Stoody® HB-56 & Stoody HB-62
RECOMMENDED HARDBANDING
PROCEDURE MANUAL

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1 GENERAL

1.1 Scope

1.1.1 This manual was developed to provide the required processes, procedures, and work instructions necessary for the application and reapplication of Stoody® HB-56 and HB-62 Hardbanding to drill stem components. Any personnel involved in the hardbanding application of Stoody HB-56 and HB-62 shall read and comply with the recommended application procedure in this manual.

1.1.2 Both Stoody HB-56 and HB-62 weld deposits were specifically designed for crack resistance, high hardness, casing friendly and applicator friendly hardbanding.

1.1.3 The first section of this manual is for the initial application of Stoody HB-56 and HB-62 hardbanding. The second section is for the reapplication of Stoody HB-62 over HB-62 and HB-56 over HB-62.

1.2 Applicators Responsibility

1.2.1 The applicator shall have the latest revision of this manual (Stoody HB-56 and Stoody HB-62 Recommended Hardbanding Procedure Manual) in their possession prior to hardbanding.

1.2.2 Shall confirm all relevant personnel have read and understood the latest revision of this manual.

1.2.3 Shall confirm all welders have been properly qualified and trained and have all relative equipment in their possession required to carry out procedure in this manual.

1.2.4 Shall confirm a functioning Quality Control System and Welding Procedure Specifications (WPS) are in place. The WPS shall be in accordance with ASME IX requirements and be supported with a Procedure Qualification Record also meeting the requirements of ASME IX. Welder Performance Qualification shall be developed and maintained per ASME IX requirements.

1.2.5 Shall confirm that all relative equipment is in proper working order.

1.2.6 Shall confirm all safety precautions are being administered per section 2.1 of this manual.

1.2.7 A pre-production meeting shall be held with all relative personnel prior to starting production.

1.2.8 The applicator should implement a log which documents the application welding parameters for each order they produced and keep records on file for future reference. They may also produce an internal QC Report. Those records should contain:

- Name of Hardband Operator and Unit Number
- The Wire Batch (Lot/Mix) number and description of the applied wire
- Preheat temperature range and periodically measured temperatures
- Actual welding parameters for: Voltage, Amperage, Gas Flow, Rotation Speed, Oscillation Speed, etc. were adhered to and were in compliance
- Inclusive dates of application
- Tool joint description, etc.
- Number of joints/ends hardbanded
- Visual and Dimensional Inspection
- Pipe/Joint Serial numbers upon request by Customer

See sample Form A (Hardbanding Application Log).

2 TYPES OF STOODY HB-56 AND HB-62 HARDBANDING APPLICATIONS

Hardbanding maybe applied raised in which the hardband is applied on the OD of the tool joint or flush in which a groove is machined into the tool joint.

2.1 Raised Hardbanding

Raised hardbanding is most common and is superior for maximum casing and tool joint protection.

2.1.1 Type A – Raised OD: One layer is applied raised on the tool joint OD. (See Figure 1.2)

2.1.2 Type A – Recessed 18°: A recess is machined into the 18° elevator shoulder and HB-56 or HB-62 is applied flush with the 18° taper. A single layer of HB-56 or HB-62 is applied raised to the OD of the tool joint. (See Figure 1.1)

2.2 Flush Hardbanding

Flush hardbanding will not prevent tool joint wear as well as raised hardbanding because the tool joint is wearing the same time as the hardbanding.

2.2.1 Flush Hardbanding is recommended only if the maximum tool joint O.D. must be restricted so as not to cause interference with the casing inside diameter.

2.2.2 For a Flush Hardband application, a recess groove is machined into the entire hardband area of the tool joint and filled with hardbanding flush with the O.D. of the tool joint. The hardband area normally includes the 18° elevator shoulder.
3 GENERAL PREPARATION GUIDELINES AND INFORMATION

3.1 Safety Guidelines:
All personnel involved in the hardbanding process must read and practice the recommendations set forth in the "Safety in Welding and Cutting—ANSI Standard Z49.1 procedure. Competence must be exhibited in the following areas:

- Protection From Exposure to Welding Noxious Fumes and Hazardous Gases
- Electrical Shock Hazards
- Arc Ray Burn Protection
- Compressed Gas Cylinder Handling Procedures
- Awareness of Welding Sparks and Volatile Environments
- Maintenance and Upkeep of Operating Regulators, Hoses, and Fittings

Caution: Practice Safety at all times when servicing equipment. Always use proper safety procedures, when handling materials and using tools. Always wear correct gear, as required, for eyes, head, hands, feet, and respiratory protection.

3.2 Welding Equipment Requirements

3.2.1 Equipment should preheat a tool at a uniform temperature between 100° and 700°F (38° and 370°C) (see Table 1 for preheat information).

3.2.2 Welding equipment should consist of a constant voltage, capable of supplying a current of 150 – 450 amperes and 19 – 35 volts.

3.2.3 The welding equipment should have a shielding gas flow meter which can provide shielding gas to the welding arc at a constant rate between 0 and 45 CFH.

3.2.4 The torch should have the ability to move off top dead center of the tool joint.

3.2.5 Welding Equipment should have the ability to grip and rotate the tool at a constant speed variable between 4 and 20 IPM.

3.2.6 The torch should have the ability to traverse parallel to the tool joint.

3.2.7 The torch angle should be adjustable between 0 – 20 degrees as measured from the top dead center of the tool joint.

3.2.8 Welding equipment should have the ability to oscillate the torch 0.0” – 1.30” oscillation width at a rate of 0.0 to 98 oscillations per minute.

3.2.9 Welding equipment should have a wire feed unit capable of supplying wire at a constant rate with variable speed controls having the ability to feed the wire from 0 to 450 IPM. Wire feed drive roll shall be suitable for feeding tubular wire and shall not damage or deform the welding wire.

3.2.10 Welding equipment should have a clean proper grounded connection.

3.2.11 The equipment should have the ability to control the cooling rate. (see Section 3.4.6 for slow cool down information.

3.3 Hardbanding Surface Preparation Requirements

3.3.1 A pre-inspection shall be performed of the tool joint hardbanding area prior to applying hardbanding. (Pre-surface inspection shall be documented on Form A)

3.3.1.1 Initial inspection shall consist of verifying the tool joint weight, grade, size, and dimensions.

3.3.1.2 Visually inspect the weld surface of all tool joints or hardband areas to ensure they are clean and free of all foreign matter such as rust, dirt, grease, oil, paint, or pipe coating.

3.3.1.3 All tool joints shall be cleaned of debris, rust, paint, lubricants, and other foreign matter using a side – grinder and/or wire wheel brush. If impurities still exist it is recommended they be removed by sand blasting or water blasting until a clean weld surface is established.

3.3.1.4 Threaded connections should be cleaned of all thread lubricants or storage compounds.

3.3.1.5 Pre-Hardbanded NDT Magnetic Particle Inspection; Tool joint O.D. surfaces 1” either side of the hardbanding area as a periodic control (Pin or Box) will undergo NDT inspection prior to preheat and hardbanding to check for cracks or per additional Customer Requirements.

3.4 Welding Parameters Guidelines and Information

3.4.1 Preheat, as defined within the AWS Standard Welding Terms and Definitions, is "the heat applied to the base metal or substrate to attain and maintain preheat temperature". The preheat temperature is defined by the same document as "the temperature of the base metal in the volume surrounding the point of welding immediately before welding is started".

3.4.2 Proper preheating of the tool joint must be performed regardless of the O.D. or ambient temperature of the steel.

3.4.3 Refer to Table 1 of this manual for the specific preheat temperature ranges for the type of steel and OD size of the parent metal and ensure that the preheat is a "soak" heat and not a surface heat.

3.4.4 A soaking preheat shall be performed while preheating tool joints. To determine a soak heat remove the tool joint from the heating source and measure the temperature of the desired heating area. Cover the tool with thermal blankets, insulation, or cool cans. Allow the tool to cool for 4 minutes in still air and measure the temperature again. If the temperature drops more than 50°F (25°C), only a surface preheat was complete. Continue to preheat until the temperature drop is within the above tolerance. Temperature should be checked using an infrared thermometer.

3.4.5 Preheat tool joints to guidelines found in the table (Table 1-next page). The preheat requirements were established by the POR and is also noted on the WPS. If welding in cold or wet weather a minimum preheat temperature of 250°F (120°C) is to be applied regardless of guidelines to dissipate moisture accumulation in the base metal.
Table 1

<table>
<thead>
<tr>
<th>Diameter of Tool</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>3” to 4” OD</td>
<td>150 - 200°F (65-93°C)</td>
</tr>
<tr>
<td>4” to 5” OD</td>
<td>200 - 250°F (93-121°C)</td>
</tr>
<tr>
<td>5” to 6” OD</td>
<td>300 - 450°F (150- 230°C)</td>
</tr>
<tr>
<td>6” to 7” OD</td>
<td>350 - 500°F (175- 260°C)</td>
</tr>
<tr>
<td>7” to 8” OD</td>
<td>400 – 600°F (205- 315°C)</td>
</tr>
<tr>
<td>8” to 9” OD</td>
<td>500 - 650°F (260- 345°C)</td>
</tr>
<tr>
<td>9” to 10” OD</td>
<td>600 - 700°F (315- 370°C)</td>
</tr>
</tbody>
</table>

The chart above is for 4140 and like material and should be used on all AISI 4137 and 4145 steel. If you are unsure of the material you are welding on please contact your supervisor before welding.

3.4.6 The hardbanded tool joint shall be slow cooled. The tool joints need to be wrapped immediately in thermally insulated blankets or canisters. The blankets or canisters shall remain on the tool joint ends (or hardband area) until the tool joint has cooled down to less than 150°F (65°C). The cooling rate should be controlled between 50°F to 75°F (25°C to 42°C) per hour. Slow cooling should take place in still air and not exposed to any wind, drafts, or rain. When slow cooling must be done in windy or cold air conditions, the ends of the drill pipe should be closed to prevent draft, or “chimney effect”, through the drill pipe.

3.4.7 Interpass temperature is defined as the highest temperature in the weld joint immediately prior to welding, or in the case of multiple pass welds, the highest temperature in the section of base metal 1” on either side of the toe of the previously deposited weld metal, immediately before the next pass is started. The Interpass temperature was established by the PQR and is also noted on the WPS. The maximum temperature of 700°F (370°C) must be carefully controlled. Welding should be stopped if the interpass exceeds 700°F (370°C) with-in 1” on either side of the toe of the weld. Welding shall not resume until the interpass temperature is below 650°F (345°C). Temperatures should be measured with a digital pyrometer. The minimum acceptable requirement is the use of two tempsticks; one for each of the minimum and maximum temperatures of the range. The operator must ensure that the desired temperature range is controlled and documented on Form A.

3.4.8 Shielding gas must be supplied to the arc when welding Stoody® HB-56 or Stoody HB-62. Stoody HB-56 and HB-62 both require a 98% Argon / 2% Oxygen shielding gas. A regulated flow of shielding gas should be controlled to deliver 30 – 45 CFH to the arc area. Precaution should be taken to protect the gas flow at the nozzle from being blown away from the arc by external air flow (such as fans) or during windy conditions.

4 WELDING PARAMETERS AND SETUP

4.1 Welding Setup

4.2 Stoody HB-56 and Stoody HB-62 Welding Parameters

<table>
<thead>
<tr>
<th></th>
<th>Stoody HB-56</th>
<th>Stoody HB-62</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding Process</td>
<td>GMAW</td>
<td>GMAW</td>
</tr>
<tr>
<td>Diameter</td>
<td>1/16”</td>
<td>1/16”</td>
</tr>
<tr>
<td>Polarity</td>
<td>Reverse (DCEP)</td>
<td>Reverse (DCEP)</td>
</tr>
<tr>
<td>Shielding Gas</td>
<td>98% Argon / 2% Oxygen</td>
<td>98% Argon / 2% Oxygen</td>
</tr>
<tr>
<td>Gas Flow</td>
<td>35 – 45 CFH</td>
<td>35 – 45 CFH</td>
</tr>
<tr>
<td>Current, Amps</td>
<td>200 – 450 (Typical 425)</td>
<td>200 – 450 (Typical 415)</td>
</tr>
<tr>
<td>Voltage, Volts</td>
<td>22 – 32 (Typical 26)</td>
<td>22 – 32 (Typical 29)</td>
</tr>
<tr>
<td>Stickout, in (mm)</td>
<td>1/2” – 1 1/4” (Typical 3/4”)</td>
<td>1/2” – 1 1/4” (Typical 3/4”)</td>
</tr>
<tr>
<td>Preheat</td>
<td>200-650°F (See Preheat Table 1, Section 3-4)</td>
<td>200-650°F (See Preheat Table 1, Section 3-4)</td>
</tr>
<tr>
<td>Maximum Interpass</td>
<td>700°F (370°C)</td>
<td>700°F (370°C)</td>
</tr>
<tr>
<td>Post Welding</td>
<td>Slow Cool to Room Temperature</td>
<td>Slow Cool to Room Temperature</td>
</tr>
<tr>
<td>Rotation Travel Speed (IPM)</td>
<td>5 – 15 IPM (Typical 7 IPM for 5° NC-50 TJ)</td>
<td>5 – 15 IPM (Typical 7 IPM for 5° NC-50 TJ)</td>
</tr>
<tr>
<td>Oscillation Speed (SPM)</td>
<td>60 – 100 (Typical 80)</td>
<td>60 – 100 (Typical 80)</td>
</tr>
<tr>
<td>Oscillation Width</td>
<td>3/4” - 1 1/8” (Typical 1”)</td>
<td>3/4” - 1 1/8” (Typical 1”)</td>
</tr>
<tr>
<td>As Welded 1 Layer Hardness Range, HRC</td>
<td>45 – 58 (Typical 53)</td>
<td>52 – 64 (Typical 60)</td>
</tr>
<tr>
<td>Reapplication Hardness Range, HRC</td>
<td>47 – 60 (Typical 55)</td>
<td>53 – 65 (Typical 61)</td>
</tr>
</tbody>
</table>
4.3 Post Weld Hardband Inspection

4.3.1 A post weld hardband inspection shall be completed after the hardband has been applied on each tool. Visual inspection of the hardband shall include:

4.3.1.1 Measure the outer diameter of the hardbanding. The hardband application should be no greater than 3/16” and no less than 1/8”.

4.3.1.2 Pinholes exceeding 1/16” in depth or 1/16” in width shall be cause for rejection unless repaired by welding using the original WPS. Cluster porosity having more than 5 holes exceeding 1/32” in depth or 1/32” in width in a 10 square inch area of the hardbanding shall be cause for rejection.

4.3.1.3 High spots, protrusions or abrupt changes in bead transition from one bead to another are cause for rejection unless removed by grinding or other suitable methods.

4.3.1.4 Weld bead profile and proper overlap is very important. Poor weld bead profile, severe concavity or convexity, and overlap areas are cause for rejection. The weld bead should be relatively flat with approximately .0625” - .125” overlap.

Adjust weld parameters to achieve best contour.

[Images showing acceptable and unacceptable weld bead profiles]

4.3.1.5 Tie-ins between the beads shall have smooth transitions. Inspect the tie-in area of the weld deposit for crevices exceeding 1/8” in depth or 1/8” in width. Tie-ins that exceed these shall be cause for rejection unless repaired by welding.

4.3.1.6 Cracking visible to the naked eye is unacceptable. Any cracks that propagate into the parent metal are cause for rejection.

4.3.1.7 Blow-holes and voids are cause for rejection unless repaired by grinding and welding using the original WPS.

4.3.1.8 Post Hardband NDT Magnetic Particle Inspection; Tool joint O.D. surfaces (Pin/Box) will be NDT inspected for transverse and longitudinal cracks after post heat cool down to ambient temperature as per Customer requirements. Micro cracks may be found by MPI testing; they are not relevant for rejection unless they extend from the hardband weld deposit into the parent metal.

4.4 Reference Photographs

[Images showing acceptable and unacceptable weld conditions]

Adjust weld parameters to achieve best contour.
5.1.1 This section of the manual was developed to provide the required process, procedures, and work instructions necessary for the reapplication of Stoody HB-56 and HB-62 over HB-62 hardbanding to drill stem components. Any personnel involved in the hardbanding application of Stoody HB-56 and HB-62 shall read and comply with the recommended application procedure in this manual.

5.1.2 Pre-Reapplication hardband inspection is extremely important. The identification of the residual hardband must be made before welding.

5.1.3 The existing hardband must be worn to 0.062" of the tool joint o.d. before reapplication.

5.1.4 The existing hardband must be worn 0.125" below nominal tool joint o.d. before a flush hardband reapplication.

5.1.5 Weld parameters (found in section 3.4 of this manual) for the application of material will be used for reapplication procedures.

5.1.6 The reapplication material must be compatible with the residual hardband as defined in paragraph 5.1.1 above and reapplied per the original application WPS supported by the original PQR.

5.2 Applicator Responsibility

5.2.1 The applicator shall have the latest revision of this manual (Stoody HB-56 and Stoody HB-62 Recommended Hardbanding Procedure Manual) in their possession prior to hardbanding.

5.2.2 Shall confirm all relevant personnel have read and understood the latest revision of this manual.

5.2.3 Shall confirm all welders have been properly qualified and trained and have all relative equipment in their possession required to carry out procedure in this manual.

5.2.4 Shall confirm a functioning Quality Control System and Welding Procedure Specifications (WPS) in place. The WPS shall be in accordance with ASME IX requirements and be supported with a Procedure Qualification Record also meeting the requirements of ASME IX. Welder Performance Qualification shall be developed and maintained per ASME IX requirements.

5.2.5 Shall confirm that all relative equipment is in proper working order.

5.2.6 Shall confirm all safety precautions are being administered per section 2.1 of this manual.

5.2.7 A pre-production meeting shall be held with all relative personnel prior to starting production.

5.2.8 The applicator should implement a log which documents the application welding parameters for each order they produced and keep records on file for future reference. They may also produce an internal QC Report. Those records should contain:

- Name of Hardband Operator and Unit Number
- The Wire Batch (Lot/Mix) number and description of the applied wire
- Preheat temperature range and periodically measured temperatures
- Actual welding parameters for; Voltage, Amperage, Gas Flow, Rotation Speed, Oscillation Speed, etc. were adhered to and were in compliance
- Inclusive dates of application
- Tool joint description, etc.
- Number of joints/ends hardbanded
- Visual and Dimensional Inspection
- Pipe/Joint Serial numbers upon request by Customer
- Previous hardbanding type

See sample Form A (Hardbanding Application Log).
6 TYPES OF STOODY® HB-56 AND HB-62 HARDBANDING REAPPLICATIONS

Hardbanding maybe reapplied raised in which the hardband is applied on the OD of the tool joint or flush in which a groove is machined into the tool joint.

6.1 Raised Hardbanding

Raised hardbanding is most common and is superior for maximum casing and tool joint protection.

6.1.1 Type A – Raised OD: One layer is reapplied raised on the tool joint OD. (See Section 2, Figure 1.2)

6.1.2 Type A – Recessed 18°: A recess is machined into the 18° elevator shoulder and HB-56 and HB-62 reapplied flush with the 18° taper. A single layer of HB-56 or HB-62 is reapplied raised to the OD of the tool joint. (See Section 2, Figure 1.1)

6.2 Flush Hardbanding

Flush hardbanding will not prevent tool joint wear as well as raised hardbanding because the tool joint is wearing the same time as the hardbanding.

6.2.1 Flush Hardbanding is recommended only if the maximum tool joint O.D. must be restricted so as not to cause interference with the casing inside diameter.

6.2.2 For a Flush Hardband reapplication, a recess groove is machined into the entire hardband area of the tool joint and filled with hardbanding flush with the O.D. of the tool joint. The hardband area normally includes the 18° elevator shoulder.

7 REAPPLICATIONS GUIDELINES AND INFORMATION

7.1 Safety Guidelines for Reapplications

See Section 3.1

7.2 Welding Equipment Requirements for Hardbanding Reapplication

See Section 3.2

7.3 Inspection of Existing Hardbanding Prior to Reapplication

7.3.1 The area to be hardbanded shall be visually inspected for cracking, voids, existing slag coverage or entrapped slag, spalling, and porosity. Dimensional measurements should be checked over and recorded to verify if reapplication of hardbanding is possible or needed.

7.3.1.1 Cracking in existing hardbanding maybe visible to the naked eye. If cracks are very fine and the cracking does not penetrate into the base metal, they are usually not detrimental to the performance of the hardband product. If the crack is 1/32” wide or are suspected to penetrate the base metal, the hardbanding shall be completely removed or rejected.

7.3.1.2 Spalling of the existing hardbanding shall be cause for rejection and not be considered for reaplication.

7.3.1.3 Porosity of the existing hardbanding greater than 1/8” in diameter or porosity having more than 5 holes in the 10 square inch area of the hardbanding shall be cause for rejection. The porosity and hardbanding shall be removed prior to reapplication of hardbanding.

7.3.1.4 Slag in or on the existing hardbanding shall be removed or be cause for rejection. Reaplication of hardbanding should never be applied over non-metallic covering (slag) on or in the weld surface. With the following exception, entrapped slag less than 1/8” or less than 5 holes not exceeding 1/16” in depth or 1/16” in width in a 10 square inch area of the hardbanding.

7.3.1.5 Voids in the existing hardbanding shall be repaired with compatible hardband weld metal or removed. Voids greater than 3/16” in diameter shall be cause for rejection.

7.3.1.6 See Section 5.1.2 thru 5.1.6 for other requirements prior to reaplication of hardbanding.

7.4 Removal of Existing Hardband Weld Deposit

The following process shall be utilized to remove previous hardband weld deposits or if the hardbanding needs to be removed when found to be rejected or not compatible with the new hardbanding to be applied. The Applicator can utilize any removal method listed below.

- By machining with a composite or ceramic type of tooling on a conventional lathe or CNC equipment.
- By grinding with stationary grinding equipment.
- By plasma-arc gouging equipment.
- By carbon-arc gouging equipment

7.5 Reaplication Hardbanding Surface Preparation Requirements

7.5.1 After removal of existing hardbanding, pre-inspection shall be performed of the tool joint hardbanding area prior to applying hardbanding. (Reaplication pre-surface inspection shall be documented on Form A)

7.5.1.1 Initial inspection shall consist of verifying the tool joint weight, grade, size, and dimensions such as minimum wall thickness and minimum hardbanding area requirements.

7.5.1.2 Visually inspect the weld surface of all tool joints or hardband areas to ensure they are clean and free of all foreign matter such as rust, dirt, grease, oil, paint, or pipe coating.

7.5.1.3 All tool joints shall be cleaned of debris, rust, paint, lubricants, and other foreign matter using a side – grinder and/or wire wheel brush. If impurities still exist it is recommended they be removed by sand blasting or water blasting until a clean weld surface is established.

7.5.1.4 Threaded connections should be cleaned of all thread lubricants or storage compounds.

7.5.1.5 Pre-Hardbanded NDT Magnetic Particle Inspection; The tool joint O.D. surfaces (Pin or Box) will undergo NDT Inspection prior to preheat and hardbanding the surface shall be free of cracks, addition Customer Requirements may apply. Micro cracks may be found by MPI testing; they are not relevant for rejection unless they extend from the hardband weld deposit into the parent metal.
7.6 Welding Parameters Guidelines and Information for Hardbanding Reapplication

7.6.1 Preheat, as defined within the AWS Standard Welding Terms and Definitions, is "the heat applied to the base metal or substrate to attain and maintain preheat temperature". The preheat temperature is defined by the same document as "the temperature of the base metal in the volume surrounding the point of welding immediately before welding is started".

7.6.2 Proper preheating of the tool joint must be performed regardless of the O.D. or ambient temperature of the steel.

7.6.3 Refer to Table 1 of this manual for the specific preheat temperature ranges for the type of steel and OD size of the parent metal and ensure that the preheat is a "soak" heat and not a surface heat.

7.6.4 A soaking preheat shall be performed while preheating tool joints. To determine a soak heat remove the tool joint from the heating source and measure the temperature of the desired heating area. Cover the tool with thermal blankets, insulation, or cool cans. Allow the tool to cool for 4 minutes in still air and measure the temperature again. If the temperature drops more than 50°F (25°C), only a surface preheat was complete. Continue to preheat until the temperature drop is within the above tolerance. Temperature should be checked using an infrared thermometer.

7.6.5 Preheat tool joints to guidelines found in the table below (Table 1). The Preheat requirements were established by the PQR and is also noted on the WPS. If welding in cold or wet weather a minimum preheat temperature of 250°F (121°C) is to be applied regardless of guidelines to dissipate moisture accumulation in the base metal.

7.6.6 The hardbanded tool joint shall be slow-cooled. The tool joints need to be wrapped immediately in thermally insulated blankets or canisters. The blankets or canisters shall remain on the tool joint ends (or hardband area) until the tool joint has cooled down to less than 150°F (65°C). The cooling rate should be controlled between 50°F to 75°F (25°C to 42°C) per hour. Slow cooling should take place in still air and not exposed to any wind, drafts, or rain. When slow cooling must be done in windy or cold air conditions, the ends of the drill pipe should be closed to prevent draft, or "chimney effect", through the drill pipe.

8 WELDING PARAMETERS AND SETUP FOR HARDBANDING REAPPLICATION

8.1 Welding Setup for Reapplication

Table 1

<table>
<thead>
<tr>
<th>Diameter of Tool</th>
<th>Temperature Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>3” to 4” OD</td>
<td>150 - 200°F (65-93°C)</td>
</tr>
<tr>
<td>4” to 5” OD</td>
<td>200 - 250°F (93-121°C)</td>
</tr>
<tr>
<td>5” to 6” OD</td>
<td>300 - 450°F (150-230°C)</td>
</tr>
<tr>
<td>6” to 7” OD</td>
<td>350 - 500°F (175-260°C)</td>
</tr>
<tr>
<td>7” to 8” OD</td>
<td>400 - 600°F (205-315°C)</td>
</tr>
<tr>
<td>8” to 9” OD</td>
<td>500 - 650°F (260-345°C)</td>
</tr>
<tr>
<td>9” to 10” OD</td>
<td>600 - 700°F (315-370°C)</td>
</tr>
</tbody>
</table>

The chart above is for 4140 and like material and should be used on all AISI 4137 and 4145 steel. If you are unsure of the material you are welding on please contact your supervisor before welding.

7.6.7 Interpass temperature is defined as the highest temperature in the weld joint immediately prior to welding, or in the case of multiple pass welds, the highest temperature in the section of base metal 1 inch on either side of the toe of the previously deposited weld metal, immediately before the next pass is started. The maximum temperature of 700°F (370°C) must be carefully controlled. Welding should be stopped if the interpass exceeds 700°F (370°C) with 1” on either side of the toe of the weld. Welding shall not resume until the interpass temperature is below 650°F (345°C). Temperatures should be measured with a digital, electronic pyrometer. The minimum acceptable requirement is the use of two tempsticks; one for each of the minimum and maximum temperatures of the range. The operator must ensure that the desired temperature range is controlled and documented on Form A.

7.6.8 Shielding gas must be supplied to the arc when welding Stoody® HB-56 or Stoody HB-62. Stoody HB-56 and HB-62 both require a 98% Argon / 2% Oxygen shielding gas. A regulated flow of shielding gas should be controlled to deliver 30 – 45 CFH to the arc area. Precaution should be taken to protect the gas flow at the nozzle from being blown away from the arc by external air flow (such as fans) or during windy conditions.

International Customer Care: 940-381-1212 / FAX 940-483-8178
www.stoody.com
8.2 Stoody® HB-56 and Stoody HB-62 Welding Parameters for Hardbanding Reapplication

<table>
<thead>
<tr>
<th></th>
<th>Stoody HB-56</th>
<th>Stoody HB-62</th>
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<tr>
<td><strong>Welding Process</strong></td>
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<td>GMAW</td>
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<td><strong>Diameter</strong></td>
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<td>1/16&quot;</td>
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<td><strong>Polarity</strong></td>
<td>Reverse (DCEP)</td>
<td>Reverse (DCEP)</td>
</tr>
<tr>
<td><strong>Shielding Gas</strong></td>
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<td>98% Argon / 2% Oxygen</td>
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<tr>
<td><strong>Gas Flow</strong></td>
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<td>35 – 45 CFH</td>
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<td><strong>Current, Amps</strong></td>
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<td>200 – 450 (Typical 415)</td>
</tr>
<tr>
<td><strong>Voltage, Volts</strong></td>
<td>22 – 32 (Typical 28)</td>
<td>22 – 32 (Typical 29)</td>
</tr>
<tr>
<td><strong>Stickout, inch (mm)</strong></td>
<td>1/2&quot; – 1 1/4&quot; (Typical 3/4&quot;)</td>
<td>1/2&quot; – 1 1/4&quot; (Typical 3/4&quot;)</td>
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<tr>
<td><strong>Preheat</strong></td>
<td>200-650°F (See Preheat Table 1, Section 3.4)</td>
<td>200-650°F (See Preheat Table 1, Section 3.4)</td>
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<td><strong>Maximum Interpass</strong></td>
<td>700°F (370°C)</td>
<td>700°F (370°C)</td>
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<td><strong>Post Welding</strong></td>
<td>Slow Cool to Room Temperature</td>
<td>Slow Cool to Room Temperature</td>
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<tr>
<td><strong>Rotation Travel Speed (IPM)</strong></td>
<td>5 – 15 IPM (Typical 7 IPM for 5° NC-50 T/J)</td>
<td>5 – 15 IPM (Typical 7 IPM for 5° NC-50 T/J)</td>
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<tr>
<td><strong>Oscillation Speed (SPM)</strong></td>
<td>60 – 100 (Typical 80)</td>
<td>60 – 100 (Typical 80)</td>
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<tr>
<td><strong>Oscillation Width</strong></td>
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<td>3/4&quot; – 1 1/8&quot; (Typical 1&quot;)</td>
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<tr>
<td><strong>As Welded 1 Layer Hardness Range, HRC</strong></td>
<td>45 – 58 (Typical 53)</td>
<td>52 – 64 (Typical 60)</td>
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<tr>
<td><strong>Reapplication Hardness Range, HRC</strong></td>
<td>47 – 60 (Typical 55)</td>
<td>53 – 65 (Typical 61)</td>
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</tbody>
</table>

8.3 Post Weld Reapplication Hardband Inspection

8.3.1 A post weld hardband inspection shall be completed after the hardband has been applied on each tool. Visual inspection of the hardband are shall include;

8.3.1.1 Measure the outer diameter of the hardbanding. The hardband application should be no greater than 3/16" and no less than 1/8".

8.3.1.2 Pinholes exceeding 1/16" in depth or 1/16" in width shall be cause for rejection unless repaired by welding.

8.3.1.3 High spots, protrusions or abrupt changes in bead transition from one bead to another are cause for rejection unless removed by grinding or other suitable methods.

8.3.1.4 Weld bead profile and proper overlap is very important. Poor weld bead profile, severe concavity or convexity, and overlap areas are cause for rejection. The weld bead should be relatively flat with approximately .0625" - .125" overlap.

Adjust weld parameters to achieve best contour.

![Acceptable Weld Bead Profile](image_url)

8.3.1.5 Tie-ins between the beads shall have smooth transitions. Inspect the tie-in area of the weld deposit for crevices exceeding 1/8" in depth or 1/8" in width. Ti-ins that exceed these shall be cause for rejection unless repaired by welding.

8.3.1.6 Cracking visible to the naked eye is unacceptable. Any cracks that propagate into the parent metal are cause for rejection.

8.3.1.7 Blow-holes and voids are cause for rejection unless repaired by grinding and welding using the original WPS.

8.3.1.8 Post Hardband NDT Magnetic Particle Inspection; Tool joint O.D. surfaces (Pin/Box) will be NDT inspected for transverse and longitudinal cracks after post heat cool down to ambient temperature as per Customer requirements. Micro cracks may be found by MPI testing; they are not relevant for rejection unless they extend from the hardband weld deposit into the parent metal.

8.4 Reference Photographs of Hardbanding Unacceptable for Reapplication

![Hardbanding Unacceptable for Reapplication Due to Porosity](image_url)
### 9 WIRE USAGE CHART AND TEMPERATURE CONVERSION CHART

#### Diameter

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<th>Tool Joint Diameter</th>
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#### Temperature Conversion Chart

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**EXAMPLE:**

Your Temperature = 100° F  
Your Conversion = 38° C  
OR  
Your Temperature = 100° C  
Your Conversion = 212° F