An Update on Security Features

by Ursula Kampmann

Almost everything you need to know about security features may be found in the MDC Technical Committee’s comprehensive handbook, Security Features of Coins.

This paper is specially written for those who find that the handbook is a bit more detailed and technical than they would like. It is not so much an “update” but a summary of what is in the handbook together with some additional information on security features. You are encouraged to read the handbook itself for useful ideas and tips on how to make life more difficult for counterfeiters and also how to do so at least cost.

This article summarizes old and new security technologies and provides additional information such as:

- Is this technology used in circulation coins today? To what extent is it used?
- Is this security feature checked by the vending industry on a regular basis?
- Is this security feature checked during security inspections at logistic centers / central banks?

To answer our first question, we have primarily used the second edition of the Directory of Circulation Coins published by Currency News in 2016. Of course, not all security features are covered there. We have restricted our research to overt security features only although we were in contact with the mints which invented or use covert and forensic security features.

To answer the last two questions, we sought the assistance of specialists. Erwin Wetzel, Director General of the European Vending Association, answered our questions on behalf of the vending industry, and Ralf Freiberger from Mühlbauer provided information on mass security inspection systems.

1. Overt security features

We define an overt security feature as:

- a security feature which can be recognized by means of the human eye without use of additional tools;
- a security feature which can be revealed to the broad public and which promotes trust in the genuineness of coins.

1.1 Measurement and weight

We should never forget that the weight, diameter and thickness of a coin are essential security features. The Handbook of Security Features dedicates a large section to diameter and thickness issues. It provides a useful guide if you want to know what tolerances you should take into account. This makes sense, especially for the vending industry, as diameter is still one of the most important features to be detected in coin validator sensor systems.

The thickness of a coin also matters. It is normally not measured in isolation but in combination with the material using inductive sensors.

For mass security inspection checking the diameter, thickness and Electromagnetic signature (EMS) are state of the art.

Weight is not a security issue, although there are still many successful fakes which can easily be detected by weighing them. Although it is state of the art and possible to check the weight during mass security inspection, it is not detected in coin validator sensors. Perhaps that is the reason why weight is not even mentioned in the Handbook of Security Features.
1.2 Shape
The shape of a coin is essential in determining whether or not a coin validator sensor system is able to “read” a coin. Erwin Wetzel writes, “The shape of the coin when rolling down a ramp passing the sensors in a coin validator affects the stability of the sensor reading. A stable coin will show less variation in the sensor reading which will improve the accuracy of differentiation and hence allow tighter coin sensor limits.

A round coin is the preferred shape and with the lowest variation in the signal. Other shapes like 7 sided, 11 sided, 12 sided etc or Spanish flower are less stable and therefore can result in less security in coin validators.”

The ability of a coin to roll is very important for EMS characteristics checking by vending machines.

Whether it is due to lobbying from the vending industry or to the preference of the minting industry for traditional shapes, most coins are round. Of 1,086 denominations struck worldwide, only 119 offer another shape. In addition, 60 of the 119 are embossed, which means they are also qualified to work in vending machines.

The other shapes used in minting are as follows:
Shape | Denominations of this shape
---|---
embossed | 60
dodecagonal (= 12 sides) | 2
hendecagonal (= 11 sides) | 1
decagonal (= 10 sides) | 3
octagonal (= 8 sides) | 2
heptagonal (= 7 sides) | 30
square | 4
triangular | 1
holed | 9
scalloped | 7

### 1.3 The edge

When edge lettering was invented, coin chipping ended. It was introduced to prohibit the most common coin fraud of the past, which was to reduce the silver content of a coin by filing off silver. The well-known Maria-Theresia-Thaler for example owed a big part of its success to its elaborate edge featuring an inscription.

Today, the edge design is still important mainly as an overt security feature visible by coin users. It is a security feature you can normally name when journalists ask how to detect a group of forgeries from authentic coins.

Edge design is less important in automatic coin inspection. Edge design is not examined on a regular basis in mass security inspection or in vending machines. The edge design of today’s circulation coin denominations accounts for that fact. 463 denominations out of 1,086 are plain without any edge design, 30 are milled and 369 are reeded. 93 denominations offer segmented reeding and only 46 denominations show a detailed edge inscription. The highest security version of edge design – reeded and lettered – is used by 16 denominations only.
Nevertheless, it would be possible to examine the edge if required by central banks. Mühlbauer is very proud of being the only company that offers a special mass security inspection system which includes examining the edge of a coin. Erwin Wetzel states for the vending industry, “This feature is normally not detected by standard sensor systems. However, in some cases, if possible and necessary, it will be applied by special sensors and will add additional cost.” He adds that edge lettering is “not detected in standard coin validators.”

The rimming is much more important for security issues, as it impacts the smooth coin run passing the sensors of a coin validator. Therefore, the vending industry has developed a lot of recommendations on how to design the best rim in order to make sure that the EMS is measured as accurately as possible. You will find all of them in the *Handbook of Security Features of Coins*.

### 1.4 The color – bicolor - tricolor

There is one feature the human eye can detect immediately and that is color. Therefore color is one of the most important overt security features. Nevertheless, it is very difficult to detect color deviations by means of automatic systems. When in 2016 Switzerland was afflicted by false 5 Franken differing from authentic pieces in color, an optic security inspection system had to be developed.
Bicolor coins are the favorites of the international minting community when it comes to producing a secure high value coin. 146 denominations are minted today in bicolor. They are mainly of high value, at least in the country where they are minted at the time of the creation of the denomination.

<table>
<thead>
<tr>
<th>Value in US-Dollars</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00277 – 0.49 $</td>
<td>54</td>
</tr>
<tr>
<td>0.50-1 $</td>
<td>20</td>
</tr>
<tr>
<td>1-2 $</td>
<td>38</td>
</tr>
<tr>
<td>more than 2 $</td>
<td>33</td>
</tr>
</tbody>
</table>

Bicolor coins are difficult to counterfeit, but they also present difficulties in automated coin inspection. As the outer ring and the inner pill are of different materials, the two materials develop something the specialists call ‘junction resistance’. This means that within the field where both metals are joined the material properties mingle and it used to be not possible to measure the properties of each of the two parts exactly. As a consequence, when it came to bicolor coins, coin validation systems had to raise the tolerance concerning the EMS of the coins accepted, which made life easier for counterfeiters.

This has changed. As Erwin Wetzel states, “Typical modern sensor systems are sensitive to detect ring and center material properties. They are optimized in size and position to detect the bicolor coins around the world.”

By the way, bicolor is somewhat less than perfect when it comes to mass security inspection systems. They can be examined, but it needs an additional system applying X-ray fluorescence. This is extremely secure, but also extremely time consuming. It would need 3 seconds per coin for inspection.

Tricolor coins have so far not found their way into use as circulation coins. If they had, sensor systems in coin validators would have the same problems. As Erwin Wetzel tells us, “When a tri-color coin is used in a modern bicolor coin validator then the inner material sensor will likely be in the wrong size and in the wrong position to give an optimum signal. This sensor will therefore give a mixed material signal from the centre and middle ring and may be affected by the junction resistance.”
The German tri-material coin has won the attention of a national and international public due to the blazing colors of its polymer ring. Being nearly impossible to imitate by counterfeiters - at least by the current state of technical knowledge - the polymer ring is a nice but expensive overt security feature.

Until now, this feature has been applied to German 5 euro coins only. These coins are something in between commemorative and circulation coins. They are struck in high numbers and could circulate, if the public let them. But of the 4 million coins – not counting the collectors’ editions – which have been released of the two issues in 2016 and 2017, not a single piece has made its way into circulation.

The vending industry would be delighted if the tri-material coin became the new European 5 euro coin. As Erwin Wetzel writes, “Standard coin validators and coin processing machines are equipped with inductive sensor systems and it is essential that new security features don’t interfere with these sensor signals. The non-metal gap between the metal ring and metal center has of course an impact on the inductive EMS signal in two aspects:

- It stabilises the junction-resistance (see 1.4 bicolor) and therefore improves the material EMS reading.
- If the gap is of a specific width it will become machine readable and can be used as additional security feature.”

For mass security inspection system there is also no problem with this feature.

1.6 Laser based augmentations of the coin image

New software and the possibility to transfer even the tiniest design components into a die by laser engraving has given the minting industry the same possibilities for security features that the bank notes printers have. It is now possible to add bar codes, micro texts and latent images to coins. All of these can be easily used as overt security features as they can be detected by every user by using a magnifier.

Though all of these features have found their way into commemorative coinage, they are not common in circulation coins. Japan and Taiwan are using latent images, and the new generation of pounds is applying micro-lettering as well as a latent image.
After the numerous articles which appeared in the daily press on the high percentage of fake pound coins in circulation, it was very necessary for the Royal Mint to win back the trust of the citizens with their new 1 pound coin. Therefore it made a lot of sense to apply bank notes- like security features to a coin. It gives every citizen the confidence that he himself can examine whether or not his pound coin is authentic.

However, it does not make as much sense to automatic coin examination. Erwin Wetzel says, “The current state of the art in coin validators for the vending industry or coin counting and classifying machines have not optical sensors to detect and authenticate these features.” But Ralf Freiberger adds that security inspection systems can easily be equipped with a customized illumination and vision technology which will be able to check these features.

2. Covert security features

We define a covert security feature

- as a security feature which can only be recognized with an additional sensor measuring the properties of the material used for the coin

2.1 Material

By the current state of scientific knowledge, one of the – if not “the” – most important security feature is the metal alloy used in producing the coin blanks, at least when it comes to automatic coin inspection, either in vending machines or in mass security inspection systems. The electrical and magnetic conductivity is the property of any coin that can be determined easily, fast and most precisely, when it comes to automates.

The material is the most important characteristic which influences the EMS. Most vending machines depend on measuring EMS.

Erwin Wetzel writes, “EMS is a term used to describe the overall electromagnetic characteristics that a particular coin has. The coin’s material, dimensions, shape, construction method, rim height, embossing etc can all affect the EMS of a coin. The type of sensor, its construction, EMS detection technology or frequency of operation can affect the EMS of a coin. The validator design determines which aspect of the EMS are actually detected and used to differentiate coins.

The magnetic properties of materials used in coins will affect the inductive sensor reading and therefore is part of the EMS signal. Magnetic properties could be changed due to mechanical stress, mechanical fatigue or annealing and a good control of the material fabrication process will reduce the variability in the EMS.”

This means the material is the basis of the security of a coin. The material is a security feature that can easily be modified and improved within an existing set of denominations, as there are various possibilities to find another, more secure alloy which meets the color of the former coins.

It is of highest importance to avoid any material that can easily be purchased. This is also the recommendation of the MDC Technical Committee. They advise mints to avoid commonly used materials when it comes to designing new denominations. They define commonly used materials as the classical materials in the industry and materials which are used already in a large variety of coins worldwide.
We will not get into the question of which material is the best, as you can read that in detail in the Handbook of Security Features. It is highly recommendable to do so before you decide to change a secure alloy to another (perhaps cheaper) one.

2.2 Multi-ply plated steel coin

The multiply plated steel coins produced by the Royal Canadian Mint are a development that takes the importance of the EMS for automatic coin inspection into account. An inner blank is covered chemically with two different layers of metal, offering five layers of metal be examined by the sensor of a coin validator.

The Royal Canadian Mint has been very successful in marketing their multi-ply plated steel blanks. Today, no less than 34 nations, among them of course Canada, are making use of these blanks.

Nevertheless, Erwin Wetzel is doubtful concerning the actual use in average vending machines: “Because the plating of layers is thin the individual layers cannot be distinguished by the sensor and a mixed effect occurs. Additionally the steel substrate material is also detected and contributes to the overall coin EMS. Because of its magnetic effect this can tend to dominate. A multi-layer construction does not offer an improvement in security using inductive sensors in today’s coin validators, when compared to a single plated layer. However, a multi-layer coin that have a buried copper layer have a characteristic that can change the EMS signal by modifying the copper layer. The thickness of the copper layer may be selected to modify the EMS, and this feature may be useful to differentiate a similar thickness single layer plated coin.”

2.3 Multi clad coin

Multi clad coins differ from multi-ply plated coins concerning the way the blank is produced. A multiply plated steel coins has – as its name implies – a steel core which is plated chemically with two different layers of metal.

Multi clad coins are blanks which have been punched out from a very special coil. This coil was made of different metal layers which were rolled and melted together to form one multi layer coil.

Multi clad material provides high security and is qualified for high value coins if the material of the layers has been chosen carefully. As the Handbook explains.

- The materials have to have significantly different conductivities
- The conductivity of the three layers has to decrease from inward to outward
- If a magnetic material is involved, it has to be in the core.

Nevertheless, there is still some ways to go before every coin validator in a vending machine is able to make use of this high security feature. Normal coin validation systems can detect two different metals only. In order to examine three different materials, they will have to be upgraded with a third sensor.
2.4 Flipflop coin

The flipflop coin combines an overt security feature which is very hard to forge with best properties when it comes to EMS and automatic security inspection. Flip flop coins are an advancement of the multi clad coin. Their blanks are also made of a specially prepared coil which is composed of various layers, of which the color of the highest layer of one side differs from the color of the highest layer of the other side. Therefore coins made of flipflop metal will feature two different colors on each side.

This makes the material very efficient when it comes to bicolor coins as the dumps of the outer rings can be turned and used as inner core parts.

Until now, no mint has realized a coin using blanks made of this special kind of coil.

3. Forensic security features

We define a forensic security feature:

- as a security feature which can only be detected with a special technology which until today is not available in automated coin inspection systems

Describing forensic security features is a nearly impossible task, as all mints which have developed and implemented a special high security feature are not too willing to share detailed information about it. Although this is completely understandable, it sets limits for a journalist. Therefore we will restrict our information in this last paragraph to the question of how far the development of the relevant special feature has proceeded.

3.1 Royal Mint’s High Security Feature

The Royal Mint has sent us the following summary concerning their High Security Feature: “The Royal Mint developed its High Security Feature (HSF) to combat the increasing threat of sophisticated counterfeiting in an era of increased cross-border criminal activity and increased access to criminal counterfeiting networks via the internet.

Since its public launch four years ago, there has been widespread interest in HSF. It has been recognized as a key feature to help central banks to provide the next generation of secure and trusted coinage.

The Royal Mint is in discussion with multiple central banks and mints regarding the inclusion of HSF in coins for various countries.

We can confirm that HSF is now in circulation in the United Kingdom’s £1 coin as well as other currencies around the world, but due to the importance of customer confidentiality, we cannot disclose which other countries or denominations have the feature.”

3.2 Mint of Finland’s CoinTune™

We received the following statement from the Mint of Finland: “We continue the work with CoinTune™, which is an active research and development project in Mint of Finland. CoinTune™ is a
sensing technology that explores the internal structural properties of a coin. We have piloted the CoinTune™ with the Finnish Ministry of Finance with two-euros and have invested in it by getting all intellectual property rights (IPR) to Mint of Finland.

We believe that CoinTune™ will benefit the whole coin industry and that the technology behind the CoinTune™ concept has a lot of potential regarding the coin security and beyond. We are developing and extending the solution into more effective sorting of coins and maintenance of coinage.”

Both features cannot be detected right now in standard coin validator sensor systems. As Erwin Wetzel tells us, for both high security features, “special individual sensors are necessary to take advantage of this feature which requires additional space and cost.”

Summary

In summary, there are many security features that can be applied to a coin, but not many that can be detected by vending machines and by routine mass security inspection systems.

Therefore the development of new security features is just one part of work. The other part is to convince the vending industry to upgrade their coin validators in order to recognize the new security features. One might suggest that the minting industry and central banks need to lobby the vending industry as intensely as the vending industry has lobbied the central banks and mints for years.

If a central bank plans to invent a new denomination system featuring more elaborate security features, it is highly recommended that this modernization of coinage is accompanied by modernization of mass security inspection systems.

However, this involves another issue. If a central bank decides to invent a new security feature and to acquire a whole set of new mass security inspection systems, it should either make sure that it controls the whole supply chain or be very careful. There is a risk to commit oneself to a monopolist owning a copyright on a product which is necessary for producing the new high security coins: Having invested much money in the invention of a denomination featuring a new security feature, the liberty of changing each supplier means constant fair prices. A central bank should never lead a supplier into temptation by committing its whole denomination system to one company only.

Let us end with a funny side aspect. Fakes are not as bad as their reputation suggests as long as they do not ruin the trust of users in cash. Just think of the attention the Swiss “Fünfliber” (= 5 francs) attracted when fakes turned up. Collectors were willing to pay a nice amount for any fake coin that was much more than the circulation coin was worth. It prompted some people to hunt for the hidden treasures in their purse, which attracted attention for cash and coins. While it is a nice PR campaign, I am not sure many mints will be inclined to imitate it.
Acknowledgements

While each and every mistake in this update is my fault, I will not omit the fact that I would not have been able to write this article without the help of three specialists.

First, I want to thank Manfred Matzinger-Leopold, Executive Director of the Austrian Mint and chair of the Technical Committees of the MDC and the MDWG. He is also a responsible convenor of the Handbook of Security Features of Coins and the Handbook on Protection of Coins, which describes the security lifecycle of a coin from design to demonetization.

If you are interested in the Handbook and your mint/central bank does not have its own copies yet, please contact Manfred Matzinger-Leopold. He is the one who can give you access to them.

Second, Erwin Wetzel has given me a lot of input on coin validator sensor systems. Erwin Wetzel, an Austrian and French national, joined the European Vending Association (EVA) in 2011 as Public Affairs Manager and became Director General in January 2014. He studied Political Science and EU Affairs at the University of Innsbruck, Austria and at the College of Europe in Bruges, Belgium. Prior to his role within the EVA, he worked as an MEP assistant in the European Parliament and as Head of Office for the Austrian Federation of Municipalities. In his current role, he coordinates the Coin as well the Banknote Group, and liaises with various stakeholders, such as Mints, Central Banks, the European Commission and the European Central Bank.

Third, I had a specialist for mass security inspection of coins, Ralf Freiberger from Mühlbauer. Ralf Freiberger studied physics in Aachen. Subsequent to his graduation he was employed by the RWTH Aachen (Technical University Aachen) where he focused on Microscopy with short wavelengths. Since 2013 he has been working in the R&D department of the Mühlbauer Group with responsibility for development and improvement of products in the field of visual inspection. Ralf Freiberger has published papers about EUV-microscopy, defect-inspection and time resolved microscopy.

Thanks also to Ross MacDiarmid who convinced me that it would be a good idea to write this update on security features. It was a good idea. I learned a lot. And it took much more time than I had ever dreamt of.