

## Interpretation of control results - with $1_{2s}$ and $1_{3s}$ rules

Use of a  $1_{2s}$  rule as a strict rejection rule would result in rejecting runs on days 5, 6, 8, 11, 13, 14, 17, 25, and 27, for a total of 9 runs, as shown by the check marks in the column for  $1_{2s}$  rule violations.

Use of a  $1_{3s}$  rejection rule would lead to rejection of only one run on day 5, as shown by the single check mark in the column for  $1_{3s}$  rule violations.

**It makes a *big* difference what control rule is being applied -- 9 rejections vs 1 rejection!**

## What if different control rules were used?

Given that the  $1_{2s}$  rule is known to cause a high level of false alarms or false rejections, it might be better to interpret the data more carefully, in effect applying additional control rules, such as the  $2_{2s}$  and  $R_{4s}$  rules:

- $2_{2s}$  indicates a rejection when two consecutive control values exceed the same mean +2s limit or the same mean -2s control limit; this rule is sensitive to shifts in the mean of the distribution, therefore it is a good indicator of increases in systematic error or changes in the accuracy of the method.
- $R_{4s}$  indicates a rejection when one control measurement in a run exceeds a +2s control limit and another exceeds a -2s control limit. This "range" rule is sensitive to changes in the width of the distribution, therefore it is a good indicator of increases in random error or changes in the precision of the method.

Use of the  $1_{3s}$  rule together with the  $2_{2s}$  and  $R_{4s}$  rules leads to a multirule QC procedure in which multiple decision criteria are applied simultaneously. If any single control rule is violated, the run is rejected.

Here's how the  $1_{3s}/2_{2s}/R_{4s}$  multirule procedure would be interpreted for this example set of control results:

- Day 5. The value for Control 1 exceeds a -3s control limit, which is a good indication that there is a problem with the method. Stop, reject the run, trouble-shoot the method, fix the cause of the problem, then restart the method and reanalyze the patient specimens.
- Day 6. The value for Control 2 exceeds a +2s control limit, but doesn't exceed a 3s limit. There might be a problem, but this might also be a false rejection. If a  $1_{2s}$  rule were strictly applied, the run would be rejected. However, because the value for Control 1 is okay, it is likely that this is a false rejection. Accept the run.
- Day 8. Both the values for Control 1 and Control 2 exceed their respective +2s control limits. It is rare to see two values in a row exceed the same +2s limit, therefore this occurrence indicates a problem with the method. Note that this interpretation applies the  $2_{2s}$  control rule, i.e., 2 values in a row exceeding the same control limit. Since both controls are out in the same direction, it is likely there is a systematic error (or problem with the accuracy of the method). Stop, reject the run, trouble-shoot the method, fix the cause of the problem, then restart the method and reanalyze the patient specimens.
- Day 11. Both control values exceed 2s control limits, but one is positive and one is negative. It is a rare occurrence and most likely there is a problem with the method. Since the two controls are out in opposite directions, it is likely that there is a random error (or problem with the precision of the method). Note that this interpretation applies the  $R_{4s}$  rule, i.e., the range of the control values exceeds 4s. Stop, reject the run, trouble-shoot the method, fix the cause of the problem, then restart the method and reanalyze the patient specimens.
- Day 13. The value for Control 2 is outside the low end of the 2s range. There is a warning of a possible problem, but this might also be a false rejection. Accept this run because none of the rejection rules are violated.
- Day 14. The value for Control 2 is again outside the low end of the 2s range. This makes 2 days or 2 runs in a row, which is unusual. Since both values for Control 2 are out in the same direction, it is likely there is a systematic error (or problem with the accuracy of the method). Stop, reject the run, trouble-shoot the method, fix the cause of the problem, then restart the method and reanalyze the patient specimens.
- Day 17. Control 1 exceeds the +2s control limit. There might be a problem, but this might also be a false rejection. If a  $1_{2s}$  rule were strictly applied, the run would be rejected. However, because the value for Control 2 is okay, it is likely that this is a false rejection. Accept the run.

- Day 25. Control 1 exceeds the  $-2s$  control limit. There might be a problem, but this might also be a false rejection. If a  $1_{2s}$  rule were strictly applied, the run would be rejected. However, because the value for Control 2 is okay, it is likely that this is a false rejection. Accept the run.
- Day 27. Control 1 exceeds the  $-2s$  control limit. There might be a problem, but this might also be a false rejection. If a  $1_{2s}$  rule were strictly applied, the run would be rejected. However, because the value for Control 2 is okay, it is likely that this is a false rejection. Accept the run.

