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CRITICAL DIMENSIONS

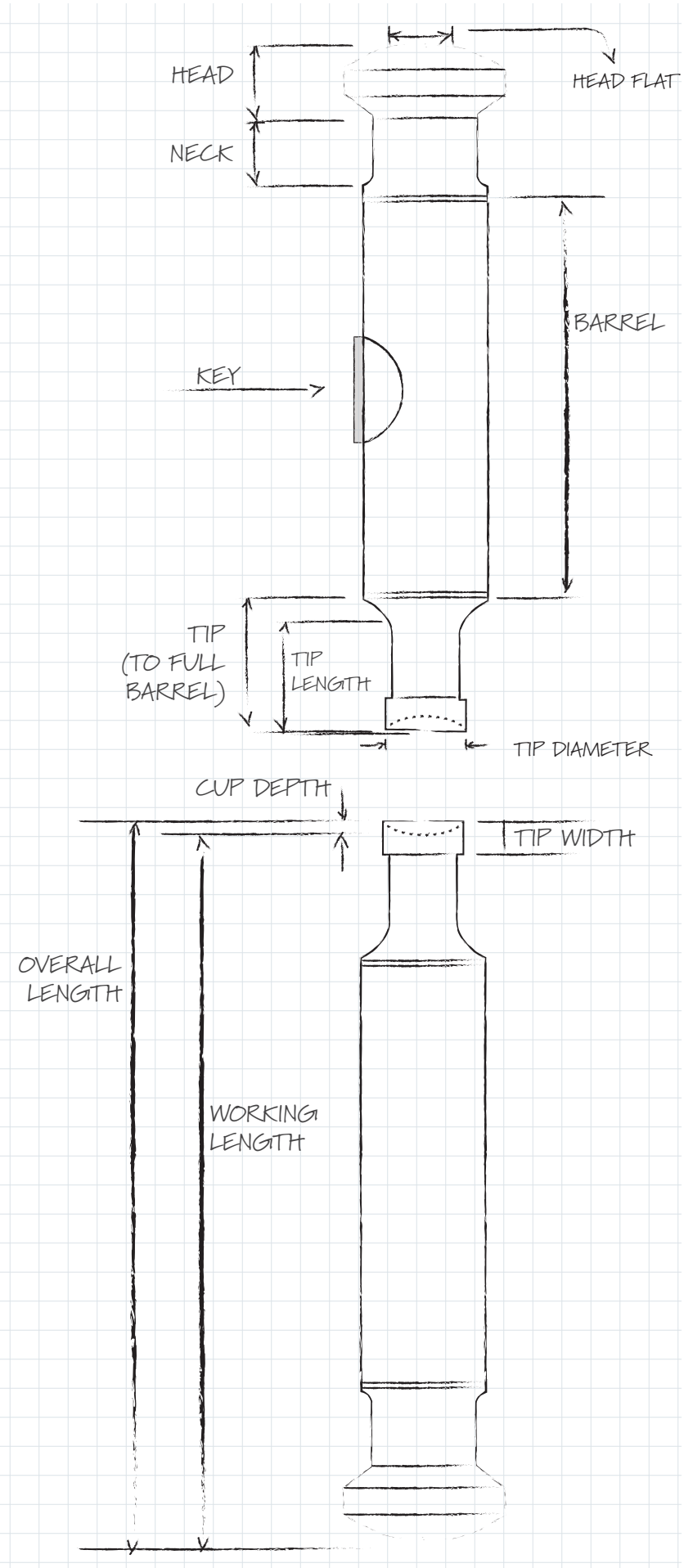
THE IMPORTANCE OF PUNCH LENGTH & CUP DEPTH

WHITEPAPER

NATOLI ENGINEERING COMPANY

WHAT ARE THE **MOST IMPORTANT DIMENSIONS** OF MY **TABLET COMPRESSION TOOLING?**

WORKING LENGTH & CUP DEPTH



Manufacturing tablets to a uniform hardness, weight, and thickness requires tablet press punches of consistent length. This whitepaper describes how to understand punch length, measure it correctly, and how wear affects tooling length and tablet consistency. This paper will also address the importance of specifying cup-depth tolerances, and establishing a punch inspection and maintenance program to verify that all punch lengths and cups are within dimensional tolerances.

These two measurements are the most critical to evaluate through the life of your tablet compression tooling.

IDENTIFY AND ACCURATELY MEASURE THE WORKING LENGTH

Punches are engineered and manufactured to consistent lengths. The working length of a punch is measured as the distance from the head flat to the lowest measurable area of the punch cup.

Specific high and low working length tolerances are established during the tooling design process to ensure the tool manufacturer produces new punches within the appropriate working length range. The distance from the head flat to punch tip is the overall length of the tooling. The punch tip comprises the cup and the land (**Figure 1**).

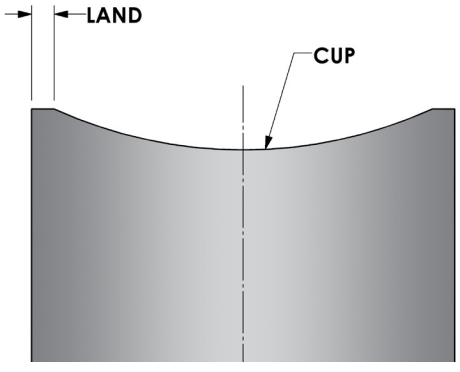


FIGURE 1

Working length is critical to consistent overall tablet hardness, weight, and thickness; it should be considered the most important dimension in a tool inspection program. If the working length varies within a set of tools, then those tablet characteristics will also vary. Working length consistency is the key. As in-process tooling begins to wear, resetting the range of working length becomes necessary. The working length of punches is engineered to a standard range of 0.051mm (0.002 inch). This means that, within a set of punches, the difference between the working lengths of the longest and shortest punch is no more than 0.051mm (0.002 inch).

IMPORTANT REMINDERS

- ***Periodically inspect punches to ensure working lengths do not exceed that tolerance (or the range your company specifies).***
- ***When inspecting to confirm a uniform working length, inspect the upper punches independent of the lower punches.***

CALCULATING THE WORKING LENGTH

It is also critical to measure correctly. Do not calculate the working length by subtracting the cup depth from the overall length, as that method can produce results showing some tools are out of specification when in fact they are not. The working length of the punches should be measured for deviation from punch to punch rather than from a calculated number. Working length can be measured using a simple digital indicator mounted on a steel post and stable base, or a more elaborate laser inspection system.

An important advantage of a laser inspection system is non-contact lasers eliminate the risk of punch-tip damage from the sharp tip of the digital indicator. Other advantages include that critical punch dimensions are measured simultaneously and can be recorded real-time into a tool management software database, saving tablet manufacturers significant time. Whatever equipment used, measuring the working length of punches that have embossing or a bisect at the lowest area of the punch cup is more complicated. In those cases, it is important to measure from the deepest accessible area of the cup with the tip of the indicator (**Figure 2**). Once the lowest area of the cup is identified, the technician must be sure to measure consistently from that point when checking the entire set.

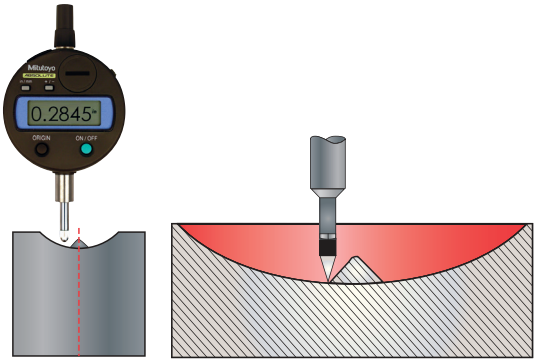
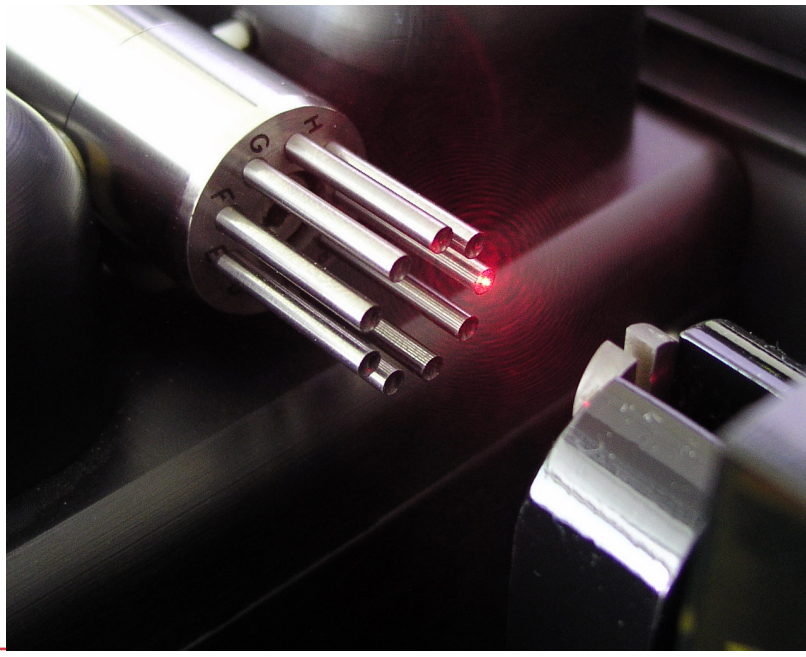


FIGURE 2

Reputable tooling manufacturers can provide a working-length matching report when they deliver a new set of punches. The matching report pairs each upper punch with a lower punch, from longest to shortest, and numbers them accordingly. Matched punch sets minimize deviation in tablet hardness and thickness, and a matching report offers helpful guidance during press setup. The length of the lower punch is more critical than that of the upper punch because the lower punch largely determines how uniformly product (granulation) fills and doses in the die. Product flow characteristics and lower punch binding also strongly influence the uniformity of die filling. Deviations in the amount of product allowed into the die affect tablet hardness and weight.



EVALUATING CUP DEPTH

The cup depth is the distance from the tip edge of the punch to the lowest theoretical point of the cup. Some cup configurations have a varying depth, such as those used to manufacture tablets with scalloped edges. The cup determines the configuration and appearance of the tablet faces.

The area between the two tablet faces created by the die is called the tablet sidewall (**Figure 3**), sometimes referred to as the tablet gate or the tablet band. Although the sidewall is generally not inspected or measured, it is critical to tablet appearance and manufacturing. Ideally, the sidewall width will be well-proportioned with the overall tablet thickness. A tablet with an excessively thick sidewall appears to be larger overall, creating the perception that the tablet will be uncomfortable to swallow. An excessively thick sidewall also requires the tablet press to exert greater force to eject the tablet from the die.

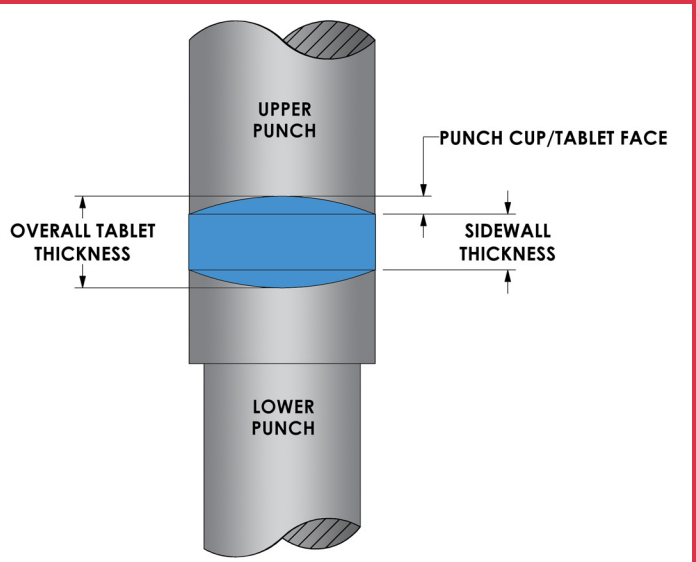
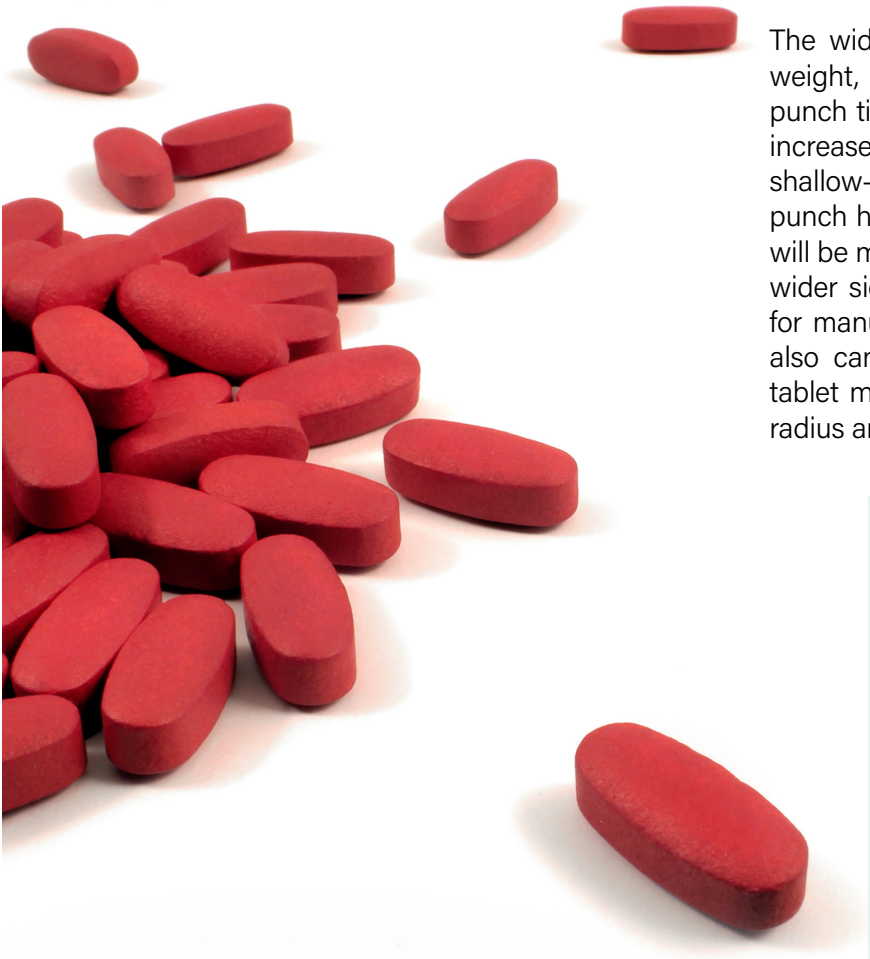


FIGURE 3



The width of the sidewall depends on the tablet hardness, weight, and thickness in relation to the cup depth. As the punch tip wears, cup depth decreases and sidewall thickness increases. Thus, when comparing two tablets—made from a shallow-cup punch and a deep-cup punch—the shallow-cup punch has a thicker sidewall. However, the shallow-cup tablet will be measurably thinner overall than the deep-cup tablet. Its wider sidewall makes it visually undesirable and unfavorable for manufacturing. The wide sidewall of a shallow-cup tablet also can cause difficulties during film coating because the tablet may erode at the sharp corner where the shallow-cup radius and the vertical sidewall meet (**Figure 4)**.

The wide sidewall of a shallow-cup tablet may create a sharp corner where the radius and the vertical sidewall meet. The corner can erode easily during film coating.

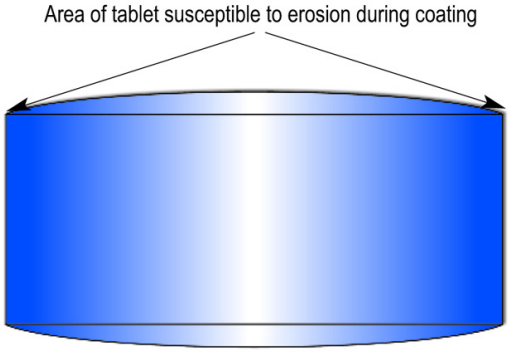


FIGURE 4

WHAT ABOUT THE OVERALL LENGTH OF THE PUNCH?

The overall length is the least important length dimension of the punch. It is the distance from the punch tip to the head flat. The overall length is a reference dimension that comprises two or more critical dimensions: the working length and the cup depth. Since both working length and cup depth are manufactured to a specific tolerance, there is no need to assign a tolerance to the overall length.

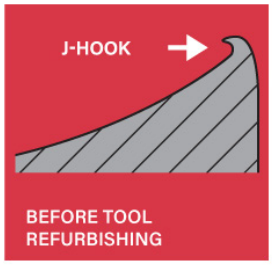
As long as the working length and the cup depth are confirmed to be within the acceptable range, then the overall length will be consistent and inspection is unnecessary. However, the overall length of the lower punch is somewhat critical when it comes to setting the punch height for uniform tablet take-off, which is important to minimize the potential for tablet damage. If your company's standard operating procedures require inspection of the overall length, the same equipment can be used to inspect the working length and cup depth. Of course, a tolerance range and a pass-fail policy must be established.

A WORD ABOUT PUNCH WEAR

With normal use, punches show the most wear at their tips, which reduces the cup depth. As a result, tip wear also reduces the overall length of the punch, but does not affect the critical working length. Any wear of the head flat (not as common as punch-tip wear) will further reduce the overall length, as well as reduce the working length. Head flat wear does not affect cup depth.

Normal maintenance of the cup face, tip, and head also can affect punch length. Polishing the face using fine abrasives, hard felt bobs, or stiff brushes can alter critical lengths. Likewise, if using hard felt bobs and/or stiff brushes with abrasive compounds to remove product adhered to the face or to remove surface discoloration or pits (typically the result of compressing abrasive products), eventually the punch cup will deepen and possibly alter the critical working length.

Wear also can occur at the land, which is the narrow flat area located at the perimeter of the punch tip. The land is subject to abrasion during compression and is commonly the first area of the punch to wear. When the land wears, the tip edge becomes very thin, even razor sharp, which can result in a condition referred to as J-hook (**Figure 6**).



J-hook is the distinctive wear pattern on punch tips that is a cause of tablet defects like capping and lamination. When detected early, J-hook can be easily and quickly repaired, thereby eliminating the need to purchase replacement tools. Refurbishing punch cups with the 10" unsewn buffing wheel eliminates J-hook.

J-hook normally occurs on the upper punch tip and is a common cause of tablet capping and lamination. Polishing the punch using a soft, unsewn cotton buff wheel and polishing compound can remove J-hook and restore land. While polishing and restoring the land will prolong the useful life of your punches, it will eventually reduce the cup depth and overall length as these are elements of controlled wear.

Uniform tool length is critical for maintaining tablet consistency and smooth press operations. The most important dimension of the punch as it relates to tablet quality is the working length, followed by the cup depth, and then the overall length. To achieve the highest level of tablet uniformity, reputable manufacturers of tablet compression tooling provide a working-length matching report. Setting up the tablet press in the sequence of the supplier's matching report will provide the best scenario for tablet consistency.

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QUALITY TABLETS COME FROM QUALITY PUNCHES.

NATOLI ENGINEERING: Dedicated to Supporting Our Industry

Natoli Engineering Company is the world-renowned leader in tablet compression tooling. **But we are far more.** Founded on the uncompromising principle to manufacture and deliver the highest quality products at a fair price with exceptional customer service, Natoli continues to build on 40 years of innovation and industry leadership.

NATOLI ENGINEERING PROVIDES UNPARALLELED SUPPORT IN:

- Tool Design
- Tablet Compression Accessories
- Technical Training
- Tablet Design
- Tablet Press Replacement Parts
- Regional Service Centers
- Tablet Press Refurbishment
- Scientific and On-Site Consulting
- Encapsulation

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