Gutterbroom Filaments:

A Comparison of Performance Characteristics of Oil Coated, Oil Tempered and Blue Steel Patented Wire

Background

Traditionally, purchasers of replacement gutterbrooms have been limited to two broad categories of products: Oil Tempered and Oil Coated (or Cold Rolled) gutterbrooms. While acknowledging that there is considerable variance (even confusion) about how steel wire is produced, the categories are named for their respective manufacturing processes.

Briefly, Oil Tempered wire follows a process of heating the wire after the flat rolling process to a tempering temperature and then quenching it in oil. The primary goal of tempering is to maintain the strength of the wire, but to alleviate the brittleness.

Oil Coated wire is not put through the tempering process. While this offers production economies, it can also create stress-induced weaknesses that leave the wire more susceptible to bending or even breakage.

More recently, considerable work has been done with “patenting,” – a process developed specifically for applications such as this – before the wire is flattened. In patenting, steel wire is gradually heated to more than 1800°F, then cooled in a very controlled environment to a temperature between 800°F and 1050°F. The resulting product can be flattened – or “Cold Rolled” – without sacrificing the original, strength-enhancing characteristics of the steel.

Before committing to Patented wire, United Rotary Brush Corporation submitted the materials to extensive metallurgical laboratory testing to ensure it could meet – or exceed – current performance standards.

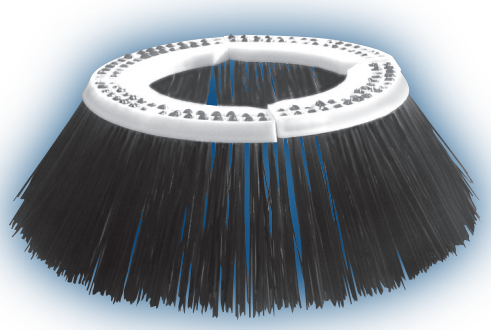
Overview

Users of gutterbrooms are concerned primarily about the strength and durability of the product. There are a number of visible indicators of these qualities, including:

- **hardness –** the degree to which the metal resists cutting, abrasion, penetration, bending and stretching
- **resilience or yield strength –** the “memory” of the material which allows it to bend and come back to its original shape (flick)
- **resistance to fatigue –** under repeated stress, steel wire can develop microscopic cracks that continue to grow and eventually lead to breakage

These qualities are created by the mechanical properties of the material from which the broom is constructed. Those properties, in turn, are the result of (a) the original chemical composition of the steel and (b) the production process by which it was formed into wire.

To objectively assess the quality of patented wire as a suitable material for gutterbrooms, United Rotary Brush set out to measure those characteristics that are the primary contributors to filament strength and durability.



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Executive Summary

Over the past several years, as the cost of material continued to rise, United Rotary Brush implemented an exhaustive assessment of available steel wire products and processes to ensure they were able to provide gutterbroom customers with the best broom value. The company determined that wire manufactured through an innovative patenting process produced a filament offering essentially the same chemical properties as Oil Tempered wire. Further, they found that this material could be processed through the same cost-saving techniques as Oil Coated (or Cold Rolled) wire without sacrificing its strength-enhancing properties. The company then subjected this new product to extensive laboratory testing to verify those claims under objective standards. Based upon the successful completion of those tests, United Rotary Brush established that Patented wire offers performance superior to that of Oil Tempered wire.

Methodology

Tests were conducted by an independent, third-party firm. All specimens and materials were in full compliance with ASTM standards.

1. Chemical Composition

All steels contain a combination of desirable elements (carbon, manganese, silicon) and undesirable elements (sulfur, phosphorous). The desirable elements create hardness and strength. The undesirable elements can produce brittleness.

The following comparison of chemical composition shows that the Patented wire contains as much or more of the "desirable" elements, while limiting the "undesirable" elements to a significantly lower threshold.

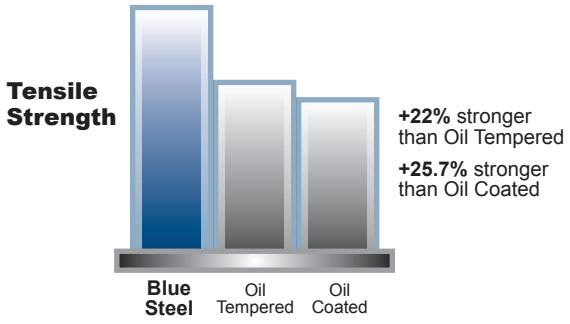
	Oil Tempered	Oil Coated	Blue Steel "Patented"
Carbon	.59-.66%	.59-.66%	.60-.66
Manganese	.30-.60%	.30-.60%	.66%
Silicon	.15-.35%	.15-.35%	.28%
Sulfur	.030% MAX	.030% MAX	.011-.023%
Phosphorus	.030% MAX	.030% MAX	.015-.028%

2. Tensile Strength

ASTM Designation E 8-04, Standard Test Methods for Tension Testing of Metallic Materials, provides the guidelines for measuring the breaking strength of a material when subjected to a tensile (stretching) force. The guidelines note that "This information may be useful in comparisons of materials, alloy development, quality control, and design under certain circumstances."

Tensile strength is typically expressed in pounds per square inch, which represents the amount of force required to break the material. Individual tests will produce a range of results, as shown in the chart below. The minimums from each range can be used for direct comparisons.

	Oil Tempered	Oil Coated	Blue Steel "Patented"
Tensile Strength (psi)	206,000-234,000	200,000-230,000	251,366-257,985



3. Rockwell Test

ASTM Designation E 18-05, Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials, is the standard method for measuring the hardness of materials. This is an indentation test; it "measures hardness by determining the difference in penetration depths under two specified forces, called the preliminary and total test forces." (from the ASTM Designation). The numbers reported here are in a "C" scale.

	Oil Tempered	Oil Coated	Blue Steel "Patented"
Rockwell Hardness	44-48	41-44	44-45

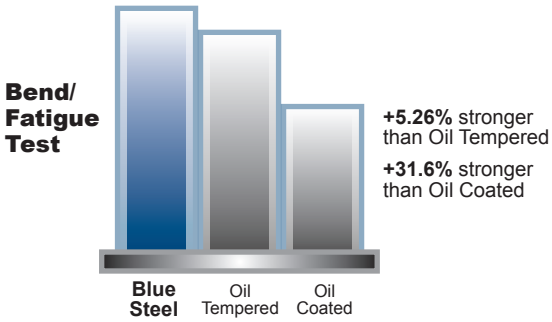
This test, which measures the hardness of the surface of the wire, reveals very little difference between the Patented and Oil Tempered wire.

4. Bend/Fatigue Test

While hardness is an important characteristic of the brush filament, it is not the most critical determinate of durability. For that reason, United Rotary Brush also subjected the material to a proprietary in-house process to test bend (resilience) and resistance to fatigue.

To test these properties, a special machine was constructed to emulate the product in use. Wire samples are bolted in place so that a rotating arm strikes them repeatedly – 80 rounds per minute over a four hour period – similar to the pressure applied as the gutterbroom strikes pavement. At the end of each test period, the number of broken strands are counted and this number of "lost tips" is averaged over multiple panels.

Blue Steel outperformed both Oil Coated and Oil Tempered wire in the Bend/Fatigue test.



Conclusion

The testing provided conclusive evidence that the Blue Steel Patented wire can meet – or exceed – performance standards for the primary current gutterbroom filament: Oil Tempered or Oil Coated.

In terms of chemical composition, the Blue Steel Patented wire contains as much or more of the "desirable" elements, while limiting the "undesirable" elements to a significantly lower threshold. Tests of tensile strength showed the Blue Steel patented wire 22% stronger than Oil Tempered wire and nearly 26% stronger than Oil Coated wire. In addition, in a proprietary bend test, Blue Steel Patented wire demonstrated more than 5% greater resistance to fatigue than Oil Tempered wire and more than 30% greater resistance to fatigue than Oil Coated wire.

Sources:

ASTM "Designation E 8-04, Standard Test Methods for Tension Testing of Metallic Materials," © ASTM International

ASTM "Designation E 18-05, Standard Test Methods for Rockwell Hardness and Rockwell Superficial Hardness of Metallic Materials," © ASTM International

Greg DuBois
CTI Engineering
Metallurgical Laboratory

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Harry Vegter
Director of Engineering
United Rotary Brush Corporation

UNITED
ROTARY BRUSH CORPORATION