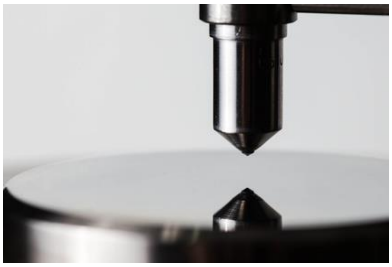
# Hardness - Introduction

**Plastic hardness qualifies the resistance to penetration of a plastic by a harder body. The harder material wears or scratches the softer material.**

It's a key engineering parameter for constructing devices, consumer products or industrial parts. This can become evident when considering cosmetic effects such as scratching or loss of surface gloss from the rubbing of two materials. Alternatively, one can consider wear from moving parts.



**How Is it Measured?**

There are a number of empirical hardness scales that have been constructed over time to try to replicate conditions of scratching, rubbing, wear between two materials. These methods aim to give a **relative ranking of the hardness of two materials**. There is no underlying theory for how they work.

Two scales are frequently used:

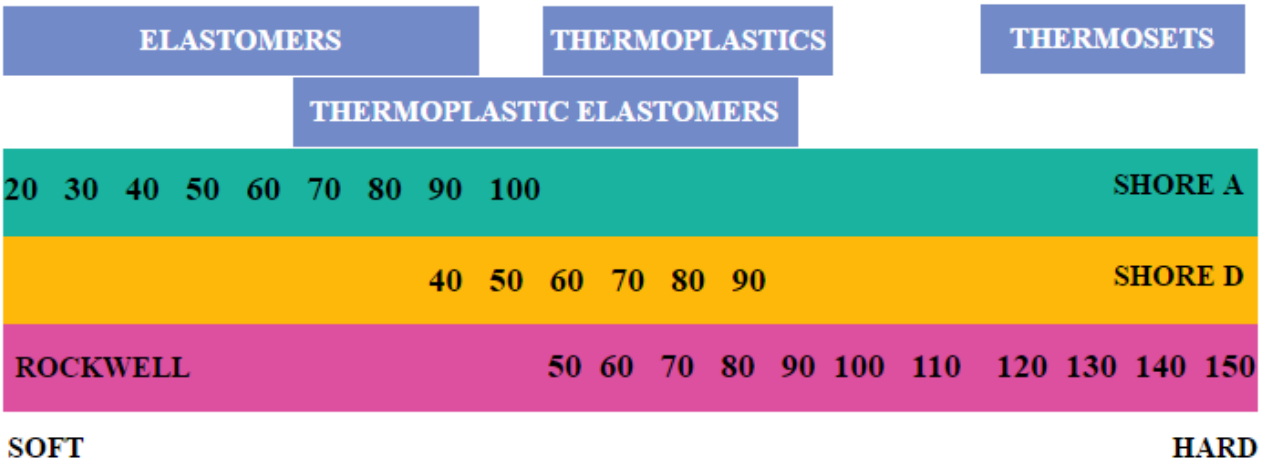
- Rockwell E, Rockwell M & Rockwell R, generally chosen to test harder plastics (PA, PC, PS...)
- Shore A, Shore D Hardness Scale, often preferred for rubbers/elastomers and softer plastics (PP, PE, PVC...)

**Which Hardness Scale Should You Use?**

The different hardness scales seem to have more popularity in different parts of the world, in different industries and in different disciplines. For someone just beginning to become interested in "HARDNESS" as a key indicator of performance, it is suggested to examine data sheets and literature references for the relevant industry, disciple or geographical region.

When making comparisons for purposes of promoting a product or material: one has to speak the language of one's peers. There are a multitude of possibilities each having a different rationale which go beyond this comparative treatise.

Here is a correspondence table between the most common methods. It gives an idea of the order of magnitude, but we do not recommend conversion between the scales.




Also read more about:

- Rockwell Hardness of Plastics
- Shore (Durometer) Hardness of Plastics

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# Hardness Rockwell M

Rockwell Hardness test is one possible method to measure the Hardness of Plastics. It is generally used for hard materials, like PA, PC, PS or POM, where the resilience or creep of the polymer is less likely to affect results.

For rubbers, elastomers & softer plastics, Shore Hardness is often prefered.

### How Does Rockwell Hardness Test Work?

The Rockwell Scale determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the indentation made by a pre-load. There are different scales, denoted by a single letter, that use different loads or indenters. The result is a dimensionless number. Indenters can be diamond tips, steel or Tungsten Carbide balls.

The Rockwell testing procedures used in the Plastic Industry are ASTM D785 and ISO2039-2.

### Rockwell Hardness Testing Conditions

As the method is extended from metals to plastics, one has to be careful to consider:

- **The effects of temperature:** Small changes in temperature can result in first and second order phase transitions which can radically alter the hardness of the material.
- **The effects of viscoelasticity:** Unlike metals, plastics are viscoelastic. The stress-strain relationships are time dependent. The results obtained by dragging the weighted indenter will be rate dependent.

Typical Hardness Rockwell M Values

| Name of the polymer | Explicit name of the polymer | Min Value | Max Value |
|---|---|---|---|
| ABS FR | Acrylonitrile-Butadiene Styrene flame retardant | 20.000 | 70.000 |

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|---|---|---|---|
| ABS High Heat | Acrylonitrile-Butadiene Styrene High Heat | 20.000 | 50.000 |
| ABS High Impact | Acrylonitrile-Butadiene Styrene High Impact | 10.000 | 30.000 |
| ABS/PC | Acrylonitrile-Butadiene Styrene/Polycarbonate | 50.000 | 70.000 |
| ABS/PC 20% GF | Acrylonitrile-Butadiene Styrene/Polycarbonate 20% glass fiber | 50.000 | 80.000 |
| ABS/PC FR | Acrylonitrile-Butadiene Styrene/Polycarbonate flame retardant | 50.000 | 80.000 |
| Amorphous TPI Blend, Ultra-high heat, Chemical Resistant (Standard Flow) | Amorphous TPI Blend, Ultra-high heat, Chemical Resistant (Standard Flow) | 112.000 | 112.000 |
| ASA | Acrylonitrile Styrene Acrylate | 10.000 | 20.000 |
| ASA/PC | Acrylonitrile Styrene Acrylate/Polycarbonate | 30.000 | 60.000 |
| ASA/PC FR | Acrylonitrile Styrene Acrylate/Polycarbonate flame retardant | 30.000 | 70.000 |
| ASA/PVC | Acrylonitrile Styrene Acrylate/Polyvinyl Chloride | 30.000 | 70.000 |
| CA - Cellulose Acetate | Cellulose Acetate | 1.000 | 80.000 |
| CAB - Cellulose Acetate Butyrate | Cellulose Acetate Butyrate | 1.000 | 70.000 |
| CP - Cellulose Proprionate | Cellulose Proprionate | 1.000 | 75.000 |
| CPVC - Chlorinated Polyvinyl Chloride | CPVC - Chlorinated Polyvinyl Chloride | 40.000 | 65.000 |

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|---|---|---|---|
| ETFE | Ethylene Tetrafluoroethylene | 1.000 | 10.000 |
| EVA | Ethylene Vinyl Acetate | 1.000 | 1.000 |
| EVOH | Ethylene Vinyl Alcohol | 85.000 | 104.000 |
| FEP | Fluorinated Ethylene Propylene | 1.000 | 1.000 |
| HDPE - High Density Polyethylene | HDPE - High Density Polyethylene | 1.000 | 1.000 |
| HIPS - High Impact Polystyrene | HIPS - High Impact Polystyrene | 1.000 | 1.000 |
| HIPS FR V0 | High Impact Polystyrene flame retardant V0 | 1.000 | 1.000 |
| Ionomer (EMAC) | Ionomer (Ethylene-Methyl Acrylate Copolymer) | 1.000 | 1.000 |
| LCP | Liquid Crystal Polymer | 40.000 | 76.000 |
| LCP CF | Liquid Crystal Polymer carbon fiber | 99.000 | 99.000 |
| LCP GF | Liquid Crystal Polymer glass fiber | 77.000 | 87.000 |
| LCP MINERAL | Liquid Crystal Polymer mineral | 63.000 | 79.000 |
| LDPE - Low Density Polyethylene | LDPE - Low Density Polyethylene | 1.000 | 1.000 |
| LLDPE - Linear Low Density Polyethylene | LLDPE - Linear Low Density Polyethylene | 1.000 | 1.000 |
| PA 11 30% Glass fiber reinforced | Polyamide 11 30% Glass fiber reinforced | 116.000 | 116.000 |
| PA 11 rigid | Polyamide 11 rigid | 1.000 | 25.000 |
| PA 12 glass filled | Polyamide 12 glass filled | 107.000 | 107.000 |
| PA 46 | Polyamide 46 | 92.000 | 92.000 |
| PA 6 | Polyamide 6 | 30.000 | 80.000 |

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|---|---|---|---|
| PA 6-10 | Polyamide 6-10 | 1.000 | 50.000 |
| PA 66 | Polyamide 6-6 | 30.000 | 80.000 |
| PA 66 30% GF | Polyamide 6-6 30% glass fiber | 30.000 | 80.000 |
| PA 66 30% mineral filled | Polyamide 6-6 30% mineral filled | 30.000 | 80.000 |
| PA 66 IM 15-30% GF | Polyamide 6-6 impact modified 15-30% glass fiber | 66.000 | 96.000 |
| PA 66 impact modified | Polyamide 6-6 impact modified | 50.000 | 94.000 |
| PAI | Polyamide-Imide | 105.000 | 120.000 |
| PAI 30% GF | Polyamide-Imide 30% glass fiber | 95.000 | 110.000 |
| PAI low friction | Polyamide-Imide low friction | 95.000 | 110.000 |
| PAN | Polyacrylonitrile | 45.000 | 78.000 |
| PARA 30-60% GF | Polyarylamide 30-60% glass fiber | 110.000 | 110.000 |
| PBT | Polybutylene Terephthalate | 70.000 | 90.000 |
| PBT 30% GF | Polybutylene Terephthalate 30% glass fiber | 90.000 | 95.000 |
| PC 20-40% GF | Polycarbonate 20-40% glass fiber | 70.000 | 95.000 |
| PC 20-40% GF FR | Polycarbonate 20-40% glass fiber flame retardant | 70.000 | 95.000 |
| PC high heat | Polycarbonate high heat | 70.000 | 90.000 |
| PCTFE | Polymonochlorotrifluoroethylene | 10.000 | 40.000 |
| PE 30% GF | Polyethylene 30% glass fiber | 1.000 | 20.000 |
| PEEK | Polyetheretherketone | 55.000 | 100.000 |
| PEEK 30% CF | Polyetheretherketone 30% carbon fiber | 70.000 | 107.000 |
| PEEK 30% GF | Polyetheretherketone 30% glass fiber | 70.000 | 103.000 |
| PEI | Polyetherimide | 100.000 | 110.000 |

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|---|---|---|---|
| PEI 30% GF | Polyetherimide 30% glass fiber | 90.000 | 125.000 |
| PEI mineral filled | Polyetherimide mineral filled | 90.000 | 120.000 |
| PESU | Polyethersulfone | 85.000 | 88.000 |
| PESU 10-30% GF | Polyethersulfone 10-30% glass fiber | 90.000 | 99.000 |
| PET | Polyethylene Terephthalate | 50.000 | 100.000 |
| PET 30% GF | Polyethylene Terephthalate 30% glass fiber | 70.000 | 95.000 |
| PET 30/35% GF Impact modified | Polyethylene Terephthalate 30/35% glass fiber impact modified | 62.000 | 62.000 |
| PE-UHMW | Polyethylene -Ultra High Molecular Weight | 1.000 | 1.000 |
| PFA | Perfluoroalkoxy | 1.000 | 1.000 |
| PI | Polyimide | 110.000 | 110.000 |
| PMMA | Polymethylmethacrylate (Acrylic) | 70.000 | 105.000 |
| PMMA high heat | Polymethylmethacrylate (Acrylic) high heat | 90.000 | 100.000 |
| PMMA Impact modified | Polymethylmethacrylate (Acrylic) impact modified | 35.000 | 80.000 |
| PMP | Polymethylpentene | 100.000 | 100.000 |
| PMP 30% GF | Polymethylpentene 30% glass fiber | 1.000 | 20.000 |
| PMP mineral filled | Polymethylpentene mineral filled | 1.000 | 20.000 |
| POM | Polyoxymethylene (acetal) | 75.000 | 94.000 |
| POM impact modified | Polyoxymethylene (acetal) impact modified | 35.000 | 79.000 |
| POM low friction | Polyoxymethylene (acetal) low friction | 58.000 | 94.000 |
| POM mineral filled | Polyoxymethylene (acetal) mineral filled | 83.000 | 90.000 |
| PP 10-20% GF | Polypropylene 10-20% glass fiber | 20.000 | 50.000 |

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|---|---|---|---|
| PP 10-40% mineral filled | Polypropylene 10-40% mineral filled | 1.000 | 20.000 |
| PP 10-40% TALC | Polypropylene 10-40% talc | 10.000 | 45.000 |
| PP 30-40% GF | Polypropylene 30-40% glass fiber | 40.000 | 50.000 |
| PP copo | Polypropylene copolymer | 1.000 | 20.000 |
| PP homo | Polypropylene homopolymer | 1.000 | 30.000 |
| PP impact modified | Polypropylene impact modified | 1.000 | 1.000 |
| PPA – 33% glass fiber | Polyphthalamide – 33% glass fiber | 124.000 | 126.000 |
| PPA – 45% glass fiber | Polyphthalamide– 45% glass fiber | 124.000 | 126.000 |
| PPE | Polyphenylene Ether | 50.000 | 70.000 |
| PPE 30% GF | Polyphenylene Ether 30% glass fiber | 50.000 | 70.000 |
| PPE FR | Polyphenylene Ether flame retardant | 50.000 | 70.000 |
| PPE impact modified | Polyphenylene Ether impact modified | 50.000 | 70.000 |
| PPE mineral filled | Polyphenylene Ether mineral filled | 60.000 | 70.000 |
| PPS | Polyphenylene Sulfide | 70.000 | 85.000 |
| PPS 20-30% GF | Polyphenylene Sulfide 20-30% glass fiber | 80.000 | 103.000 |
| PPS 40% GF | Polyphenylene Sulfide 40% glass fiber | 100.000 | 104.000 |
| PPS conductive | Polyphenylene Sulfide conductive | 70.000 | 100.000 |
| PPS GF & mineral | Polyphenylene Sulfide glass fiber & mineral | 66.000 | 102.000 |
| PPSU | Polyphenylene Sulfone | 80.000 | 80.000 |
| PS 30 % GF | Polystyrene 30% glass fiber | 80.000 | 91.000 |
| PS crystal | Polystyrene crystal | 60.000 | 75.000 |

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|---|---|---|---|
| PS high heat | Polystyrene high heat | 75.000 | 85.000 |
| PSU | Polysulfone | 69.000 | 91.000 |
| PSU 30% GF | Polysulfone 30% glass fiber | 87.000 | 100.000 |
| PSU mineral filled | Polysulfone mineral filled | 70.000 | 74.000 |
| PTFE | Polytetrafluoroethylene | 1.000 | 1.000 |
| PTFE 25% GF | Polytetrafluoroethylene 25% glass fiber | 1.000 | 1.000 |
| PVC 20% GF | Polyvinyl Chloride 20% glass fiber | 50.000 | 70.000 |
| PVC plasticized | Polyvinyl Chloride plasticized | 1.000 | 1.000 |
| PVC plasticized filled | Polyvinyl Chloride plasticized filled | 1.000 | 1.000 |
| PVC rigid | Polyvinyl Chloride rigid | 1.000 | 70.000 |
| PVDC | Polyvinylidene Chloride | 60.000 | 65.000 |
| PVDF | Polyvinylidene Fluoride | 75.000 | 75.000 |
| SAN | Styrene Acrylonitrile | 10.000 | 80.000 |
| SAN 20% GF | Styrene Acrylonitrile 20% glass fiber | 80.000 | 100.000 |
| SMA | Styrene Maleic Anhydride | 30.000 | 40.000 |
| SMA 20% GF | Styrene Maleic Anhydride 20% glass fiber | 30.000 | 40.000 |
| SMA FR V0 | Styrene Maleic Anhydride flame retardant V0 | 30.000 | 40.000 |
| SMMA | Styrene Methyl Methacrylate | 65.000 | 75.000 |
| XLPE - Crosslinked Polyethylene | XLPE - Crosslinked Polyethylene | 1.000 | 20.000 |