3.3 Hardness

3.3.1 What, Exactly, is Measured by Hardness?

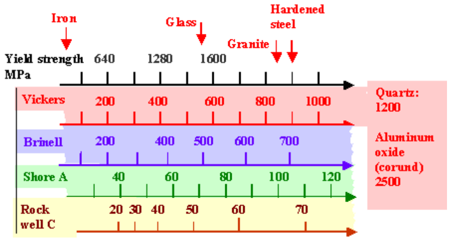
- All of us have a pretty good notion of what "*hardness*" means in the context of materials properties.
  - Only a select few people, to whom you now belong, have a decent notion of what the terms " *yield stress*", "*ultimate tensile strength*", or "*ductility* " tells us about materials properties. As you just learned, these properties are very well defined and measurable by tensile testing.
    There is a catch, however. You need expensive equipment and standardized specimen that must be cut from the material you want to investigate.
    If you own some blade and want to know its mechanical properties, you have to *destroy* it completely in order to produce a specimen that can be tested in a tensile test. That's not something you like to do.
- **Hardness** is different. It is easy to measure for any specimen and only "destroys" a tiny part by leaving a barely visible indentation
  - There is a catch, however. The **first law of economics** applies:

First Law of Economics
There is no such thing as a free lunch.

  - Nothing is for free. Somebody always pays. Mostly it is you. You usually pay for your free lunch sometime after it took place, directly or indirectly.
    Even if you are lucky and don't pay now or ever, somebody else pays. It's never free. "Free gifts" are not only an oxymoron but even worse. They are neither free nor gifts.
- You should therefore not be surprised that there is a price to pay for the ease of hardness testing: it measures a jumble of primary properties, all mixed up somehow.
  As far as *metals* are concerned, hardness measures in some lumped way a combination of elastic, plastic, and fracture properties. Hardness then combines somehow *yield stress*, *Young's modulus* and *fracture* parameters.
  - The *bad news* is: There is no simple equation that relates the hardness number of some material to the far more fundamental primary parameters obtained by tensile testing or other clean tests. The best one can do is to provide some *approximate* relations for certain classes of materials
  - The *good news* is: For most metals including steel there is a very simple relation between the **Vickers Hardness *HV*** and the *yield stress* (or the *ultimate tensile strength* if the stress-strain curve goes right up to it).

What is commonly known as hardness is nothing more than (approximately) the yield stress, just measured in different units.

  - That's straight from subchapter 3.1.4; I thought you liked to see that really important statement once more. Here are some data to illustrate this important point.
- The figure below shows the (approximate) relation between the various hardness scales and the yield strength. Again: be aware that this is only approximate!



Hardness scales and relation to yield strength

- Getting a number for hardness is far easier (and cheaper) than getting a complete stress-strain curve. So life becomes easier if you just measure and discuss hardness. That explains why you find a lot of hardness numbers concerning steel out there in the Net and rather few numbers for yield strength and so on. But you also miss a lot.
    - In the inner circle of the cognoscenti (that's me and my buddies) it is the other way around. You, the tax payer, have given us all that money to buy the expensive machinery needed for going beyond hardness, and we sure use it. I hope that this hyperscript will convince you that we used that money wisely.
      The reason why hardness is not so popular among working engineers is that you can't do the necessary calculations with just a hardness number. It is simply not sophisticated enough because you just cannot describe the response of a material to mechanical stress by just *one* number.
- Life would be even easier if we all would use the same hardness scale. Life would be easier too if we all would use the same scales for lengths weight and so on.
    - Of course, we don't. In the case of hardness there is even a good reason fort this If we want to measure hardness for all kinds materials, including very soft and very brittle stuff, *one* method is not good enough to cover the whole range encountered.