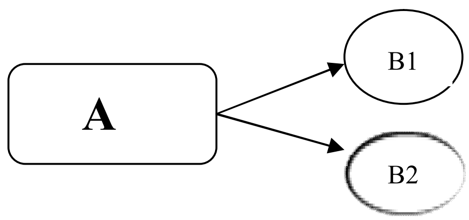
Cleaning Memo for December 2016

Limits for Batch Splitting – Part 2

This is a continuation of last month's Cleaning Memo dealing with batch splitting (if you haven't read last month's Cleaning Memo, please do so before proceeding with this one). In this Cleaning Memo we will consider another case of batch splitting, in which the *final processing step* involves a split batch. The idea is that you start off processing a given product in a relatively large batch size on initial equipment, and then the batch is split in two or more small batches for processing separately on two or more subsequent "equivalent" equipment items as the *last* processing step. In other words, there is *no subsequent blending* of the smaller batches to uniformly disperse residues throughout the larger batch.

Here is a schematic of this processing:



In this *first* example, I'll consider the case where the batch is *evenly split* between B1 and B2. Let's also assume that the total batch size is Q kg, and that Q kg are processed in A, but only Q/2 kg are processed in each of B1 and B2. Let's also assume that the surface areas of each equipment item are SA_A (for equipment A), SA_{B1} (for Equipment B1), SA_{B2} (for equipment B2), and that $SA_{B1} = SA_{B2}$.

For this first example the approach is to set L1 limits (limits as concentration in the next product, such as in ppm or mg/kg) *the same* for the split batch coming out of B1 and the split batch coming out of B2. [For those of you not familiar with my shorthand designations – L0, L1, L2, L3 and L4 – for different expressions of limits, please see the September 2012 Cleaning Memo.] Furthermore, in this example, I will allow half of the L1 concentration to come from processing in A with the other half coming from processing in either B1 or B2. What this means is that although I will have the same L3 values for B1 and B2 (based on the same split batch size and the same surface area), I will possibly have L3 values for A different from L3 values for B1 and B2.

Here are the equations for determination of L3 values for A and for B1 (note that the L3 value for B2 will be exactly the same as L3 value for B1 because the batch sizes and surface area are the same).

$$L3_A = \frac{0.5 * L1 * BS_A}{SA_A} \qquad \text{Equation I}$$

$$L3_{B1} = \frac{0.5 * L1 * BS_{B1}}{SA_{B1}} \qquad \text{Equation II}$$

$$L3_{B2} = \frac{0.5 * L1 * BS_{B2}}{SA_{B2}} \qquad \text{Equation III}$$

What is being done here is to allow half of the L1 value to be due to processing in A and half of the L1 value to be due to processing in B1. Note that in this case, the L3 values will vary depending on the relative surface areas of A and B1. Let me reiterate that in this example the L3 values for B1 and B2 are identical because of the 50/50 batch split and because the surface areas of B1 and B2 are identical..

What if the batch is *not* split evenly, but a larger amount is processed on either B1 or B2? And what if the surface areas of B1 and B2 are *not* identical? In this *second* example, I will still assume the batch size processed on A is Q kg. However, the fraction (as a decimal) processed on B1 is F, meaning that the fraction processed on B2 is (1 – F). Therefore, the batch size processed on B1 is $F*BS_A$ and the batch size processed on B2 is $(1 – F)*BS_A$. The designation for the surface areas will be the same, but in this example the surface areas of B1 and B2 *may* be different. And, as in the first example, I am assuming that the L1 value is the same for material processed in B1 and B2, and that half of that L1 comes from processing on A while the other half comes from processing on either B1 or B2. In this example, the L3 values for the three equipment items are *not* necessarily the same.

Here are the equations for this situation:

$$L3_A = \frac{0.5 * L1 * BS_A}{SA_A} \qquad \text{Equation IV}$$

$$L3_{B1} = \frac{0.5 * L1 * F * BS_A}{SA_{B1}} \qquad \text{Equation V}$$

$$L3_{B2} = \frac{0.5 * L1 * (1 - F) * BS_A}{SA_{B2}} \qquad \text{Equation VI}$$

Note also that if the split batch sizes are equal, that is F = (1 – F), and if the surface areas of B1 and B2 are equal, then the Equations V and VI simplify to Equations II and III. So, if you must be flexible in terms of the batch split ratio, it may be simpler to just use Equations IV through VI.

As mentioned, in this situation different L3 values are possible for each of the three equipment items. However, it is possible to select the lowest L3 value of the three and hold all three equipment items to that worst case value.

Furthermore, if the split ratio varies, you should consider doing calculations at the extremes. What I mean is that if the split can vary from 30% on B1 and 70% on B2 to 50% on each, then I do calculations for both situations and use the lowest result for each equipment item on that equipment item. That way I have covered all possible ratios *between* those extremes.

Finally, the examples given are where the batch is split into two portions, each going into separate equipment (B1 or B2). Note that while I used $F*BS_A$ and $(1 – F)*BS_A$ for the split batch sizes, you could just as easily use BS_{B1} and BS_{B2} respectively. The equations can also be expanded to three or more equipment items by having additional fractional values to correct the batch sizes. If that approach is required, then it may be simpler just to use BS_{B1}, BS_{B2} and BS_{B3} instead of introducing fractions to multiply with BS_A. However, realize that in either case, either the fractions used have to add up to 1 or the individual batch sizes on the B series equipment have to add up to BS_A.

Here is a third example, but one that most companies won't want to consider. This approach is to establish the *same* L3 for the B series equipment (B1 and B2, for example). I don't think it is possible under this approach of having the split batch being the last processing step to have L3 values for B1, B2 *and A* all be the same, unless by some quirk of an ideal combination of batch sizes, surface areas and batch split ratios. That said, I might be wrong, so if anybody can work that out, let me know and I will amend this Cleaning Memo. (Note that it may be possible to have all equipment with the same L3 by selecting the lowest L3 of any one equipment item and apply that to all equipment, but that approach is not the focus of this third option.) But, if the goal is just to have the L3 values for B1 and B2 be the same, then for the Equation V and VI, establish the value for F as follows:

$$F = \frac{1}{1 + SA_{B2}/SA_{B1}} \quad \text{or} \quad F = \frac{SA_{B1}}{SA_{B1} + SA_{B2}}$$

Either presentation will give the same answer for the F value to select for the split. Why I think this won't be feasible for most companies is that it locks you into a *fixed ratio* for splitting the batch. Any variation from that fixed ratio will cause limits to be different (higher on one equipment item and lower on another equipment item).

There certainly are more possible variations, such as whether a batch is split and then first half is processed on B1 followed by subsequent processing of the second half on the same B1 equipment. However, that is probably another Cleaning Memo.