SURO720	Tin-Nickel	Electroless Nickel-Phosphorus
+	+	-	++

Table 8 Visual evaluation of corrosion after 720 hrs salt mist test



# Corrosion

## **Corrosion of plated connectors mounted on aluminium – visual evaluation**

RF connectors are frequently mounted on aluminium housings. As aluminium is a non-noble metal with a very negative standard potential in the galvanic series, electrochemical corrosion is a serious issue if other metals are in direct contact with aluminium. To study this phenomenon, RF connectors with different platings were mounted on an aluminium plate and then subjected to 720 hrs salt mist test. The screws used were M3 stainless steel DIN7986 cheese head Torx both with and without an anti-friction coating (Gleitmo605). One important point to consider is that the aluminium used in this test was without any treatment in order to intensify the test conditions, but the aluminium used in telecommunications equipment, such as radios and antennas is usually treated, or has an insulation between connector and aluminium panel. Therefore, the results below should be carefully used as different applications can have different scenarios of contact between the connector and panel.

Similar to the results of the 720 hrs salt mist test of individual connectors, silver plating with anti-tarnish post-treatment and electroless nickel-phosphorus plating, show the best results.

Electroless nickel-phosphorus platings are merely affected by corrosion. They exhibit a slight discolouration caused by passivation of the surface.

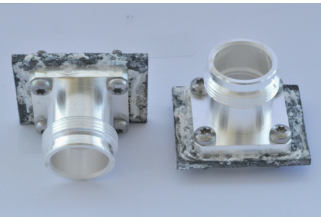
Silver platings with anti-tarnish post-treatment do not show any discoloration on surface. However, some devices have small spots of corrosion products originating from the base material; very likely caused by mechanical damage of the plating during handling and transport.

Tin-nickel platings are affected by severe discoloration. White rust or any other base material related corrosion products were not observed.

In contrast to the results of 720 hrs salt mist test on individual connectors, white bronze platings show severe corrosion. Even the improved white bronze-based plating SURO720, which was only merely affected by corrosion as single part, was not able to withstand corrosion.

Regardless of the plating type, raw aluminium was in every case severely affected by corrosion.

# Corrosion



Silver with thiol-based anti-tarnish



SURO720



Tin-nickel



Electroless nickel-phosphorus

Figure 7 Corrosion of samples after 720 hrs salt mist test on aluminium (without insulation)

Silver	White Bronze and SURO720	Tin-Nickel	Electroless Nickel-Phosphorus
+	--	-	+

Table 9 Visual evaluation of corrosion of differently plated RF connectors mounted on aluminium plates after 720 hrs salt mist test

# Costs

For most RF connectors, economic factors are of utmost importance. Thus, it is essential to consider the cost of plating during the design process. The plating on one hand has to fulfil numerous technical requirements, but on the other hand, the expenditures for the plating should be as low as possible.

The costs of different plating types vary significantly, and the metal price is not the only parameter that has an impact on the total costs of a plating. The type of plating process chosen has a major influence on the costs as well. In general, platings deposited by electroless processes are more expensive than platings deposited by conventional electrodeposition processes. For connectors that require soldering onto cables, the ease of soldering, use of flux and after-cleaning processes can also add additional cost.

Among the investigated platings, white bronze including the new SURO720 is – by far – the most cost-effective option. One might expect that silver, as a noble metal, might be the most expensive plating; but in fact, it is not as expensive as it might appear. Actually, the costs of silver and tin-nickel platings are in the same range.

The costs of tin-nickel platings also strongly depend on environmental regulations, as the electrolytes for tin-nickel contain aggressive chemicals. Thus, local safety and disposal regulations significantly affect the total costs of this plating. electroless nickel-phosphorus platings are the most expensive option among the investigated platings. The handling of the electrolyte is relatively complex, resulting in a higher price, which – however – is still much lower compared to gold platings.

Silver	White Bronze and SURO720	Tin-Nickel	Electroless Nickel-Phosphorus
+	++	+/-	-

Table 10 Relative comparison of total plating costs for different platings

# Summary

Due to different advantages and disadvantages of each plating type, it is not possible to give a general recommendation for one plating type that is always the best solution for all cases. The individual requirements for a certain RF connector have to be taken into consideration by the product designer, who has to choose the right plating based on technical and economic requirements. The results of this study should act as a reference guide for choosing the right type of plating for a particular application.

			Silver (Anti-Tarnish)	White Bronze (SURO720)	Tin-Nickel	Electroless Nickel-Phosphorus
After corrosion test (720 hrs salt mist)	Contact resistance		++	–	–	--
	Visual	solo	+	+	–	+ / +
		on Al	+	--	–	+
Contact resistance			++	+	+	–
Ductility			++	+	+	--
Wear/abrasion			--	–	–	+
Wettability (wetting balance)			++	++	–	--
Passive intermodulation			++	++	++	++
Relative costs			+	++	+ / -	–

Table 11 Summary of test results

# Conclusion

## Silver

Silver platings with their excellent corrosion resistance and superior electric properties will be a suitable option for most RF connectors. The use of silver platings might be restricted for RF connectors with increased demands concerning wear or if a high number of mating cycles is required. Silver is also the first choice for plating where electrical contacts are sensitive to PIM. However, silver has the drawback that it can tarnish over time due to  $H_2S$  which – in most cases – does not affect the technical properties and the effect can be slowed down by appropriate anti-tarnish post-treatments.

## White bronze

White bronze platings are now state of the art and the preferred option if a cost-effective plating with acceptable electrical properties and minimum corrosion resistance of at least 96 hrs.

## SURO720

SURO720 is an improved version of white bronze plating which provides a much higher level of corrosion resistance and should meet most requirements of RF connectors regarding 720 hrs corrosion test. However, due to electrochemical difference, direct contact with aluminium should be avoided.

One major advantage of SURO720 compared to nickel based plating is its superior solderability. Since most antenna connectors are in the form of PIM stable cable assemblies, SURO720 offers one solution which can be used for filter connectors as well as antenna connectors.

Therefore, considering cost, PIM, solderability, corrosion and mechanical properties, SURO720 seems to have an edge when compared to all other plating options.

## Nickel based platings

### Tin-nickel

Tin-nickel platings are comparable to SURO720 regarding corrosion. However, slightly higher costs as well as the poor solderability of tin-nickel platings hamper a widespread use of this plating type. The corrosion resistance and the electric properties are inferior to silver. Tin-nickel shows a better wear resistance compared to silver but does not reach the wear resistance of electroless nickel-phosphorus platings. Looking at the overall performance offering and cost, tin-nickel does not seem to offer any significant advantages compared to well-established RF connector platings.

# Conclusion

**Electroless nickel-phosphorus** platings show superior wear resistance. Therefore, they might be the preferred plating for RF connectors that are designed for a high number of mating cycles and at the same time have low requirements concerning the contact resistance. However, high costs, poor electric properties, poor solderability, and brittleness are disadvantages of this plating. The corrosion resistance appears to be satisfying by means of visual assessment, but electric properties show a distinct degradation in the course of a 720 hrs salt mist test if the electrical contact areas are exposed to corrosion (not typical for RF connectors). Since nickel is magnetic in nature and can lead to big problems regarding PIM, the percentage of tin and phosphorus is very critical in nickel-based platings (tin-nickel/nickel-phosphorus). If the concentration of nickel becomes higher than specified, the connector can show bad PIM performance and that can only be detected if specific PIM tests are done on final connectors assembled on equipment or cable assemblies. This can lead to huge economic damages if the problem is not early detected.

Additionally, nickel and nickel related compounds can cause allergic reactions. Therefore, certain countries and applications restrict the use of nickel in products where they can be in direct contact with humans. It should also be carefully evaluated that there is no Cr(VI) involved in the plating process. Therefore, the use of nickel and nickel containing plating should be carefully considered for each application.

## Note

The information and recommendations in this document are based upon tests and experiences that HUBER+SUHNER and Rosenberger believe are reliable and done with the best of expertise. However, the accuracy or completeness of such information is not guaranteed.

# About the companies

HUBER+SUHNER is a leading international manufacturer and supplier of components and systems for electrical and optical connectivity. HUBER+SUHNER unites technical expertise in radio frequency technology, fiber optics and low frequency under one roof and offers a high-quality product range for the communication, transport, space & defence, test & measurement and other industrial markets.

Rosenberger is one of the worldwide leading suppliers of controlled impedance and optical connectivity solutions, system components for mobile communications networks, data centres and test & measurement as well as high voltage contact systems. The Rosenberger group operates manufacturing and assembly locations in over 10 countries as well as a global sales network.

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