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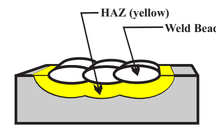
3/27/2013

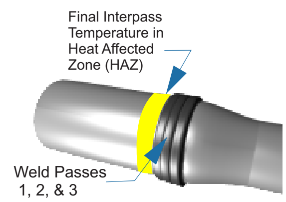
IDEAL FOR SOUR GAS

NON CRACKING ***NS-1 APPROVED*** ***100% REBUILDABLE***

Critical Temperatures

***Preheating**: The process of heating the tool joint to proper temperatures prior to hardbanding.*
***Interpass:** The temperature of the tool joint at which the next weld pass will be deposited. The final interpass is measured after completing the hardband.*
***Post Weld Cooling**: The process of protecting the tool joint and hardbanding with insulation to avoid cooling too quickly.*
***Heat Affected Zone (HAZ)**: The portion of base metal heated by the welding arc.*





Hardbanding Procedures for Sour Gas Environment

Preheats, Weld Interpass Temperatures, and Post Weld Cooling Considerations

As the oil field industry moves forward in their quest to reduce stresses of drill string components operating in Sour Gas environments, the initial and reapplication hardbanding procedures of tool joints must be revisited. The standard hardbanding procedure, by it's own nature, induces stresses in the tool joints, which will serve as potential sites for SCC (Stress Corrosion Cracking). This can be minimized however, providing close attention is paid to the welding preheats, welding interpass temperatures, and post weld slow cooling procedures. In ***all*** cases where Sour Gas is encountered, the standard hardbanding procedure preheats and weld interpass temperatures must be revised upward to reduce HAZ, (Heat Affected Zone) hardness to acceptable levels.

The Industry Recommended Practices (IRP) Committee has issued specification IRP 1.8 for SS grades of tubulars and stated limited guidelines for hardbanding. Postle Industries feels that the hardbanding references should be revised to reflect the critical preheating temperatures, weld interpass temperatures, and slow cooling procedures to ensure hardbanding Heat Affected Zone properties that are in the spirit of stress reduction for Sour Gas environments. In addition, reapplication procedures of hardbanding to worn tool joints should be included, as this can potentially be quite damaging if not carefully controlled.

Traditional Chrome-Moly steels have been successfully modified to produce high or deep hardenability tool joint chemistries. These modifications address the requirement for tool joint through the thickness hardening in the initial stages of heat treatment. 4137M is a case in point, and has served the industry well. High hardenability steels however, are typically difficult to weld, since their HAZ produce high hardness values. This is kept in check by carefully controlling preheating temperatures prior to hardbanding, controlling weld interpass temperatures during hardbanding, and ensuring very slow cooling procedures by deploying insulation over the weld after hardbanding.

A recently introduced 0.25% Carbon tool joint material, for sour gas environment, has prompted some to suggest lowering the preheat temperatures for hardbanding. The chemistry would certainly be easier to hardband than 4137M because of the lower carbon. The lower carbon would also help in controlling the HAZ hardness levels, assuming sound hardbanding fundamentals were practiced. This chemistry, along with the standard 4137M chemistry, displays good hardenability, although the Jominy[1] curves for lower carbon material are not available at this time. Hardenability plays a major role in the metallurgy of tool joints and their response to heat treatments. It is this deep hardenability that directly impacts the preheat and weld interpass temperatures of hardbanding procedures.

Preheat and weld interpass temperatures are closely related. In assessing any hardbanding procedure, the preheat temperature is evaluated for *both* the Base and the Hardband materials. The rule of thumb is that whatever preheat temperature is the more critical between the two, is the one that should be selected and used as a guide in developing the hardbanding procedure. In the case of 4137M, the restrictions on 40Rc Max in the HAZ of the tool joint, dictates that the tool joint preheat temperature is the more critical. Hence, the preheats that are typically specified for hardbanding, including all those in the Postle Industries NS-1 Approved Hardbanding Procedure, are based on this criteria.

Preheats are varied according to the tool joint diameter. In the cases where the carbon is lower in the tool joint, then hardbanding material preheat criteria requires an evaluation. Tuffband and Duraband, as well as other competitive non-cracking products are *all* martensitic materials and require a minimum of 400ºF *(204ºC)* preheat. Some preheats are currently lower than this for smaller diameter tool joints, which are acceptable. Dropping the preheat temperature, as proposed by some, for whatever reason or to accommodate lower carbon tool joints, as a general practice could lead to cracking and spalling of the hardbanding, and certainly put the tool joint in jeopardy of Sulfur related attack. It will also most likely result in elevated hardness values in the Heat Affected Zone, and be in direct violation of IRP 1.8. From a metallurgical, welding, and geometrical standpoint, lowering preheats as suggested, is a poor recommendation and should be dismissed as contrary to the intent of lowering stresses in Sour Gas drilling components.

In fact, Postle Industries has discovered through a great deal of research that, in order to meet the guidelines and requirements of IRP 1.8, it will be necessary to increase the preheat temperature even higher. IRP 1.8 states the hardness of the tool joint shall be approximately 30 Rc and not over 32 Rc.

To ensure low HAZ hardness values and low hoop stresses in 4137M and other proprietary tool joints for sour gas connections, Postle Industries published new hardbanding guidelines. ***Ref: Working Instructions for Duraband® NC and Tuffband® NC Application and Re-Application for Sour Gas***. *Hoop stresses are the tensile stresses that develop when circumferential welds are applied to cylindrical objects*. The higher the temperature of the cylindrical object (tool joint), the lower the hoop stresses will be. The essential change to this procedure over the standard procedure is to INCREASE preheats, and to adjust those preheats accordingly to ensure a final weld interpass temperature of 900ºF *(482ºC)*. Postle has data (**see Fig. 1, page 3**) showing that HAZ hardness values can be lowered to 30Rc and below just underneath the hardbanding. These values typically transfer to the HAZ on the surface of the tool joint, shown in Yellow on Page 1. The average in this case was 29.6 Rc. Although hoop stresses were not measured, logic would indicate that hoop stresses would be lowered as well. These factors are critical to lowering high stress sites around and including the hardbanding weld metal.

Slow cooling the hardbanding is the last step, but not the least important. All precautions practiced up until this point will be worthless unless proper insulation is applied to the hardbanding immediately after the tool joint has been hardbanded. The hardbanding is allowed to cool to 100ºF *(38ºC)* over an 8 hour period. This step ensures that the HAZ will be as low as possible.

Initial applications of hardbanding to new tool joints is relatively easier than reapplications. For reapplications, standard inspection procedures should be followed as described in Postle's NS-1 Procedure Manual. Low preheats and accelerated cooling of the hardbanding could potentially lead to a catastrophic failure. Therefore it is imperative that higher preheats, weld interpass temperatures and slow cooling rates, be implemented to assure conformance to IRP 1.8.

In conclusion, proper preheats are essential in order to achieve the proper final weld interpass temperature, especially for Sour Gas service, where the goal is to reduce the stress as much as possible. IRP 1.8 requires a hardness in the HAZ of approximately 30 Rc. The HAZ is the area beneath the hardband and extends to that area on the surface of the tool joint directly adjacent to the hardband. Too low a preheat would contradict our findings, be in direct violation of IRP 1.8, and render the tool joint more susceptible to cracking and sulfur related attack. The lower preheats would certainly subject the tool joint to an unwanted "quench".

Tuffband® NC and Duraband NC® are perfectly suited for Sour Gas environments. They are non-cracking, 100% rebuildable, and NS-1 approved.

[1] *Jominy: A standard test for alloy hardenability*

Bob Miller

Robert F. Miller
Materials Engineer
Postle Industries, Inc.
Hardbanding Solutions

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Hardness report for TJP-G1811-1 DB R3 [redacted]

Testing equipment: Tukon 2500 Certification expires: 4/12
Readings converted from Vickers HV10, reported in Rockwell C scale

Track 1	Track 2	Track 3

Readings Taken Through the Hardbanding

Track 1	Track 2	Track 3
DB Weld Bead 1 Surface/**59.4RC**	DB Weld Bead 2 Surface/**59.3RC**	DB Weld Bead 3 Surface/**60.5RC**
DB Weld Bead 0.020/**59.0RC**	DB Weld Bead 0.020/**59.0RC**	DB Weld Bead 0.020/**59.9RC**
DB Weld Bead 0.040/**59.3RC**	DB Weld Bead 0.040/**59.5RC**	DB Weld Bead 0.040/**59.3RC**
DB Weld Bead 0.060/**58.3RC**	DB Weld Bead 0.060/**61.1RC**	DB Weld Bead 0.060/**59.9RC**
DB Weld Bead 0.080/**60.3RC**	DB Weld Bead 0.080/**60.7RC**	DB Weld Bead 0.080/**59.9RC**
DB Weld Bead 0.100/**60.8RC**	DB Weld Bead 0.100/**61.2RC**	DB Weld Bead 0.100/**61.0RC**
DB Weld Bead 0.120/**46.2RC**	DB Weld Bead 0.120/**61.5RC**	DB Weld Bead 0.120/**61.3RC**
DB Weld Bead 0.140/RC	DB Weld Bead 0.140/RC	DB Weld Bead 0.140/**61.2RC**
DB Weld Bead 0.160/RC	DB Weld Bead 0.160/RC	DB Weld Bead 0.160/RC
DB Weld Bead 0.180/RC	DB Weld Bead 0.180/RC	DB Weld Bead 0.180/RC

AVG = 29.6 Rc

Readings taken through the HAZ

Track 1	Track 2	Track 3
HAZ0.020/**30.1RC**	HAZ0.020/**29.1RC**	HAZ0.020/**30.1RC**
HAZ0.040/**29.9RC**	HAZ0.040/**29.0RC**	HAZ0.040/**30.1RC**
HAZ0.060/**27.6RC**	HAZ0.060/**29.9RC**	HAZ0.060/**29.0RC**
HAZ0.080/**29.0RC**	HAZ0.080/**30.3RC**	HAZ0.080/**29.5RC**
HAZ0.100/**30.4RC**	HAZ0.100/**29.9RC**	HAZ0.100/**30.1RC**

Readings taken in the Base metal

Track 1	Track 2	Track 3
TJ Base **25.3RC**	TJ Base **28.6RC**	TJ Base **31.6RC**
TJ Base **26.3RC**	TJ Base **30.9RC**	TJ Base **33.7RC**
TJ Base **25.7RC**	TJ Base **30.3RC**	TJ Base **31.1RC**

FIG. 1

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HARDBANDING SOLUTIONS
by POSTLE INDUSTRIES

POSTALLOY DURABAND® NC

• Best Wear Protection • Best Casing Protection

• Ideal for Sour Gas Service Environments

DURABAND® NC is a 100% crack-free hardband that provides maximum protection of the tool joint and casing.

DURABAND® NC microstructure consists of a hard, but tough tool steel matrix with a high volume of tightly packed micro-constituents. This combination ensures excellent wear resistance in open hole drilling, as well as being *CASING FRIENDLY*. Deposits are smooth and free of any slag. DURABAND® NC can be applied over itself and over TUFFBAND® NC without removal, but only if the surface has been properly cleaned and inspected. DURABAND® NC can be applied over some competitive products without removal. Please contact Postle offices for further information .

NS-1 LEVEL 2

Duraband® NC Hardbanding
Uses: New Application and
Re-Application to Tool Joints

POSTALLOY TUFFBAND® NC

• Best for Applications Over Unknown Previous Hardbanding

TUFFBAND® NC is a 100% crack-free hardband that provides excellent protection of the tool joint and casing. A good choice when the abrasive conditions are not severe.

NS-1 LEVEL 2

Tuffband® NC Hardbanding
Uses: New Application and
Re-Application to Tool Joints

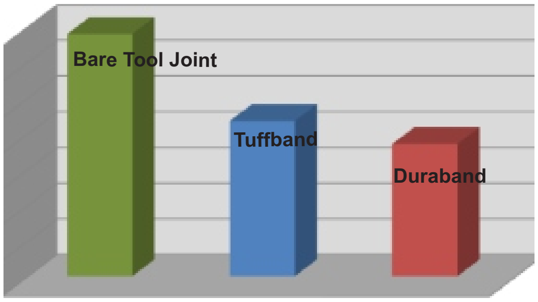
• Ideal for Sour Gas Service Environments

Ideal for application over previously unknown hardbands or hardbands that are not in the best condition. This will create a good base for later applications of Duraband® NC

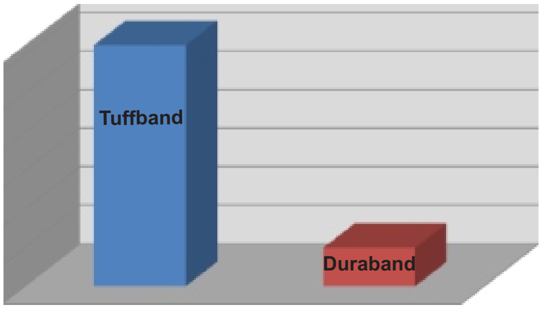
On new tool joints or when re-applied over itself, Tuffband® NC deposits are Non-Cracking providing proper preheat, interpass and cooling temperature procedures are followed.

TUFFBAND® NC can be applied over itself without removal, provided the surface has been properly cleaned and inspected. TUFFBAND® NC can be applied over certain previously hardbanded competitive products providing that the worn deposit is 1/32” thick or less. Please contact Postle offices for further information.

The World's Most Trusted Hardbanding



Casing Wear



Hardbanding Wear

03/13SS-1

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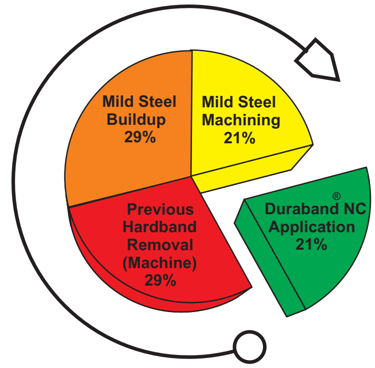
HARDBANDING SOLUTIONS by POSTLE INDUSTRIES

HARDBANDING RE-APPLICATION COST COMPARISON

Hardbanding Costs are Dramatically Reduced with Tuffband NC and Duraband NC

The cost of hardband re-application can be very expensive if the previous hardband must be removed before re-application can be completed. As the chart shows - close to 80% of the total cost of the re-application is dominated by the previous hardbanding removal, the application of mild steel as a build-up, and subsequent machining of the mild steel to prepare the tool joint for application of the new hardband.



The Relative Cost of Worn Hardbanding Removal and Application of Duraband or Tuffband

Duraband NC or Tuffband NC can substantially reduce the cost of re-application since they can be applied over some previous hardbandings without the need for removal, providing the proper inspection procedures have been carried out. However, there are certain ones that they cannot go over. If this is the case, then the complete re-application is required, which includes previous hardbanding removal, mild steel build-up and machining. It should be noted that once this procedure has been completed, any subsequent re-application of Duraband NC or Tuffband NC should not include removal of the hardbanding and any associated procedures.

For a string of 600 worn tools joints with Duraband NC, applied from the beginning, the re-application will be achieved much faster and with significant savings (see examples below). If everyone used Duraband NC, costly hardband repairs would be a thing of the past.

There is far less risk associated with a straight new application of Duraband NC, with no need to remove material from your tool joint. Duraband NC requires no dressing because it has no slag, which is another cost saving. With consistent re-application, the performance of the Duraband NC will get better and better as there is no dilution from a steel base.

Industry Average Cost for Procedure per Tool Joint (USD)

Hardband Removal $112
Mild Steel Build-Up $112
Machining $80
Hardband Application $112

Example 1 - Removal/Re-Application of Previous Hardbanding
Over time all 600 tool joints required complete procedure; removal, build-up and machining, followed by hardbanding.
Total Estimated Cost: $250,000

Example 2 - Removal/Re-Application of 20% of Previous Hardbanding
During life of drill string **25%** of the tool joints were rejected and required complete procedure; removal, build-up and machining, followed by hardbanding.
Total Estimated Cost: $115,000

Example 3 - Re-Application Only - No Removal Required
Duraband NC was applied to new pipe. Removal of previous hardbanding is **NOT** necessary. Tool joints re-hardbanded.
Total Estimated Cost: $65,000