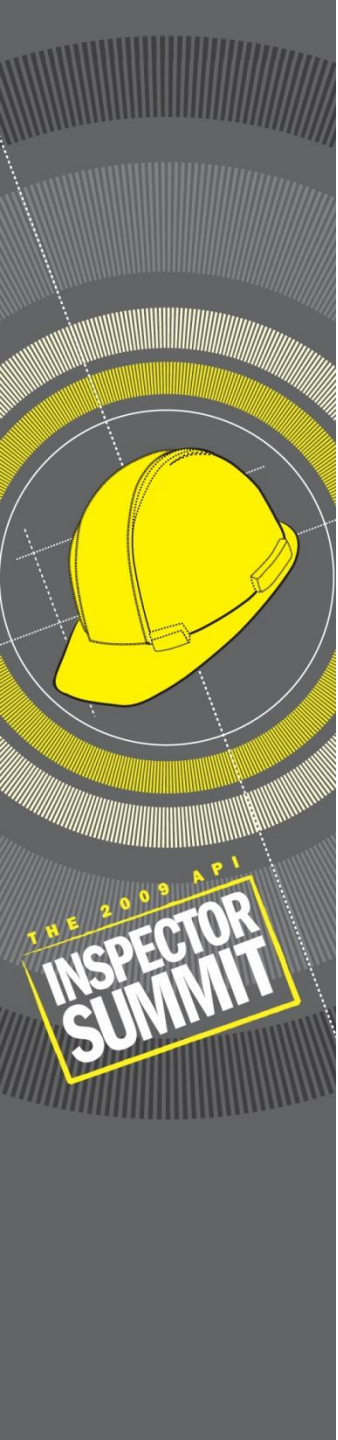


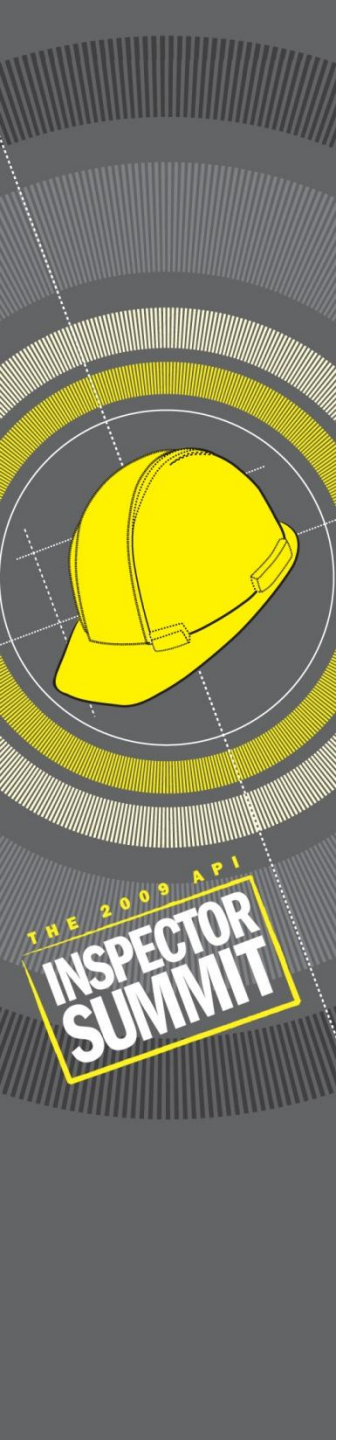
# Appendix

## Hardness Testing for Field Applications



# Hardness Testing Used with Metallography to Confirm Metal Strength Changes

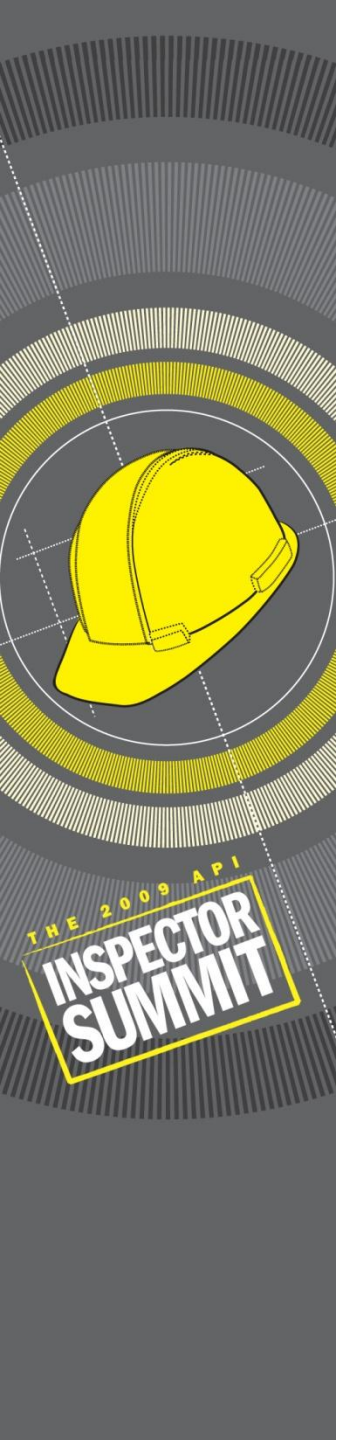
- Hardness is generally proportional to strength in carbon steels, so measuring hardness in possibly damaged areas gives relative strength change from the original.
- Hardness methods in the field can be very subjective (surface roughness, method type and operator technique).



# Hardness Methods

Brinell (Gold Standard if conditions permit).

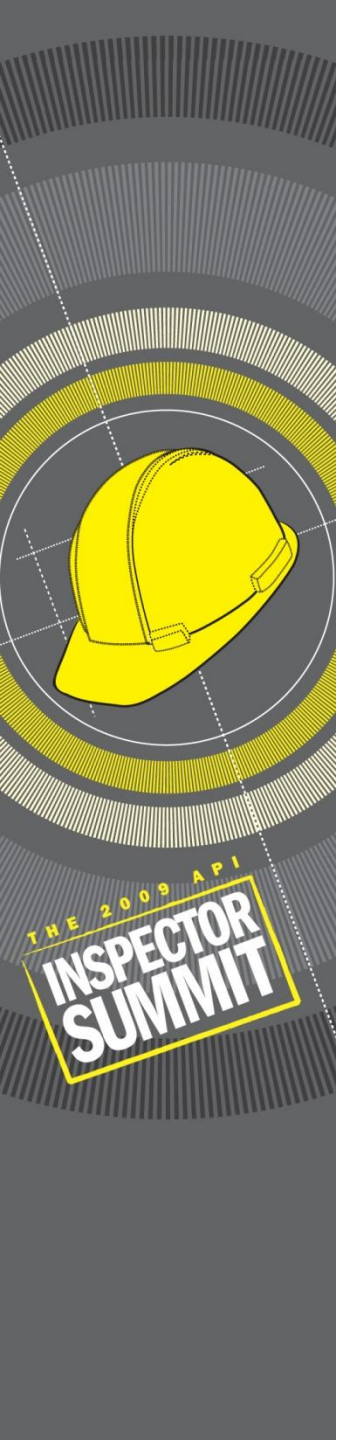
- Direct physical measurement of metal “indentability”.
- Requires:
  - Visual measurement of indentation size.
  - Access for larger unit or hammer swing.
  - Thin material (like pipe) may affect accuracy.
- Methods include, Brinell Hardness, Pin Brinell and Tela Brinell.



# Hardness Methods

Equotip™ Rebound Energy Method.

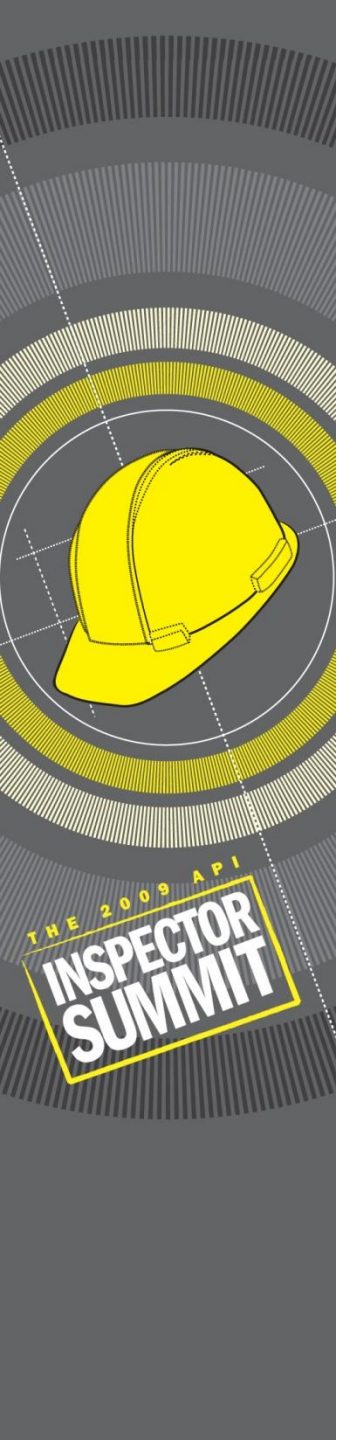
- Digital read-out of converted hardness number.
  - Takes average of the tests done.
  - Out-of-position conversion done.
- Surface roughness will change hardness value.
- Thin material will change hardness value.
- Relative hardness reading instead of absolute reading may be useful for hardness change question of fire damage.
- Small instrument for difficult access areas.



# Hardness Methods

Microdur™ Hardness Testing method.

- Energy vibration calculation on diamond indenter.
- Measures in digital conversion read-out.
- Surface roughness will change hardness value.
- Generally good access for instrument.
- Little or no out-of-position variation.
- Delicate diamond may be damaged easily.



# Interpreting Hardness Results

## Fire Damage Areas:

- Hardness decreases from original—some may be acceptable, a lot may be too damaged for service (i.e., “toast”).
- Hardness increases significantly from original, component is “toast”.

## Creep Damage Areas:

- Less likely to change field measurement, lab micro hardness required.

