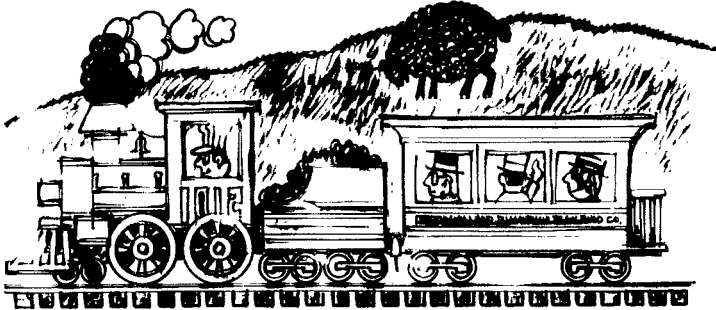


# Don't Expose Yourself To Flow Rate Confusion

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**H**ow important is flow rate to the shot peening process? That's not an easy question to answer. First, we must understand what it is that we are supposed to be doing. One simple description is, "We make dimples". That's a good beginning, but we need to say more.



Remember the story about the train traveling through the countryside in Scotland? Not far away up on a hill stood a black sheep. A parapsychologist noticed the sheep and exclaimed, "Ah, look. All sheep in Scotland are black". Others around him mused about this for a while. Finally someone spoke up, "That's not what you can say about that," said the Physicist. "All you can say about that observation is that some sheep in Scotland are black."

Consternation set in. Soon, the mathematician spoke up, "No, no, no, that's not it. All you can say is at least one sheep in Scotland is black." Smiles broke out as confidence increased. Until the logician, clearing his throat, said "Wait, you're not right yet. All you can say about this is that at least one sheep in Scotland is black—on at least one side." A pause was followed with applause. "How definite!" "Great work!" "Bravo!"

But it wasn't much longer until a puzzleist, setting at the end of the group quietly added, "At least some of the time."

Alas, life is indeed complex; and so is shot peening. There are times when shot flow rate is very critical, as in peen forming when coverage may be 30-40%. In other cases, like saturation peening, if the machine cycle time significantly exceeds the time necessary to achieve coverage, the flow rate may be less critical.

If saturation peening is done in high volume and production cycle time is critical, then it is more likely that the exposure time will be close to the time needed to achieve 70-100% coverage. Now we have to be careful with measurements of exposure time and shot flow rate.

We also have to be careful in two other aspects. First, monitoring shot flow rate can be classified as a safety feature. Just as you want a speed alarm in case a turntable stops rotating—you should know if you have a catastrophic shot flow rate failure.

And, something overheard from Geppetto, shot flow rate can also influence shot velocity (in air blast machines). Significantly. In fact, one of the best ways to get a high peening intensity is to apply maximum air pressure and use a very low shot flow rate (2-4 lb/min). And, conversely, one of the ways to get a low peening intensity is to reduce the air pressure (20-30 psi) and increase the shot flow rate as high as possible while maintaining shot conveyance without pulsation.

Returning now to our original mission—making dimples. Peening requires the making of dimples of a certain size and certain quantity. Many specifications describe complete coverage as "the complete obliteration of the original surface with overlapping indentations". Coverage of 98% is often considered to be complete coverage since estimates above 98% are difficult to make. When 200% coverage is requested it means to peen for twice the time required to achieve 98% coverage.

Obviously, continued exposure beyond complete coverage does not add to the process. If exposure time of 1 minute provides complete coverage, then exposure time of 1 minute 15 seconds is superfluous. However, exposure time of 45 seconds may be meaningful.

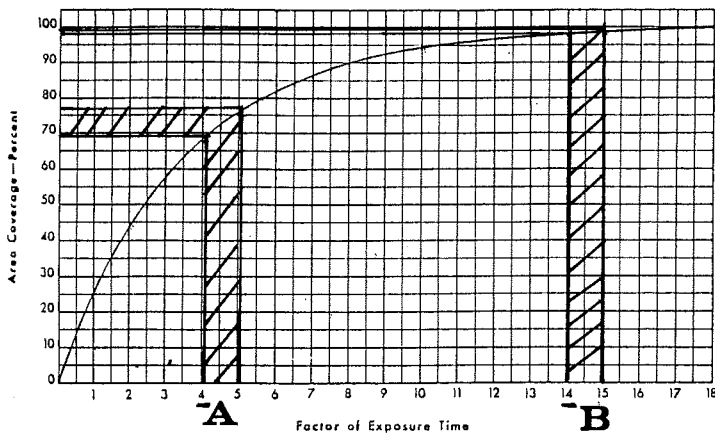
The coverage is the result of number of shots indenting a surface area. The flow rate is shots/minute (or more commonly pounds/minute). The exposure time is in minutes. Multiplying the two gives

$$\frac{\text{pounds}}{\text{minute}} \times \frac{\text{minutes}}{1} = \text{pounds}$$

This amount of shot will strike a given area creating a coverage factor. To increase or decrease the coverage, you can increase or decrease either the exposure time or shot flow rate. Variations of one by 10% will produce exactly the same results as variation of the other by 10%. Decreasing the exposure time by 10% is no different than decreasing the flow rate by 10%. They are both equally effective.

But the question remains—how important is flow rate accuracy or exposure time accuracy? That depends upon "At least some of the time". If your coverage exceeds 100% (complete) coverage, then variations are less significant compared to less than 100% coverage.

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**Figure 2**

**Relationship Between Area Coverage and Exposure Time**

To determine the significance, or sensitivity, requires experimentation. Refer to the graph in Figure 2 which shows coverage as a factor of exposure time. A change in exposure time from 4 to 5 (at point "A") results in a 7% change in coverage. A change in exposure time from 14 to 15 (at point "B") results in only a 1.5% change in coverage. Obviously this is less sensitive.

Furthermore, if your exposure time is greater than 98% coverage or if it is a multiple of 98% coverage, then the variations are even less significant.

- C** =  $1 - (1 - C_1)^n$
- C** = % covered after n cycles - Decimal
- C<sub>1</sub>** = % covered after one cycle
- n** = number of cycles

**Figure 3**

Exposure	Coverage	Coverage
1	.25	25%
2	.44	44%
3	.57	57%
4	.68	68%
5	.76	76%
10	.9437	94%
14	.9822	98%
28	.9997	200%
42	.999994	300%
56	.99999990	400%

**Table 1**

But before you jump to the conclusion that you can be careless about flow rate accuracy, remember that you still need to know if you have a catastrophic flow rate change (blockage etc.). Also, variations in flow rate can profoundly influence shot velocity (in air blast machines).

You can investigate this factor by running various flow rates and monitoring the intensity. Just be sure that the exposure time of the Almen strip allows for saturation of the Almen strip or you'll get a false reading for intensity.

We'll talk more about flow rate and velocity in the next issue. Until then, remember shot flow rate and exposure time are critical and "All sheep are (not necessarily) black".

