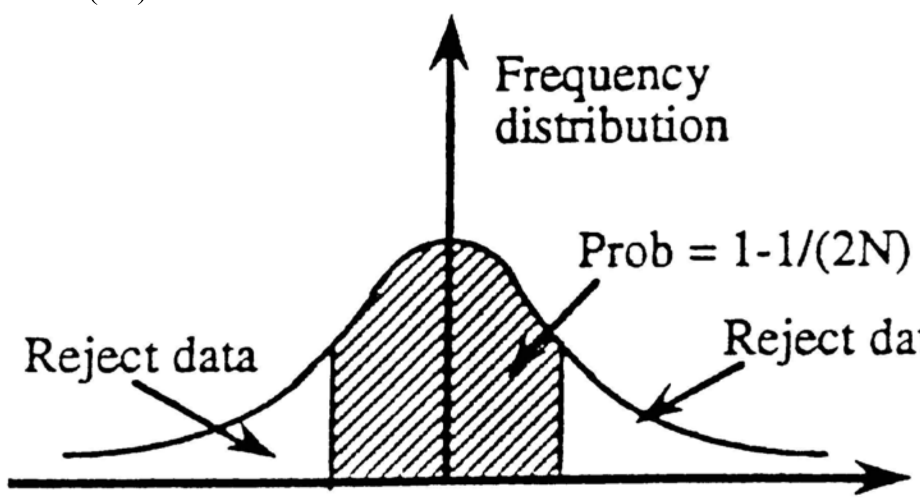
Statistical Rejection of “Bad” Data – Chauvenet’s Criterion

Occasionally, when a sample of N measurements of a variable is obtained, there may be one or more that appear to differ markedly from the others. If some extraneous influence or mistake in experimental technique can be identified, these “bad data” or “wild points” can simply be discarded. More difficult is the common situation in which no explanation is readily available. In such situations, the experimenter may be tempted to discard the values on the basis that something must surely have gone wrong. However, this temptation must be resisted, since such data may be significant either in terms of the phenomena being studied or in detecting flaws in the experimental technique. On the other hand, one does not want an erroneous value to bias the results. In this case, a *statistical* criterion must be used to identify points that can be considered for rejection. There is no other justifiable method to “throw away” data points.

One method that has gained wide acceptance is *Chauvenet’s criterion*; this technique defines an acceptable scatter, in a statistical sense, around the mean value from a given sample of N measurements. The criterion states that all data points should be retained that fall within a band around the mean that corresponds to a probability of 1-1/(2N). In other words, data points can be considered for rejection only if the probability of obtaining their deviation from the mean is less than 1/(2N). This is illustrated below.



The probability 1-1/(2N) for retention of data distributed about the mean can be related to a maximum deviation d_{max} away from the mean by using the Gaussian probabilities in Appendix A. For the given probability, the nondimensional maximum deviation τ_{max} can be determined from the table where

$$\tau_{max} = \frac{\left|(X_i - \overline{X})\right|_{max}}{S_X} = \frac{d_{max}}{S_X}$$

and S_X is the precision index of the sample. Therefore, all measurements that deviate from the mean by more than $\tau_{max}S_X$ can be rejected. A new mean value and a new precision index can then be calculated from the remaining measurements. No further application of the criterion to the sample is allowed; Chauvenet's criterion may be applied only *once* to a given sample of readings.

The table below gives the maximum acceptable deviations for various sample sizes. Values of d_{max}/S_X for other sample sizes can easily be determined using the Gaussian probability table in Appendix A.

Chauvenet's Criterion for Rejecting a Reading

Number of Readings (N)	Ratio of Maximum Acceptable Deviation to Precision Index (d_{max}/S_X)
3	1.38
4	1.54
5	1.65
6	1.73
7	1.80
8	1.87
9	1.91
10	1.96
15	2.13
20	2.24
25	2.33
50	2.57
100	2.81
300	3.14
500	3.29
1,000	3.48

Example 4

For the 10 temperature measurements in Example 2, determine if any should be rejected by Chauvenet's criterion.

SOLUTION

Inspecting the data from Example 2, the fifth reading of T=98.5ºF appears to deviate substantially from the others and is therefore a candidate for rejection. From the table above for N=10, the maximum dimensionless deviation is $d_{max}/S_X=1.96$. Since $S_X \approx 0.49°F$ in this case, $d_{max}=1.96S_X=(1.96)(0.49°F)=0.96°F$. The deviation for the fifth reading is 1.125°F so it can indeed be rejected, although no others can. Eliminating this point and recalculating the mean and precision index results in

$$\overline{X} = 97.25^{\circ}\,F$$

$$S_X = 0.31^{\circ}\,F$$

Comparing these values with those calculated in Example 2, $\overline{X}$ is decreased by only about 0.13% while S_X is decreased by over 37%.