QUALITY CONTROL AT THE US MINT

►AN OVERVIEW BY PETE APPLE

►INCLUDING DIFFERENCES BETWEEN THE PHILADELPHIA AND DENVER MINTS

The US Mint applies quality control procedures at multiple points in the coin production process. Continual efforts have been underway to evaluate and improve on those procedures.

RAW MATERIALS

One of the initial places that quality control is exercised is in the quality of materials as measured against required specifications.

The Mint relies mainly on its material suppliers for raw materials quality assurance of circulating coins,[1] but also tests the raw materials. An Audit in 2020 found that the Mint and material suppliers have mature processes in place which yield minimal quality issues; and that the Mint relies mainly on the suppliers' Quality Management System (QMS) and International Standards Organization (ISO) certification to ensure the quality of the raw materials.[2] *However*, the inspection and testing conducted by the Mint to validate the quality of incoming raw materials is limited and inconsistent between Mint facilities.

The Mint's contracts with its material suppliers specify that the composition of raw materials provided for circulating coins meet the requirements prescribed under U.S. law, and include specific dimensional, thickness, and other physical requirements for which the Mint conducts various inspections and tests to assess the raw materials conformity.[3] These include:

• visual inspections for defects and damage;

• dimensional and thickness inspections with a micrometer;

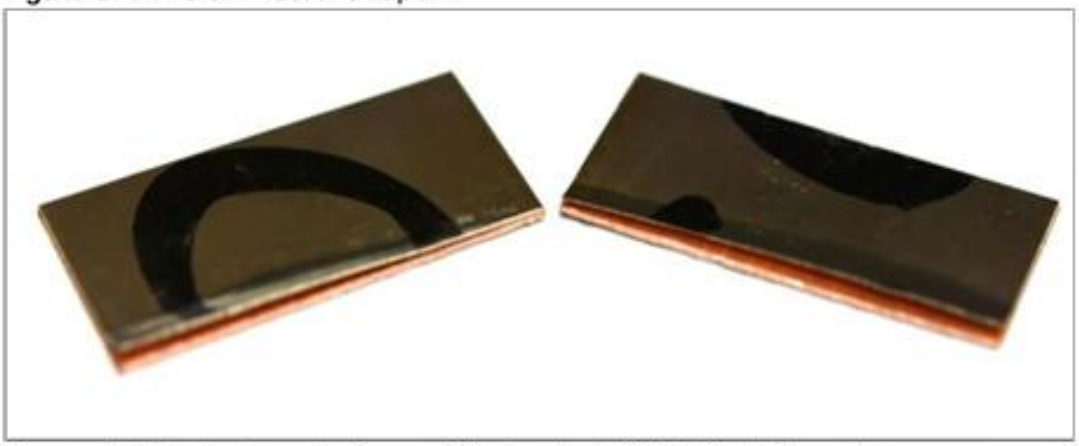
and

• hardness testing and chemical analysis.

The U S Mint uses a Rockwell Hardness Test on all raw coinage material and on the steel for dies and hubs.[4] The Rockwell 15T scale is used for all coinage material except for 40% Silver Clad Kennedy Half Dollar material where the Rockwell B Scale is used. The Rockwell C Scale is used for die and hub steel. It is highly unlikely that remnants of a Rockwell Test will be identifiable, since the test is performed on the die neck and has no effect on the face, and the test on a planchet will not survive a strike in any identifiable form.[5]

One of the primary testing procedures is using coupons (see image). Coupons are small sections of the material used for testing against specifications, including thickness, hardness, composition, and lamination[6] tendencies. Material suppliers are contractually obligated to send a coupon from each coil in advance of the coil shipment for testing.[7]

Figure 5: A Delaminated Coupon



Source: Mint photograph from a September 2015 Mint internal quality report.

A 2020 Audit found that only 13% of the coupons were tested by the Mint.[8]

<u>DIFFERENCES IN QUALITY CONTROL</u>[9]

Policies and procedures for testing were not consistent between each facility, which resulted in not all tests being performed and logged for each coupon tested. Although both facilities tested some coupons for physical characteristics such as hardness and thickness, the following tests were not consistent or documented:

- **Philadelphia Mint did not conduct delamination testing on coupons.**
- **Denver Mint officials stated coupons are tested for delamination, but they did not document the results.**
- **Denver Mint did not conduct chemical analysis on the coupons.**
- **At the time of our May 2018 site visit to the Philadelphia facility, we found chemical analysis testing had been suspended in January 2018 due to equipment failure and had not resumed after replacement equipment was onsite.**
- **Philadelphia lacked formal written procedures over penny blank[10] inspection and testing.**

BLANKING, ANNEALING, BURNISHING, AND UPSETTING

Production scrap material includes the excess material left from punching coin blanks from coils referred to as web scrap, as well as condemned coins or blanks rejected during the manufacturing process for various quality reasons.[11] These materials are returned to the suppliers for reprocessing.
Once a defective coin is discovered during quality control procedures, multiple bags and process hoppers are potentially contaminated and sent to recycling,[12] and a Non-Conformance Report (NCR) is generated. From observations, there are very few rejects from the blanking operation. Condemned blanks mostly occur because of issues with annealing, burnishing, or upsetting.[13]

Based on production figures for the past five years, the mean condemned scrap rates of total production (excluding web scrap) vary from 1.3% for the one-cent coin, 8.6% for the 5-cent coin, 6.6% for the dime coin, 8.2% for the quarter dollar coin and 10.1% for the dollar coin; this condemned scrap was diverted to the recycling stream. Scrap rates for one-cent coins are typically lower than for other denominations, largely because fewer operations are performed by the United States Mint. Blanking, cleaning, and upsetting are performed at the cent planchet vendor and any scrap associated with these operations is not included in the one-cent total at the United States Mint.[13]

RIDDLER

Quality control differs between the Philadelphia and Denver Mints. The placement of Riddlers is one example. Philadelphia uses the Riddlers at more stages in the minting process than does the Denver Mint. (At Denver, riddlers are normally used only after the coin is struck, whereas at Philadelphia they might be used at each or any step in the manufacturing process.)[14]

After the coins are minted, a test is performed to make sure the coins are properly sized. The coins are placed in a machine the Mint calls a riddler. A riddler consists of several levels of sizing screens that have holes in them. The first screen consists of holes that are slightly larger than the actual size of the coin. The screen is shaken and the coins that fall through the holes reach the second level. Coins that do not fall through are too big and are recycled.

The holes in the second sizing screen are slightly smaller than the proper diameter of the coin. Any coins that fall through the holes of this screen are too small and are recycled.[15]

STRIKING

The United States Mint currently uses conventional stamping machinery to produce precisely detailed metal surfaces, with very tight quality control of each coin's diameter, edge thickness, and weight.[16] Tolerances used by the mint are listed below.

US MINT TOLERANCES FOR CIRCULATING COINS

	WEIGHT (g)	THICKNESS (mm)	DIAMETER (mm)
CENT	2.50 ± 0.10	1.52 -0.102 to + 0.152	19.05 ± 0.1016
NICKEL	5.00 ± 0.194	1.95 ± 0.102	21.209 ± 0.1016
DIME	2.268 ± 0.091	1.35 - 0.076 to + 0.127	17.91 ± 0.1016
QUARTER	5.670 ± 0.227	1.75 ± 0.102	24.26 ± 0.1016
HALF	11.340 ± 0.454	2.15 ± 0.102	30.61
DOLLAR	8.1 ± 0.3	2.00 ± 0.076	26.4922 ± 0.0762

INSTALLED DIES INSPECTION TO CONFIRM ACCURATE INSTALLATION

William Tan operates the Press Die Vision System (PDVS), which is integrated with the coin press so that no striking can occur until the system inspects and approves the installed dies. This integration was created by a group in San Francisco. The system uses technology such as computer-controlled servo motors, infrared lights, special mirrors, and a camera to inspect the installed dies in the press. If the dies are not an appropriate pair, striking is interlocked and prevents the striking of mule coins (obverses and reverses not meant to be together) for all denominations, increasing efficiency and lowering production costs.[17]

The PDVS appears to have become fully integrated in all Mint Press Rooms over the following few years. After acknowledging that the mint was aware of a 2014-D mule dollar, U.S. Mint spokesman Michael White told Coin World in a Jan. 14 statement. "Since 2014 we have implemented multiple controls and mistake-proofing measures both within the Coining Die Vault and Numismatics operations which will prevent a similar error from occurring again."[18]

DEFECTIVE COINS

The Mint does not attempt to prevent coins with minor "defects" (cracks, chips Doubled Dies, Clashes, etc.) from entering circulation. The following references substantiate this observation.

Circulating coins are not free from defects, but the coins must be within dimensional tolerances and observed defects must be limited in size.[19]

From die life tests run by the mint, we know that dies are not retired simply because there is a small piece out[20] of the die, or even more than one, and that coins exhibiting such are considered acceptable for circulating.[21]

The Mint states, in response to a coin sent to them for examination, that: "Subtle imperfections on circulating quality coins, such as the image found on the 2004 Peace Medal nickel that was examined (See Photo), are inherent in the coin making process. Such slight imperfections do not affect the coin's use in commercial transactions."[22]

"As a note on coin and die inspection, operators at the press use low power magnification (3X to 7X) to inspect coins against a visual standard. Operators

focus on problem areas such as crack propagation and areas known to have high wear. It is highly doubtful that the type of imperfection found on the 2004 Peace Medal nickel would be caught by an operator at the press. The photographs published of the specimen were at much higher magnification, 30X-100X. The quality systems in place at the Mint are not designed nor intended to screen out these very small, subtle imperfections." From a 2005 Letter from the Mint to Ken Potter

The precise meaning of "visible" in the following statement is unclear. It may mean either unassisted by any magnification or it could be under 3x to 7x magnification. In either case, it is clear that the possibility for less stringent requirements for acceptable coinage for circulation is being considered.

> **"Currently any visible defect, such as possible staining from improper cleaning or a mark from a small crack in the die or misalignment of the obverse and reverse dies, is cause for rejection of all potentially affected batches of coins at any point in the production process. Given the difficulty in detecting such defects, and given the difficulty of tracking the exact time that any given piece completed a suspect process, detection of a defective piece typically impacts a substantial number of otherwise acceptable coins. Allowing small numbers of occasional mistakes to be released would enable a considerable reclamation of mostly good production without impacting the commercial utility of circulating coinage while also reducing production costs at the United States Mint."[23]**

<u>DIE ROTATION</u>

The rotation of dies produces a large amount of condemned material because 1) a misaligned coin is considered a major error coin, 2) these misaligned coins are co-mingled with otherwise acceptable coins produced on neighboring presses and 3) as explained below, sorting equipment is not 100% effective in removing these pieces. Once a defective coin is discovered, multiple bags and process hoppers are potentially contaminated.[23]

In response to my e-mailed question, the mint has stated:

> **"For circulating denominations, the coin rotation tolerance is typically: ± 6°. For numismatic (proof coins, precious metals, commemoratives, etc.) denominations the coin rotation tolerance is typically: ± 3°."**

The Mint began a program, at least as early as 1995, of selling defaced retired dies to the public. A Certificate of Authenticity was provided with each die that included information of the date range of service, number of strikes, denomination of coin, type of press, and reason for retirement, along with additional information. I am actively recording this information with over 100 certificates recorded. Those certificates report that 20% of the dies were retired because they were worn and the other 80% were retired primarily due to being cracked or "Come Together" (clashed) or "Piece Out".[20] I think it is safe to assume that the dies at this point had begun to produce coins beyond acceptable levels and sizes of defects and that those coins were kept from circulation and added to the condemned scrap bin for recycling.

FOOTNOTES

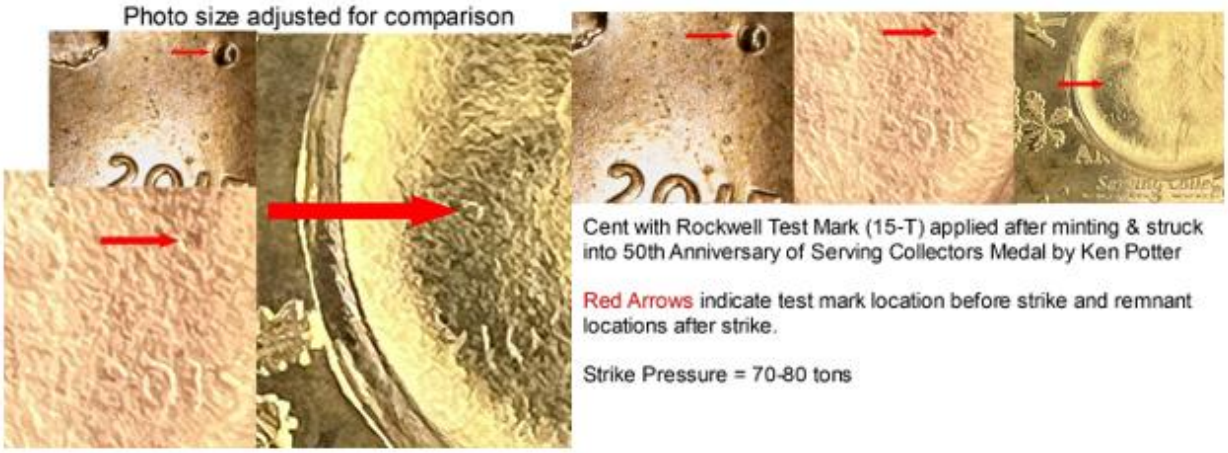
1. Page 13, Audit Report, OIG-20-042, MANUFACTURING AND REVENUE, August 18, 2020, Office of Inspector General, Department of the Treasury

2. Ibid Page 13, Footnote 22: A QMS is a formalized quality system that documents processes, procedures, and responsibilities and helps to coordinate and direct activities to meet customer requirements. ISO 9001 is an international standard which defines standardized quality assurance processes based on industry best practices. ISO 9001 is the most prominent approach in specifying requirements for QMS. (ISO = International Standards Organization)

3. Ibid., Pages 8-9.

4. Rockwell Hardness Test Marks on Lincoln Cents by Pete Apple https://conecaonline.org/rockwell-hardness-test-marks-on-lincoln-cents/

5. Ken Potter took a coin that I had impressed with a Rockwell 15-T test and used it with the striking of his 50th Anniversary of Serving Collectors Medal so that we could examine the effects of a strike on a Rockwell Test Mark. The Test Mark was not identifiable as a test mark after the strike.



Cent with Rockwell Test Mark (15-T) applied after minting & struck into 50th Anniversary of Serving Collectors Medal by Ken Potter

Red Arrows indicate test mark location before strike and remnant locations after strike.

Strike Pressure = 70-80 tons

Cent with Rockwell Test Mark struck into Ken Potter's 50th Anniversary of Serving Collectors Medal

Photos by Ken Potter

6. The Mint normally does not use the numismatic definition for (de)lamination = a separation of an alloy along horizontal planes of weakness, but instead uses: Delamination is the separation of the outer layer of a coin, or blank, due to incomplete bonding or impurities and is more likely to occur when

the alloy is subjected to stress as during the process when a coin is struck. According to Mint officials, delamination can occur in any part of the coil and predominately occurs in quarters, as it is a clad alloy. Ibid., Page 15.

7. Ibid., Page 17.

8. Ibid., Page 18.

9. Ibid., Pages 19-20.

10. The terminology of a blank being a metal disk as punched from a strip and planchet being a blank that has passed through a Rimmer (Upsetting Machine) is not strictly followed in US Mint reports. Jarden Zinc (now rebranded as Artazn) delivers RTS (Ready To strike) planchets to the US Mint.

11. Ibid., Page 8.

12. Page 304, 2012 Biennial Report to the Congress on the Current Status of Coin Production Costs and Analysis of Alternative Content, United States Mint, Department of the Treasury, December 2012

13. Ibid., Page 305.

14. Page 6, THE MODERN MINTING PROCESS AND U.S. MINTING ERRORS AND VARIETIES, By James Wiles, (ANA correspondence course), 1996.

15. Page 292, 2012 Biennial Report, op. cit.

16. Page 9, The United States Mint, 2013 Annual Report.

17. Ibid., Page 9.

18. Mint officials were aware of the 2014-D mule dollar, By Paul Gilkes , Coin World, Published: Jan 22, 2021, https://www.coinworld.com/news/us-coins/mint-officials-were-aware-of-the-2014-d-mule-dollar#:

19. Page 107, 2014 Biennial Report to the Congress as required by The Coin Modernization, Oversight, and Continuity Act of 2010 (Public Law 111-302), United States Mint, Department of the Treasury, December 2014

20. "A piece out defect occurs when a small piece of the die breaks off (typically due to a local fatigue failure) and alters the local shape of the struck image." Footnote 140, Page 305, 2012 Biennial Report, op. cit.

21. Page 109, Biennial Report 2014, op. cit.

22. From a 2005 Letter from the Mint to Ken Potter https://www.facebook.com/groups/517126888733698/posts/1547014905744886

23. Page 305, 2012 Biennial Report, op. cit.