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# An alternative method for designating flute sizes

## Scope and significance

Many corrugated board manufacturers appear to be confused by what appears to be a random assignment of flute names by corrugating roll manufacturers. About 100 years ago, in the early days of the corrugated box industry, it seemed reasonable to designate flute profiles by letters in the order in which they were developed ('A', 'B', 'C'). The "alpha" designation had no other significance. This was acceptable in the early days of the corrugated industry, but now it is out of control.

Today, when someone creates a new flute profile they assign an "alpha" designation to it without knowledge of what others in the industry are doing. For example, there are currently multiple definitions of some flute sizes such as 'D' and 'K.' Is 'D' flute 2.21 mm (0.087 inch) deep or 6.60 mm (0.260 inch) deep? Is 'K' flute 6.35 mm (0.250 inch) deep or 7.00 mm (0.276 inch) deep? Also, prefixes such as micro, mini, special, double, super, and ultra have been added to existing "alpha" designations. This has created confusion in the industry among corrugated board manufacturers, and, if left uncontrolled, will lead to more confusion in the future. Clearly, we need something better than the "alpha" flute specification.

Flute profiles are precisely specified by the corrugating roll manufacturer by depth, flutes per meter (foot), take-up ratio, and specific dimensions. A corrugating roll manufacturer may have a hundred flute profiles that are classified as 'C' flutes. For the purposes of this discussion, the term "flute profile" refers to a manufacturing tool whether it be hardware or software. The term "flute size" refers to a classification such as 'C' flute that may include hundreds of flute profiles. The corrugated board manufacturer combines the "flute profile" with papers of specific quality to produce a "flute size" that meets the performance requirements of the customer. The "flute profile" and the paper quality can be changed and still satisfy the "flute size" and performance requirements.

With the new standards for corrugated board performance and the proliferation of flute sizes it is now desirable to have a scheme for the classification of flute sizes that will:

1. Be easy to understand and allow for immediate recognition
2. Organize flute sizes
3. Allow for the addition of new flute sizes in the future in an orderly way
4. Serve the purpose for a long time
5. Protect proprietary information.

This TIP is a proposal to standardize flute size classification to bring order to the process. It is based on presentations given to the TAPPI Engineering Committee of the Corrugated Containers Division by Tom Keeny (1).

## Proposal for flute sizes

Figure 1 is a plot of flutes per meter versus height for flute profiles from published data from many manufacturers of corrugating rolls. Each dot represents one or more flute profiles. There is definitely a pattern to the data because there are real and well-known limitations to flute profile design. It should be possible to draw two lines that represent the reasonable limits of flutes per meter versus height that would include all current and future profiles.

Figure 2 shows the proposed limit lines. The high limit (maximum flutes per meter versus height line) represents an unreasonably high cost of the corrugated board because of the relatively high take-up ratio and low runability. This high cost would put the manufacturer at a competitive disadvantage without providing any

significant structural advantage. Also, it is not necessary to exceed the high limit because the present flute designs are satisfactory. The best curve for the high limit is consistent runability.

The estimated low limit (minimum flutes per meter versus height line) represents an unreasonably weak structure of the corrugated board. The resultant structure will not support the liners sufficiently to develop the strength of the liners in edge crush, bending, stacking strength, or print quality. This low limit allows for reducing the flutes per meter and take-up ratio below that which is current in the industry in search of optimum flute profiles.

All known flute profiles fall between the two lines. More than that, all-meaningful, structurally sound and cost effective (high runability and low take-up ratio) flute designs will be in the zone labeled “useful flutes” which is bounded by the “cost limit” and “structural limit” lines. Note that the limit lines are defined by simple equations which are straight lines on log-log graph paper. In the future it may be possible to narrow the “useful flutes” zone as we learn more about the limits of structural strength of corrugated board.

Figure 3 is the same as Figure 2 with the addition of “Flute Gage Numbers.” The “Gage Number” is borrowed from other industries where it is used to define thickness or diameter either directly or by use of an easy to remember formula. The “useful flutes” zone has been sliced into 0.25-mm-wide cells. Each cell represents the limits of height and flutes per meter of a Corrugated Container Flute Gage Number.

The graphs are tabulated in Table 1. The “Flute Letter” column shows why there is confusion (multiple definitions of ‘D’ and ‘K’ flutes, etc.). Note the association between the flute gage number and height. The flute gage number multiplied by 0.25 mm equals the minimum flute height. What we currently call ‘C’ flute is a 14 gage flute; ‘A’ flute is an 18 gage flute and so on. The table shows that each gage number is defined by a maximum and minimum height, and a maximum and minimum number of flutes per meter. For different gage numbers the heights are unique, they do not overlap, but the flutes per meter do overlap.

Corrugated Container Flute Gage Numbers reduce confusion among users and do not limit the creativity of corrugating roll manufacturers. Flute gage numbers are proposed as a reasonable alternative to flute letters (the “alpha” designation) for the classification of flute sizes.

It is recommend that the corrugating industry adopt Corrugated Container Flute Gage Numbers as an approved alternative to flute letters.

## Keywords

Rolls, Corrugating, Corrugated medium, Flutes, Singlefacer

## References

1. Keeny, T., “Guidelines for Flute Sizes and Standardized Terminology,” presentations made to the Engineering Committee of the TAPPI Corrugated Containers Division: Oct. 6, 1998; March 30, 1999; and Nov. 2, 1999.

## Additional information

Effective date of issue: July 5, 2001.

Working Group Members:

John Troyke, Chairman – Georgia Pacific Corp.  
Tom Keeny, PE – Consulting Engineer  
Steve Schmidt – COPAR Corp.

