Brinell Hardness Sensitivity Coefficients

ISO 6506-1 defines the Brinell hardness value, *HBW*, as:

$$HBW = 0.102 \times \frac{2F}{\pi D\left(D - \sqrt{D^2 - d^2}\right)}$$

where: F = force (in N)
D = ball diameter (in mm)
d = mean indentation diameter (in mm)

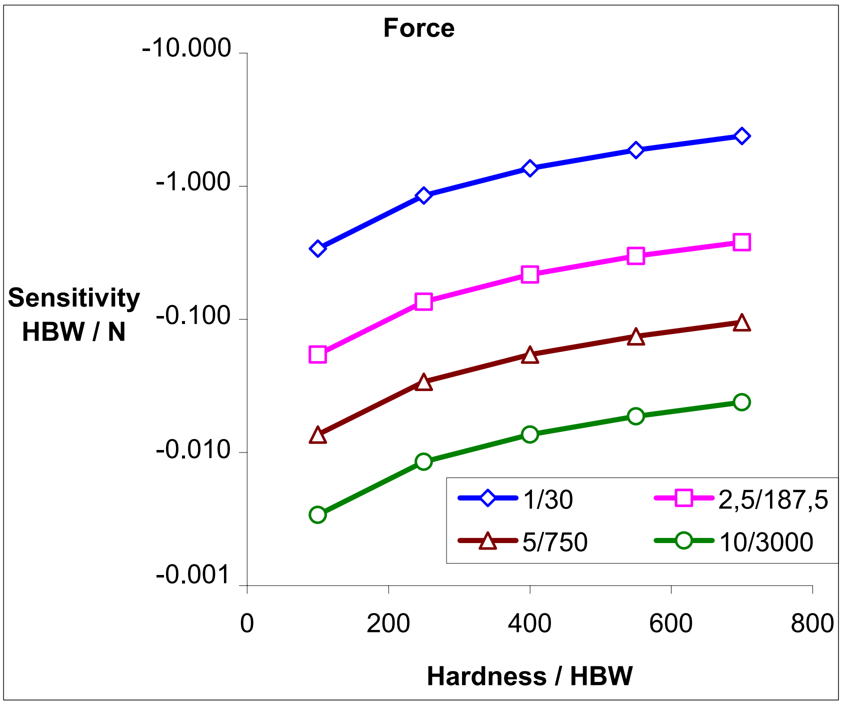
Partial derivatives allow the sensitivity coefficients for force, ball diameter, and indentation diameter to be determined:

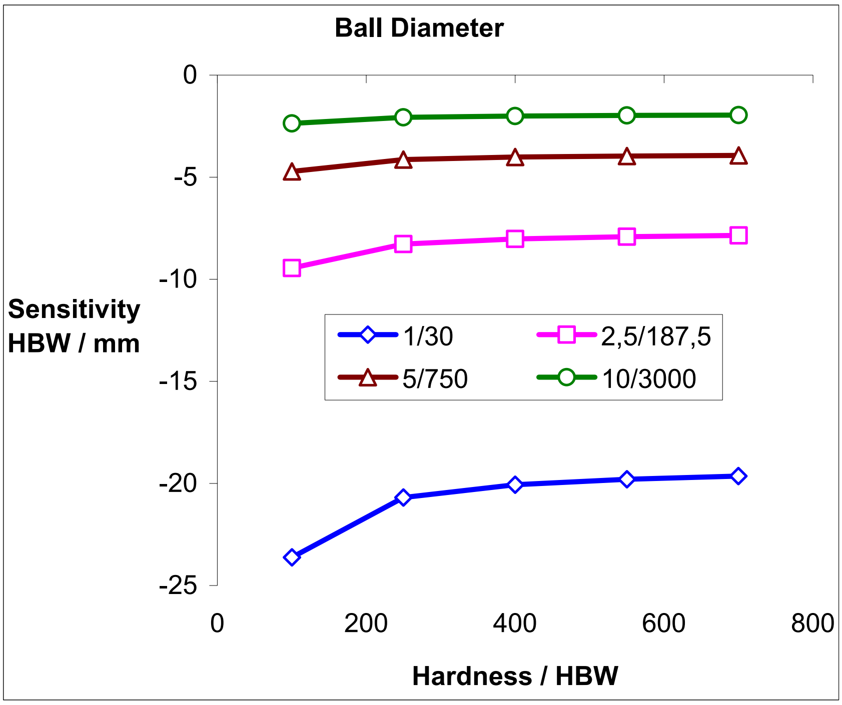
$$\frac{\partial HBW}{\partial F} = \frac{HBW}{F}$$

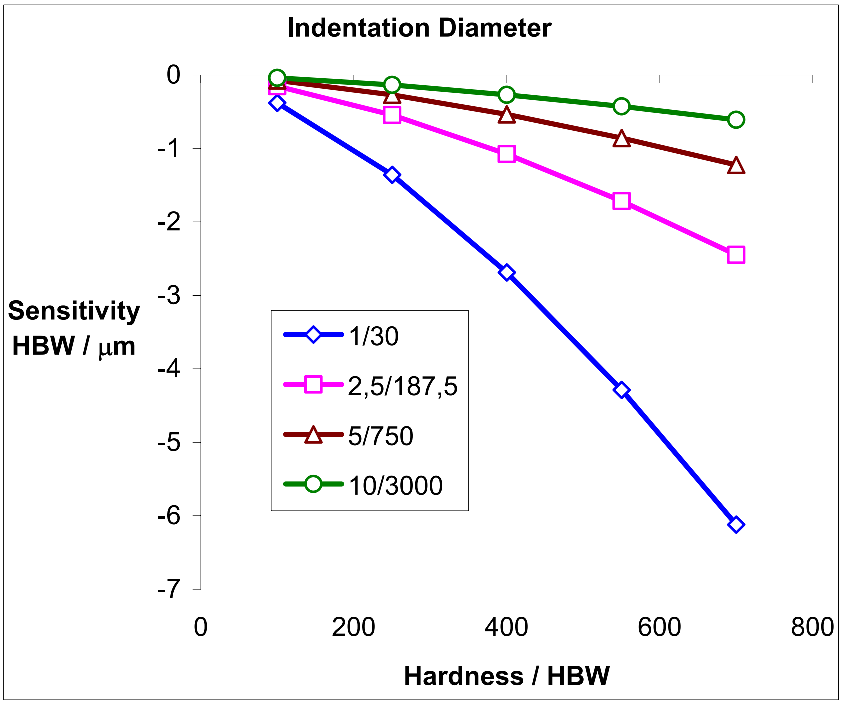
$$\frac{\partial HBW}{\partial D} = \frac{HBW}{D} \times \frac{D - \sqrt{D^2 - d^2}}{\sqrt{D^2 - d^2}}$$

$$\frac{\partial HBW}{\partial d} = -\frac{HBW}{d} \times \frac{D + \sqrt{D^2 - d^2}}{\sqrt{D^2 - d^2}}$$

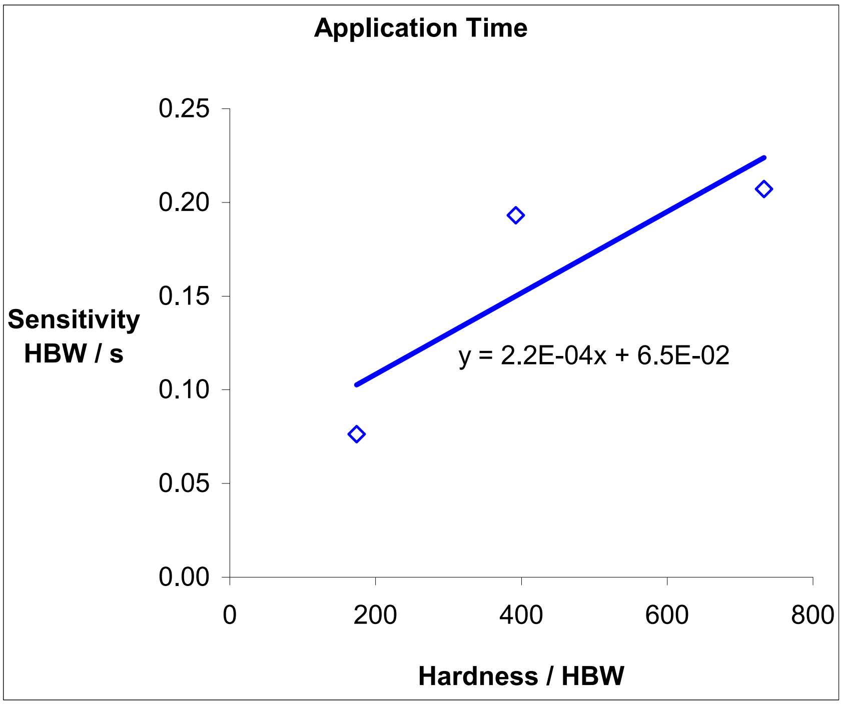
Important note: the first two equations suggest that the sensitivity coefficients for force and ball diameter are positive - i.e. an increase in force or ball diameter will increase the hardness value. This is only the case if the resulting indentation diameter does not also increase - in practice, it always will, to give a similar hardness value. As the hardness value is actually calculated from the nominal force and ball diameter values, together with the measured indentation diameter, the sensitivity coefficient values for force and ball diameter should be treated as negative - an increase in the parameter value will lead to a decrease in the calculated hardness - and they are plotted as such in the following graphs, for four commonly-used Brinell hardness scales:

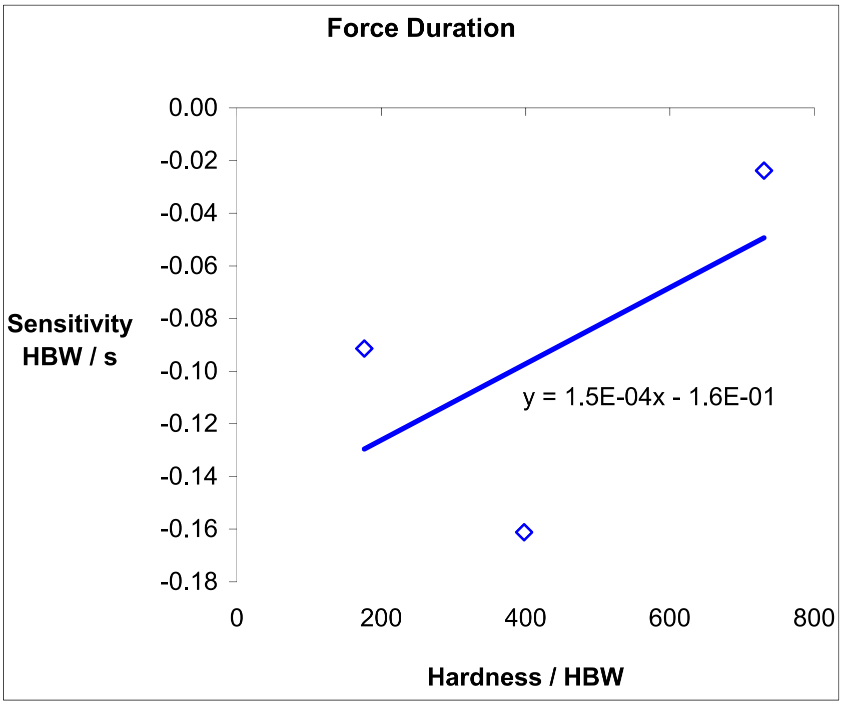






The following two graphs display the sensitivity coefficients for application time and force duration. These values are based on practical work carried out at the Physikalisch-Technische Bundesanstalt (PTB) in Germany and, unlike the previous graphs, are specific to the material (steel) used during the tests.


Application Time
0.25
0.20
0.15
0.10
0.05
0.00
Sensitivity HBW / s
y = 2.2E-04x + 6.5E-02
0
200
400
600
800
Hardness / HBW


Force Duration
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
Sensitivity HBW / s
y = 1.5E-04x - 1.6E-01
0
200
400
600
800
Hardness / HBW