ARE PROOF CENTS "DOUBLE PLATED"?

Version 3.0

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I have been researching plating mechanics and various plating issues on copper plated zinc (CPZ) cents with their underlying causes, including cracks, splits, bulges, blisters, wrinkles, and ripples. During my discussion of these issues in various venues, I was challenged by Ken Potter to explore the question of whether Proof Cents were double plated.

After discovering the following statement by David Lange, a well-respected numismatist, that proof cents received a second copper plating and finding no other identifiable source making such a claim, I decided to explore the subject further.

> **"It was found that the underlying zinc broke through its thin copper plating under the repeated impressions given to proof coins. This problem was solved in 1983 and subsequent years by furnishing each proof planchet with a second copper plating."[1]**

After being unable to find any documentation of a second plating in the literature, I sent inquiries to some knowledgeable individuals in numismatics. Some responded with interest while others ignored my question. None provided any additional confirming information. Some entertained the possibility of double plating, while others stated that they had never heard the claim and still others stated that proofs were not double plated.

I contacted the US Mint with this question: "Can you tell me the specification for the copper plating thickness on a modern proof cent?"
Response:

"The penny material consists of 97.5 percent zinc, 2.5 percent copper (inner core alloy of 99.2% zinc and 0.8% copper and outer plating of 100% copper)

Plating Thickness: 0.008 mm + 0.017 mm/-0.003 mm (0.0003 inches +.0007/-.0001 inches)"

Converting mm to µ:

Tolerance = 8µ (17µ to 3µ)

Converting Inches to µ:

Tolerance = 7.62µ (17.78µ to 2.54µ)

Clearly, the tolerance for proof cent plating is adequate to allow for a plating layer double the thickness of the reported thickness of 8µ on a CPZ business strike cent.[2,3]

I have calculated that the weight of 8µ thick copper plating on a cent = 0.05g.

I have found comparing weights between proof and business strike cents to be enlightening, even with the caveat that in using weight as a diagnostic it must be acknowledged that there are at least 2 variables for weight: plating volume and zinc core volume. Using the weight of a coin to draw conclusions about plating thickness is, therefore, suggestive.

I have undertaken a summary survey of random CPZ proof and business strike cents, comparing surface characteristics, weight, diameter, and thickness.

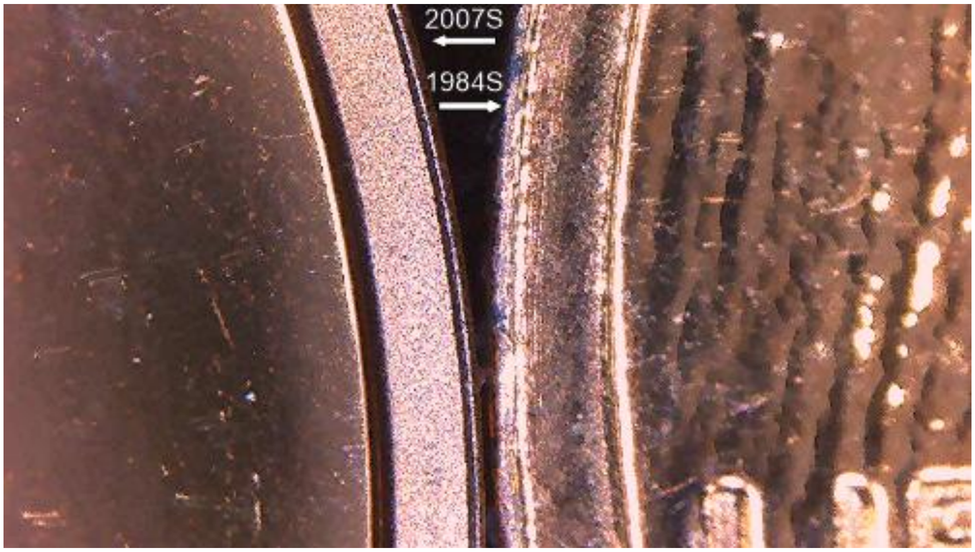
Regarding surface characteristics, it rapidly becomes apparent that the mint experienced a learning curve: earlier plating examples show bubbling and rippling (photo below) and visually obvious variations of thickness. Later examples show flat, smoother, more even, plating.

We know that:

> **"Plating thickness varies over the surface of the piece with heavier thicknesses on the edge, as a function of the plating physics. This variation in plating thickness contributes to a varying ("wider") EMS on plated coins."[4]**

The variations in plating thicknesses are visually apparent on coins from the 1980s more than in later years. The undulations, in addition to ripples, in the

plating are also more obvious in the early years and can be seen as a coin is moved and tilted under light.



Planchets used by the US Mint for the cent are obtained from Jarden Zinc where they use a barrel plating process (see photo below). Plating is applied after the blanks pass through the upsetting mill.[5]

Barrel Plating Line, Jarden Zinc
http://jardenzinc-com.web01.adigitalhost.com/Plant-tour-jarden-zinc.aspx

Adjusting power supply (voltage), temperature variability, plating time, solution concentration, and pH level are key techniques used to achieve a smoother application of copper plating. It is likely that the planchet supplier learned optimal settings for these elements during the early years of planchet production.[6,7] An improper balancing of these elements can create internal plating stresses due to lattice mismatch, grain boundary interactions, and the incorporation of impurities, leading to a stress gradient across the film thickness.

Stress gradients can significantly affect the mechanical properties of the copper film, including its adhesion to the substrate, susceptibility to cracking, and potential for delamination (Delamination is not being used here in the numismatic sense of separation of an alloy along internal planes of weakness. It is used in reference to the separation of the copper plated film from the substrate).

Residual stresses in thin film structures significantly impact their mechanical properties and affect interface delamination. Highly compressively stressed thin films buckling, which we see in examples from the 1980s, is the predominant interfacial failure mode due to strain energy release.[8]

As may be seen from the following tables, the early years of proof cent production also saw more weight variability than later years. Even so, the average proof cent weight is greater than the average business strike weight by an amount equal to the weight of an extra layer of plating. This difference carries forward into later years and even widens, along with less variability in weight and surface abnormalities.

	TOLERANCES ZINC CENTS
Thickness	1.52 (+1.52/-1.02)mm
Diameter	19.05 (±0.1016)mm
Plating	8µ (+17/-3)µ
Weight	2.50g (±0.10g)
Calculated Plating Weight @8µ: 0.05g	

BUSINESS STRIKE CENTS								
ID#	Date/Mint		DIAMETER		THICKNESS			
		WEIGHT	Vert	Horiz	K12	K3	K6	K9
		Grams	Millimeters		Millimeters			
PA101	1982DSD	2.49	19.00	19.04	1.31	1.45	1.47	1.47
PA102	1982DSD	2.43	18.98	18.9[illegible]	1.35	1.45	1.32	1.35
PA103	1983	2.46	19.00	19.01	1.45	1.41	1.43	1.40
PA104	1983	2.49	18.93	18.94	1.52	1.64	1.54	1.39
PA107	1983D	2.54	19.02	19.02	1.46	1.43	1.36	1.52
PA108	1983D	2.52	18.96	18.87	1.39	1.53	1.49	1.47
PA105	1984	2.50	19.01	19.02	1.39	1.49	1.40	1.36
PA114	1984	2.52	18.97	19.03	1.44	1.46	1.41	1.46
PA106	1984D	2.48	19.01	19.02	1.42	1.50	1.42	1.54
PA109	1984D	2.49	19.00	19.00	1.47	1.52	1.31	1.52
PA110	1985	2.54	19.01	19.03	1.38	1.45	1.35	1.42
PA111	1985	2.52	19.01	19.02	1.34	1.49	1.37	1.43
PA112	1985D	2.52	19.02	19.02	1.38	1.53	1.37	1.40
PA113	1985D	2.52	18.98	19.04	1.38	1.52	1.49	1.50
	AVE	2.50						
PA115	2007	2.50	19.02	19.05	1.40	1.56	1.48	1.38
PA116	2007D	2.50	19.01	19.00	1.33	1.44	1.50	1.44
PA118	2010	2.52	19.05	19.05	1.46	1.50	1.35	1.51
PA117	2010D	2.50	19.04	19.04	1.42	1.42	1.37	1.46
PA120	2014	2.50	19.02	19.05	1.33	1.33	1.41	1.46
PA119	2014D	2.49	19.01	19.02	1.28	1.35	1.40	1.52
PA121	2019D	2.46	19.03	19.03	1.40	1.41	1.32	1.40
	AVE	2.50						

	PROOF	CENTS						
ID#	Date/Mint		DIAMETER		THICKNESS*			
		WEIGHT	Vert	Horiz	K12	K3	K6	K9
		Grams	Millimeters		Millimeters			
TG004	1983S	2.52	19.04	19.06	1.47	1.66	1.51	1.58
TG003	1983S	2.64	19.03	19.07	1.50	1.80	1.54	1.59
EBMC2	1983S	2.52	19.04	19.05	1.48	1.60	1.49	1.55
EBMC3	1983S	2.54	19.04	19.06	1.48	1.54	1.50	1.52
EBMC4	1983S	2.51	19.03	19.03	1.49	1.49	1.44	1.57
TG001	1984S	2.56	19.06	19.10	1.51	1.60	1.55	1.57
TG002	1984S	2.52	19.08	19.05	1.53	1.50	1.49	1.58
EBMC1	1984S	2.56	19.02	19.02	1.38	1.53	1.37	1.40
EBOC1	1985S	2.55	19.06	19.09	1.49	1.53	1.47	1.53
	AVE	2.55						
BKS01	2007S	2.58	19.06	19.04	1.67	1.83	1.68	1.73
BKS02	2007S	2.59	19.06	19.10	1.65	1.81	1.71	1.81
BKS03	2007S	2.61	19.05	19.03	1.67	1.73	1.72	1.75
EBMC5	2010S	2.61	19.05	19.05	1.62	1.62	1.59	1.62
EBMC6	2010S	2.64	19.03	19.07	1.59	1.62	1.54	1.67
EBCN1	2014S	2.59	19.04	19.05	1.61	1.66	1.55	1.71
EBMC7	2019S	2.58	19.05	19.05	1.52	1.64	1.51	1.59
	AVE	2.60						

Contracts awarded[10] by the US Mint for the delivery of CPZ Ready-to-strike planchets specify three types of planchets: CIRCUALTING, UN-CIRCULATING AND PROOF. I have requested specifications for each planchet type both from the US Mint and the current supplier with no response from either. While the Mint has been of some help with questions in the past, it appears to be withholding information on this question. I am considering a FOIA request, but suspect a response under Exemption 4, which protects action obtained from a person that is privileged or concerns confidential trade secrets, would be forthcoming.

Nevertheless, the fact that three planchet types are specified in the various contracts (example referenced in footnotes) suggests that each planchet type exhibits different specifications. It is up to us to deduce what those specifications might be!

The possibility that plating may be applied to the planchets[8,9] differently for Proof cents than for Business Strike cents is certainly present, as evidenced by the following:

►The supplier can apply plating in different thicknesses, and has done so while the mint was evaluating alternative metals during Phase II testing.[3] (There is little argument for an actual double application of plating because of the additional labor required).

►The mint tolerance for plating thickness is adequate to allow for a double thickness of plating on a proof cent.

{Thickness and diameter measurements: thickness measurements are taken at the edge of the coin. Proof cent strikes usually leave some degree of finning which extends above the face of the rim. I think readings being lower at K12 and K6 are due to metal being drawn into the head and bust during the strike and away from fin formation. A similar effect may be seen with lower diameter readings for vertical diameter compared to horizontal diameter.}

CONCLUSION

The average weight of Copper Plated Zinc (CPZ) Proof Cents, compared to the average weight of CPZ Business Strike Cents, along with a permissive Mint Tolerance for Copper Plating Thickness on Proof Cents, and separate specifications for each of the three planchet types in use, suggest that the copper plating on proof cents is at least twice as thick (or more) as the copper plating on business strike cents.

FOOTNOTES

1. **https://www.ngccoin.com/news/article/646/**

2. ALTERNATIVE METALS STUDY Contract Number: TM-HQ-11-C-0049 FINAL REPORT August 31, 2012 by Concurrent Technologies Corporation, Submitted to: United States Mint, Page 1, Section 1.1

3. Alternative Metals Study, Phase II Technical Report, 2014 Biennial Report to the Congress For Phase II testing, United States Mint, Department of the Treasury, FINAL, August 11, 2014, page ii.

4. EMS = Electromagnetic Signature Ibid., Page 28-29

5. The modern minting process and U.S. minting errors and varieties (ANA correspondence course), by James Wiles, Jan 1, 1997, Page 54.

The Mint receives Ready To Strike (RTS) Planchets from its supplier, ARTAZN LLC. Jarden Zinc Products, based in Greeneville, has changed its name to ARTAZN LLC, and its parent company has changed its name from Jarden Process Solutions to Jadex Inc., according to a news release of 3/3/2020. Jarden Zinc Products LLC, which was a subsidiary of Ball Corporation. A contract was awarded July 22, 1981 to the Ball Corporation of Greenville, Tennessee for press-ready planchets[1] (Jarden is also mentioned in the literature as Alltrista, a previous name).

6. https://www.pfonline.com/articles/ripple-effect-researchers-say-leveling-of-electrodeposits-can-be-achieved-by-applying-a-small-forcing-voltage

https://www.bltlplating.com/info/the-secret-between-the-electroplating-process-67909680.html

7. https://www.proplate.com/how-is-coating-thickness-controlled-during-the-electroplating-process-and-what-are-the-primary-methods-and-techniques-used-for-this-purpose/

8. Thickness Effect on Microstructure and Residual Stress of Annealed Copper Thin Films, Article in Materials Science Forum, March 2011, DOI: .4028/www.scientific.net/MSF.681.139 by: Renaud Vayrette, Christian Rivero, S. Blayac, Karim Inal, Pages 139,144.

9. Note that the supplier does not normally distinguish between “blank” and “planchet” and neither does the mint, on occasion. It is clear that when the mint

does distinguish, their definition of "Planchet" is having been through the upsetting mill. (Alternative Metals Study, Phase II Technical Report, 2014, op. cit. page 4.)

There are even examples where Mint personnel use the 2 terms interchangeably:
From a 1983 letter about the plated cents:

> **"Conversion to the copper-plated zinc cent has been successfully implemented with full public acceptance. During 1983, one-cent coins will be produced from purchased copper-plated zinc blanks. Both types are circulating simultaneously. The copper-plated cents are identical in size. Shape, color and design to the predominantly copper cents but are somewhat lighter, having a standard weight of 2.50 grams as opposed to the 3.11-gram standard weight of the copper cent. The new cent contains 2.4 per cent copper and 97.6 per cent zinc. The core is an alloy of zinc with 0.8 percent copper. The outer surface of the planchet or blank, including the edge, is barrel electroplated with copper. This modification will reduce metal costs by $25 million a year. Background material is enclosed."**

[RG104 E-77 Box 6 folder 26 Public Corr 1982-1986. Letter dated March 24, 1983 to C. F. Dockstader from Francis B. Frere, Asst Director] → Resource provided by Roger Burdette: https://boards.ngccoin.com/topic/437331-proof-cent-plating/#comment-9904481

10. https://govtribe.com/award/federal-vehicle/1-cent-planchets