



DURABAND® NC/TUFFBAND® NC HEAT AFFECTED ZONE PROPERTIES

by Bob Miller, Materials Engineer

Base Metal Heat Affected Zones provide more benefits than most realize. Fatigue Life and Abrasion Resistance are improved.

While much attention has been given to hardbanding alloy chemistries, wear resistance, cracking tendencies, and rebuilding properties, little attention has been given to the one common denominator of ALL hardbandings, the base metal Heat Affected Zone or more commonly referred to as the “HAZ”. The HAZ is a direct result of the arc welding process. It is the zone directly below and adjacent to the weld bead and wholly consists of base metal, and not the hardbanding alloy itself. **Fig. 1** It is the distinct zone that has been heated by the welding arc to very high temperatures (usually greater than 1500°F (815°C)) and subsequently quenched by the cooling media surrounding the weld nugget. That media can be ambient air or a preheated tool joint. The properties of the HAZ are directly associated with the chemistry of the base material. In this case, the resulting hardness is dictated by the tool joint (usually 4137M) chemistry and the type of cooling regardless of the hardbanding alloy used. The depth of this zone directly beneath the hardbanding is typically 3/32” (2.4mm), and decreases as it wraps its way up to the tool joint O.D. surface.

The hardness of the HAZ is of particular importance because if this zone is too hard (generally over 50Rc), a crack in the hardbanding could potentially penetrate into the base metal, and perhaps lead to a catastrophic failure. **Fig. 2**. The Fearnley Procter Group¹ has assigned a hardness value of 40Rc or less to the HAZ specification. It can be debated whether or not the 40Rc hardness is the threshold of failure, but that is another subject matter. The 40Rc is achieved by adjusting the preheat of the tool joint and ensuring that the tool joint is slowly cooled. **Fig. 3**. It should be noted that the HAZ hardness is only

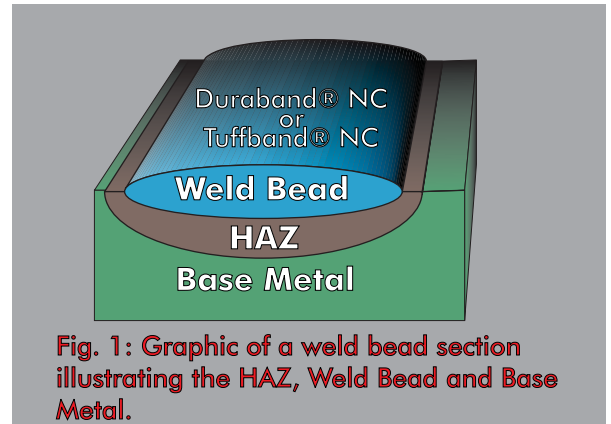


Fig. 1: Graphic of a weld bead section illustrating the HAZ, Weld Bead and Base Metal.



Fig. 2: Catastrophic failure of a drill pipe due to excessive hardness in the HAZ.

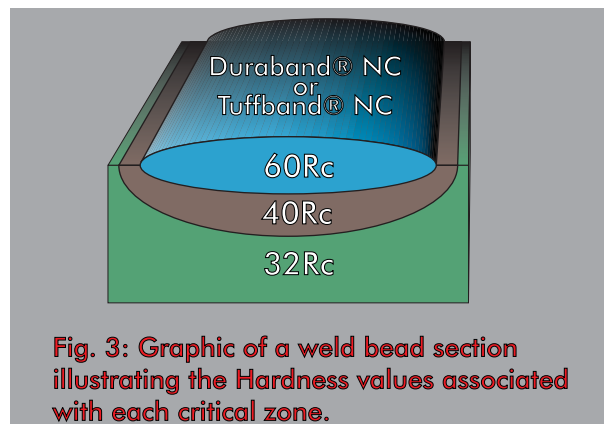


Fig. 3: Graphic of a weld bead section illustrating the Hardness values associated with each critical zone.

measured during the ASME WPS & WPQ procedure and is almost never monitored during any hardbanding procedure.

It may be viewed by some that high hardness values (40Rc) in the HAZ critical areas (Fig. 4) resulting from the application of the hardbanding alloy, are not desirable, but few realize the highly beneficial affects of applying Tuffband® NC or Duraband® NC. To appreciate the benefits, it is essential to understand that hardness and tensile stress are directly proportional. The higher the hardness value, the higher the tensile stress. Understanding this relates to two highly beneficial effects of HAZ properties at the tool joint surface;

- ✓ **Fatigue Life**
- ✓ **Abrasion Wear Resistance**

Fatigue Life

HAZ hardness has a direct bearing on the fatigue life of the HAZ. Fatigue life usually occurs at a certain percentage of the tensile strength of the material under question. It then follows that because the HAZ is harder than the tool joint, (40Rc vs 32Rc) the HAZ has a greater fatigue life than the tool joint at the surface. Postle has proven this during fatigue testing of Tuffband® NC and Duraband® NC and their associated HAZ. Fig. 5.

Abrasive Wear Resistance

While it can be heavily argued that hardness is not a good criteria for estimating abrasive wear resistance, there are some circumstances that it can be a good indicator. And this is one of those circumstances. Generally speaking, within a specific chemistry or alloy, increasing hardness values results in increased abrasive wear resistance. Therefore, at the tool joint surface, the HAZ being harder than the tool joint itself, has better abrasive wear resistance. Fig. 6. The HAZ is relatively small in comparison to the standard abrasive wear testing sample of the ASTM G65 procedure, and therefore little if any real data can be presented here. However, experience tells us that for alloys such as 4137M tool joints, hardness and abrasive wear resistance can be correlated.

Summary

The tool joint HAZ hardness properties have been discussed, and it is clear that there are some benefits beyond the obvious cushion zone for in-service cracking. The benefits of a high fatigue life and wear resistance in the HAZ, resulting from the application of Duraband® NC or Tuffband® NC warrants serious consideration when evaluating tool joint performance. It also begs the question, "Can the current specification hardness of 40Rc Max in the HAZ be re-evaluated upward"? In the spirit of pursuing, this Postle is continuing a greater in-depth study of fatigue life, not just in the HAZ but in the actual hardbanding itself, and will report at a later time.

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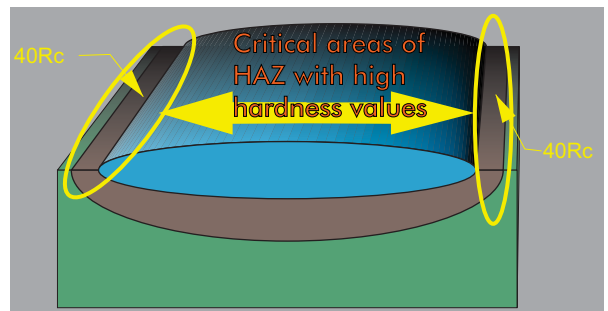


Fig. 4: Graphic of a weld bead section illustrating the critical area of the HAZ.

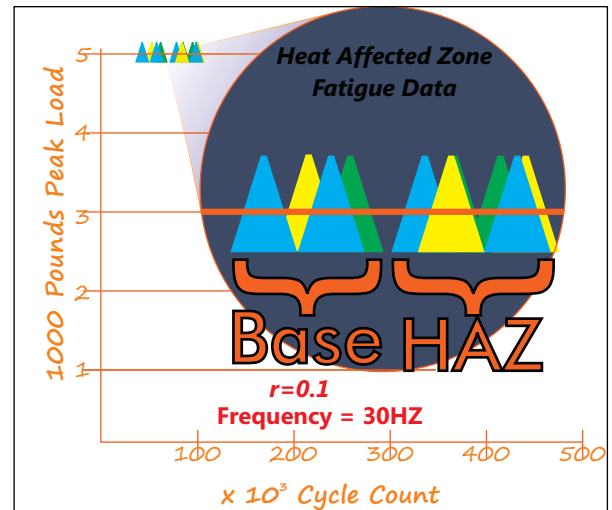


Fig. 5: Fatigue Life of Base Material and HAZ. Note the increase if Fatigue Life over the Base Material.

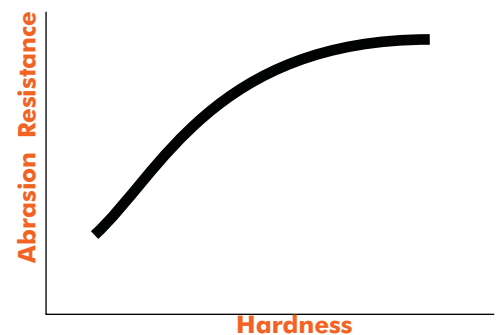


Fig. 6: Graph showing the relationship of hardness and abrasion resistance.

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Bob has 45 years experience in hardfacing metallurgy, tubular wire formulations and wear applications. He has authored 6 US Patents, the most recent in the Hardbanding field. In addition to writing many articles, he is currently engaging in hosting *Hardbanding Webinars*. Please email or contact him to schedule an event for you or your company.