



GUIDELINES FOR PDC DRILL BIT REPAIR

1.0 PURPOSE:

To establish a specification that details procedures for repair PDC bit brazing, order processing, bit pre-assessment, post-repair procedures, data reporting, and other requirements as specified.

2.0 SCOPE:

This specification is a worldwide standard, applicable to all facilities performing thermal processes on NOV Downhole PDC Drill Bits.

3.0 REFERENCES:

- FCPS-003 Replacing Upper Sections on PDC Matrix Bits
- DSP9004 Manual Torch Brazing of PDC Bits, Gage Subs, Steel Blocks, Reamers
- DSP9005 Procedure for PDC Bit Cosmetic Repair
- DSP9006 DuraShell Hardfacing
- DSP9007 Procedure for Brazing Bits on a Positioner
- FCQA-004 Qualification of Personnel Performing FC Thermal Operations

4.0 DEFINITIONS:

- 4.1. Repair Request – A request for replacement of new or reclaim PDC cutters and replaceable inserts, or rebuild body damage on bits. A request for modification of a new or repair bit that is covered in existing procedures. Repair requests to alter bit features not allowed for in bit repair procedures must be processed as a Special Bit Request (SBR).
- 4.2. Repair Bit – Any used fixed cutter drill bit returned from the field for repair work or modification.
- 4.3. Customer Bits – Bits owned by a customer.
- 4.4. Rental / Reclaim / Regular Grade Cutters – Cutters considered opportunity cutters, or seconds, acceptable for the repair market.

5.0 EXHIBITS (Typical):

- 5.1. Example of Used Cutter Acceptance Criteria Exhibit "A"
- 5.2. Bit Repair Quality Record Exhibit "B"
- 5.3. PDC Repair Request / Transfer Form Exhibit "C"
- 5.4. Cutter Replacement Report Exhibit "D"

6.0 BIT REPAIR ADMINISTRATION:

6.1. REPAIR CATEGORIES and REBRAZE REQUIREMENTS:

6.1.1. Bit repairs fall into two categories:

- Standard Repair: Components with wear flats or damage shall be replaced so the repaired product has all cutters with sharp cutting tips. Inserts replaced according to guidelines for wear.
- Non-Standard Repair: Components replaced and repairs made as requested. Exactly what is needed must be clearly specified by the requestor. E.g. blade number and cutter number. Modifications to bits are treated as a non-standard and requests must be clearly documented.

6.2. RESPONSIBILITIES:

6.2.1. **Management:** Responsible for the selection of operators, training, enforcement of legal, company, and local safety regulations, as well as meeting delivery, maintaining quality, making judgments on body rebuild, compliance with specification requirements, selecting components for potential reuse, and the general tidiness and safety of the shop.

6.2.2. **Operators:** Responsible for adhering to operational and safety requirements. Making determinations on the reparability of bits, in conjunction, as necessary, with supervisory personnel.

6.3. MATERIALS AND EQUIPMENT REQUIREMENTS:

Only materials and process consumables approved by Engineering shall be used, as noted in relevant repair specifications. Approved materials and equipment may be purchased through the Product Centers as necessary. Locally procured alternatives must be approved by Engineering in writing, with a copy maintained at the local repair center.

6.4. BIT REPAIR ORDER PROCESSING:

6.4.1. Field requests must be forwarded to the repair center for the product being processed. The following information is required (noted by an *) or requested:

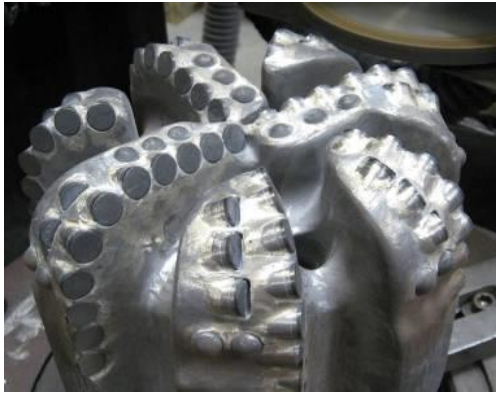
- Transfer Information, as appropriate
- Size, Type, and/or Serial Number *
- Standard or Non Standard Repair *
- Details for Non-Standard Repair
- Shipping Information or Instructions as appropriate

6.4.2. Typical form for this purpose is shown in Exhibit "C".

- 6.5. Product shall be assessed prior to repair for damage, wear, erosion, etc. to determine repairability. This decision shall be made by Repair personnel, with the support of Management and Engineering as needed.
- 6.6. A Work Order shall be generated for each repair, and a packet shall be created that shall contain applicable paperwork. A copy of the Repair Request Form shall be placed with each work order packet or the applicable information off the form shall be transposed to the packet for proper bit repair tracking.
- 6.7. Once a bit has been completed, it is transferred to Shipping. Shipping documents are prepared and processed per Shipping and Receiving protocol.
- 6.8. PRE-REPAIR ASSESSMENT:
- 6.8.1. The following shall be conducted on all bits prior to commencement of any repairs:
- General cleaning by spray wash or grit blasting as needed.
 - Visual assessment for cracking, particularly at blade roots, nozzle port edges, cutter pockets, and gage surfaces. Abnormalities should be documented on repair paperwork. Dye penetrant inspection may be used to aid in crack detection / documentation.
 - Visual assessment of pin connection.
 - Component part grading for replacement.
 - Visual assessment of Braze line erosion.
 - Visual assessment for internal erosion.
 - Bit Ring Gauging
- 6.9. Exceptional Damage: Anything necessitating more than rebuild of the immediate cutter pocket or hardfacing, e.g. chunks of missing matrix, deep gouges, excessive erosion, nozzle bore damage, etc.
- 6.10. Whether repair is possible shall be a judgment based on the employee knowledge and experience based on basic requirements set by management with the requestor's knowledge of local drilling conditions.
- 6.11. Cutter/Insert Replacement (Exhibit "D") shall be documented if the repair job includes component replacement. Pre-Assessment shall also be documented on a Repair Quality Record (Exhibit "B").
- 6.12. POST-REPAIR PROCEDURES:
- 6.12.1. Gage Diameter
- All repaired bits shall be ring gauged with calibrated go/no-go gages to verify compliance with API / NOV specifications.
 - Bits shall be processed, as necessary, to achieve proper diameter on a machine suitable for cylindrical grinding and fitted with a diamond-grinding wheel.

6.12.2. Visual Inspection

- Braze flow, braze bubbling
- Cutter Seating
- General Cosmetics



Good Cosmetics



Excessive Braze Bubbling

6.12.3. Pin Connection Inspection

- Magnetic Particle Inspection (MPI) shall be performed on pin connections of all bits repaired. This will be accomplished by qualified internal or 3rd party inspection services, such as NOV Tuboscope.
- Pin connection inspection will include use of a thread profile gage, and a visual for excessive thread or pin connection sealing face damage.
- Records of inspection results shall be maintained in repair bit packets.
- Bits rejected due to defects, can be sent back to the Conroe Product Center for pin replacement.

Note: Product Centers will perform normal dye-penetrant inspection of new or repaired bits.

6.12.4. ExxonMobil Requirements:

- A tempstick or pyrometer shall be used after each blade is brazed to ensure cutters and bit body did not exceed temperatures. This shall be documented on the QC sheet.
- DS-1 Inspection – Rotary Shouldered connections for ExxonMobil bits shall be inspected to DS-1 requirements.
- A Certificate of Conformance to specification requirements shall be generated.
- Bits shall have an “R” stamped at the end of the bit serial number on the pin and body to indicate the bit is a repaired product.
- Bits shall be liquid dye-penetrant inspected (LPI) for cracks.

6.13. DATA REQUIREMENTS AND REPORTING:

- 6.13.1. Summary data for each repaired bit including size, type, serial number, number of the repair, and the number of cutters replaced shall be reported to Downhole QA or Operations on a monthly basis.
- 6.13.2. Locations of cutter replacement shall be documented for all repaired bits using a form similar to that as shown in Exhibit "D".
- 6.13.3. Bit Modifications:
 - Bits that are modified from their original design shall be updated by serial number in the business system in order to maintain accurate inventory accounting.
 - Examples include bits that have had their overall diameter modified, gage shortened, ports closed, or basic cutter designation altered.

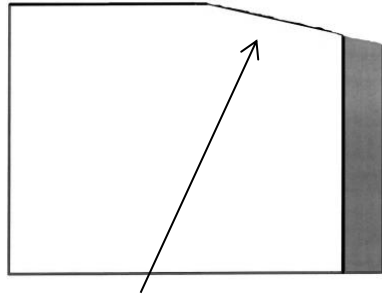
7.0 DOCUMENTATION:

- 7.1. The Repair Request Form, Repair Quality Record, Cutter/Insert Replacement data, Inspections, and any other documentation required by the applicable specifications shall be maintained for each bit repaired at the facility level.
- 7.2. Work Orders, Quality Records and Cutter Replacement forms may be developed by the repair facilities, provided they provide the information required by this specification.

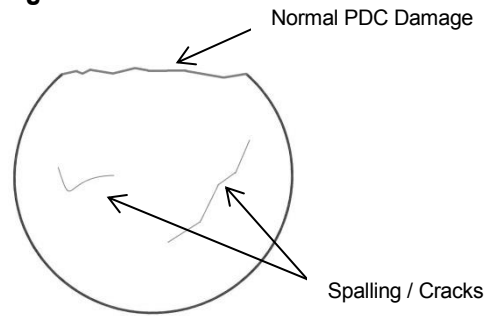
EXHIBIT "A"

EXAMPLE OF USED CUTTER ACCEPTANCE CRITERIA (REFERENCE GUIDELINE)

Erosion, Wear and PDC Damage



Erosion / Wear on the cutter OD shall not exceed 50% of the length of the carbide substrate



Though re-used cutters will have PDC damage, there must be a good cutting edge exposed to the formation, and no cracks or spalls on the PDC surface



Cutters exhibiting carbide substrate cracking or heat checking as exhibited above, shall be replaced and not used as reclaim cutters