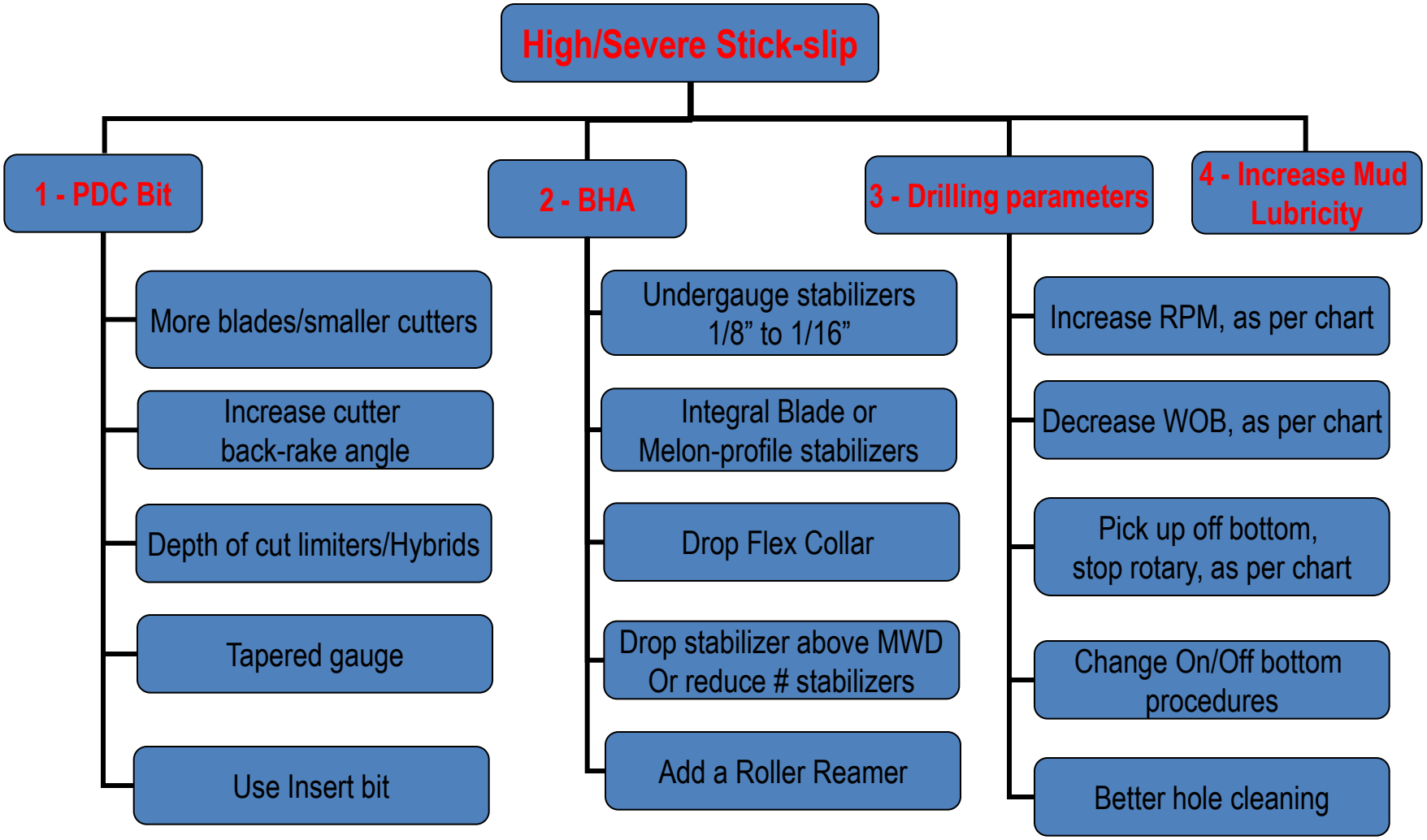
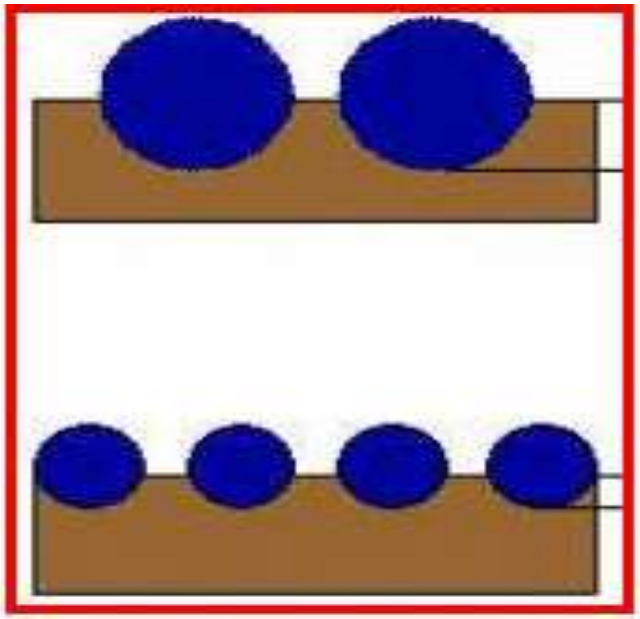
Stick-Slip Mitigation

Stick-slip Mitigation Option Tree



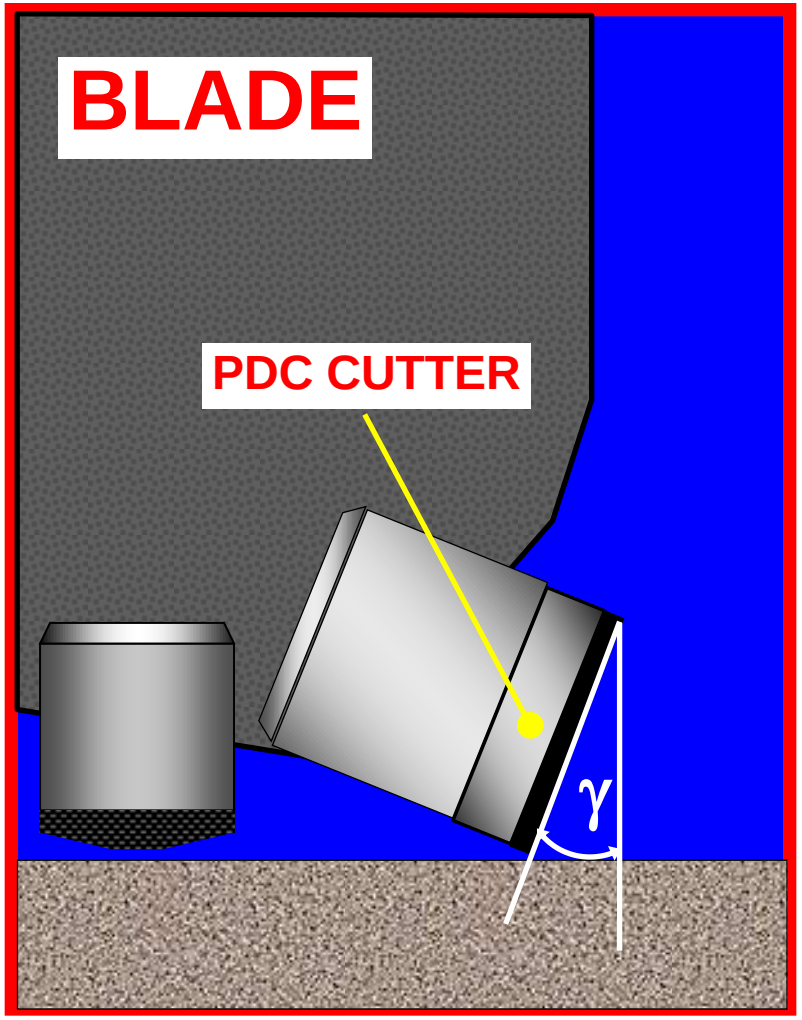
Cutters & Blades

- More blades and smaller cutters
  - ✓ More blades mean load better distributed over more cutters
  - ✓ With larger cutters, depth of cut is deeper, giving a higher Torque response
  - ✓ With smaller and more cutters, depth of penetration is smaller, which gives a lower Torque response



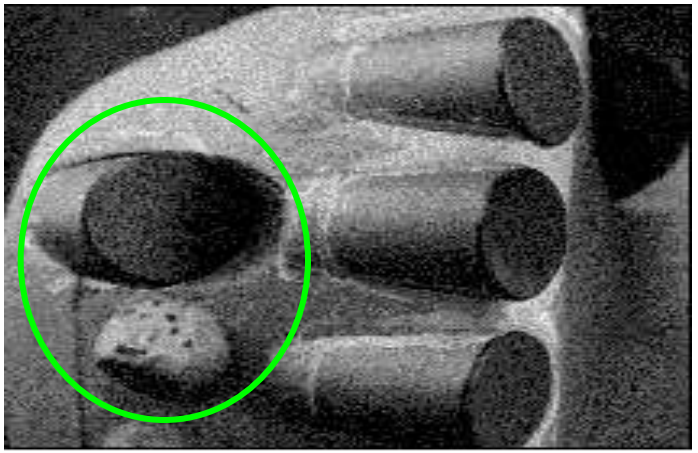
Back-rake Angle

- Increase cutter back-rake angle
  - ✓ Back rake angle typically varies between 15 to 45 degrees (angle from vertical)
  - ✓ Lower back rake angle, larger depth of cut, more aggressive = higher Torque and potential for Stick-slip
  - ✓ Higher back rake angle, less aggressive = lower Torque
  - ✓ Higher angle gives smaller vertical and higher horizontal component of force, so less potential for stick-slip



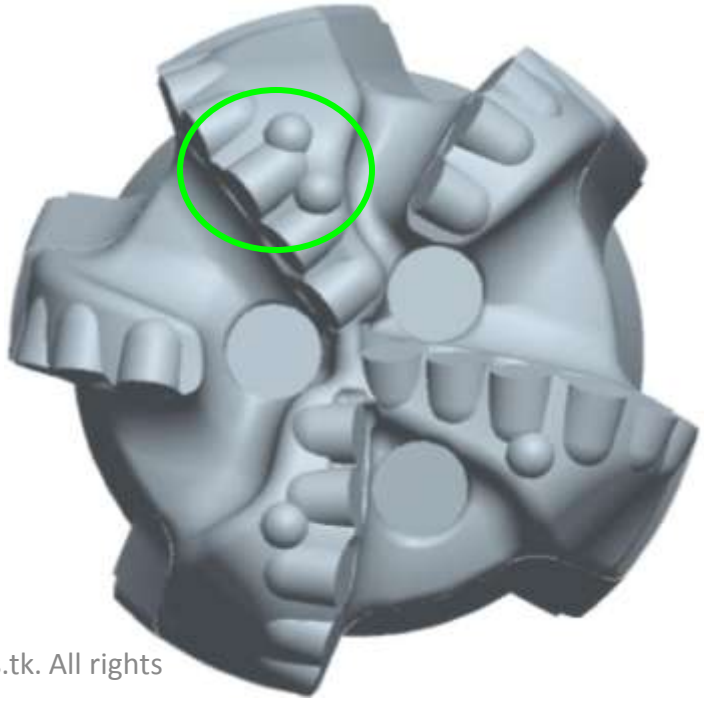
Depth of cut limiters

- **Depth of cut limiters / Hybrids**



  - ✓ **Depth of cut limiters "limit" the cutter penetration into the formation, thereby decreasing Torque**

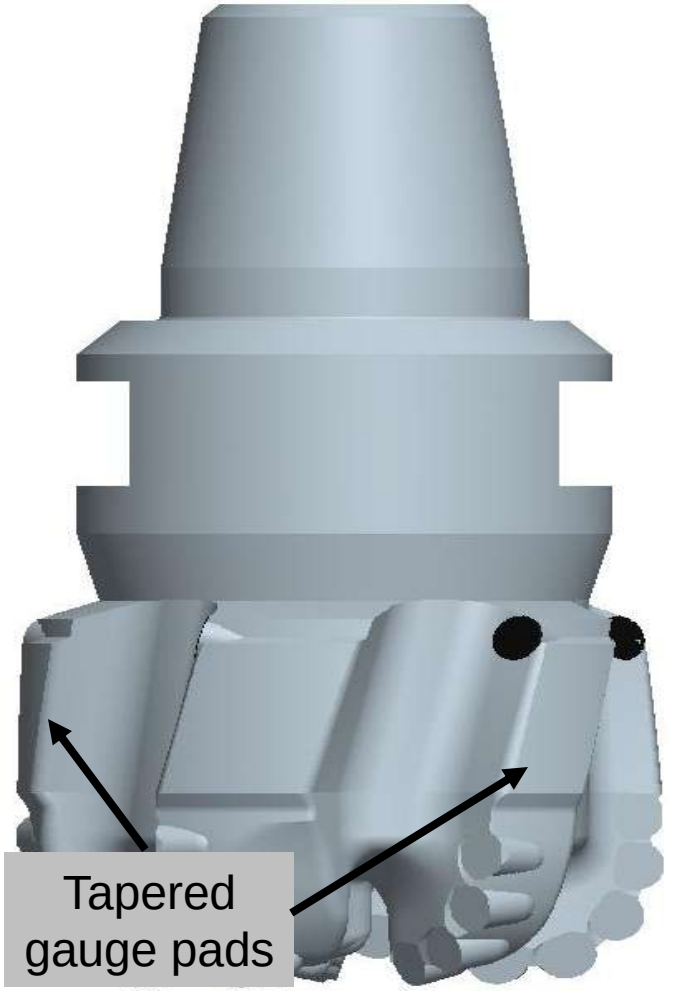
  - ✓ **When mitigating stick-slip with depth of cut limiters, DO NOT reduce WOB as per usual guidelines – actually, increase WOB to bury the cutters and allow the limiters to do their job**



Tapered Gauge

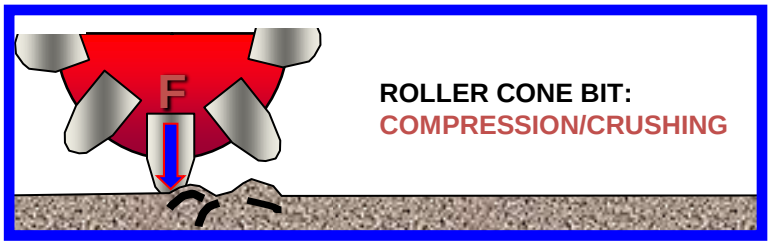
- **Tapered gauge**

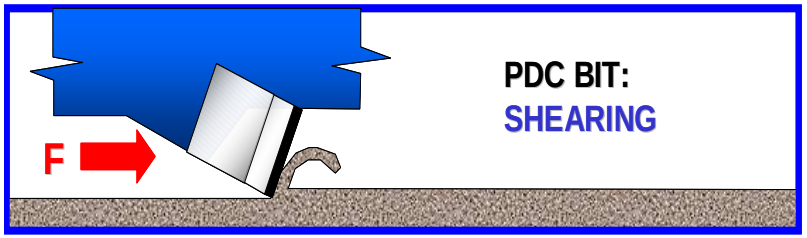
  - ✓ **Tapered gauge will help decrease the Torque generated at the upper gauge pad area, allowing the cutters only to generate Torque**



Insert Bit

- **Change to Insert bit**
  - ✓ **Roller cone insert bits have a different cutting action than PDC bits, which cut by shearing and can generate high Torque**
  - ✓ **Insert bits cut by rolling and crushing actions and do not generate as much Torque**





Undergauge Stabilizers

- **Use undergauge stabilization – 1/16” to 1/8”**
  - ✓ **As well as helping with directional control, using undergauge stabilizers help reduce borehole wall contact and resultant friction forces**
  - ✓ **Gauge stabilizers increase friction factors and will help increase stick-slip levels due to interactions with the wellbore**

Stabilizer Types

- Use spiral Integral blade stabilizers instead of welded, straight blade stabilizers

- Use melon-profile stabilizers instead of stabilizers with 90-degree or high angle leading edges
  - ✓ Smoother angle and profile helps reduce chance of generating shocks and stick-slip when interacting with formations, formations changes, ledges, etc

Flex Collar

- **Flex collars have been known to generate stick-slip due to their flexibility**
  - ✓ **Only use Flex collars when directional responses in an area/well are unknown, or you need DLS >3 degrees/100ft**

Reduce Stabilization

- **Keep the number of stabilizers to a minimum, just enough to accomplish your directional goals**
  - ✓ **Dropping the stabilizer above the MWD collar has been observed to reduce stick-slip – in most cases, high MWD shocks do not decrease because of this, but MWD shocks have increased in some other cases – use a rigid-mount collar to offset MWD shock generation if you drop the stabilizer**
  - ✓ **Less stabilization means less borehole wall contact, less friction forces, less torque and thus the less chance to generate stick-slip**

Roller Reamers

- **Add a roller reamer**
  - ✓ **Adding a roller reamer will reduce BHA to borehole friction and torque and thus reduce the chance for stick-slip generation**
  - ✓ **Note that some operators do not like to use roller reamers due to their sometimes short bearing life and propensity to come apart downhole**

Increase RPM

- **Increasing RPM will help increase the drillstring inertia and help overcome the formation friction factor**

- **Remember that changing RPM and WOB to reduce stick-slip can initiate other even more destructive vibration types, such as BHA whirl**

- **Try to optimize RPM/WOB to maximize ROP**

Reduce WOB

- **Reducing Weight On Bit pulls the cutters out of the formation a little, thereby reducing torque and side forces on the BHA**
- **Reducing WOB will often result in a decrease in ROP?**
- **Remember that changing RPM and WOB to reduce stick-slip can initiate other even more destructive vibration types, such as BHA whirl**
- **Try to optimize RPM/WOB to maximize ROP**

Pick up off bottom

- **Picking up off bottom and stopping the drillstring is often the cure when stick-slip levels are severe.**

- **Reducing WOB will often result in a decrease in ROP, which will not make the client happy?**

- **Try to optimize RPM/WOB to maximize ROP**

On/Off bottom Procedure

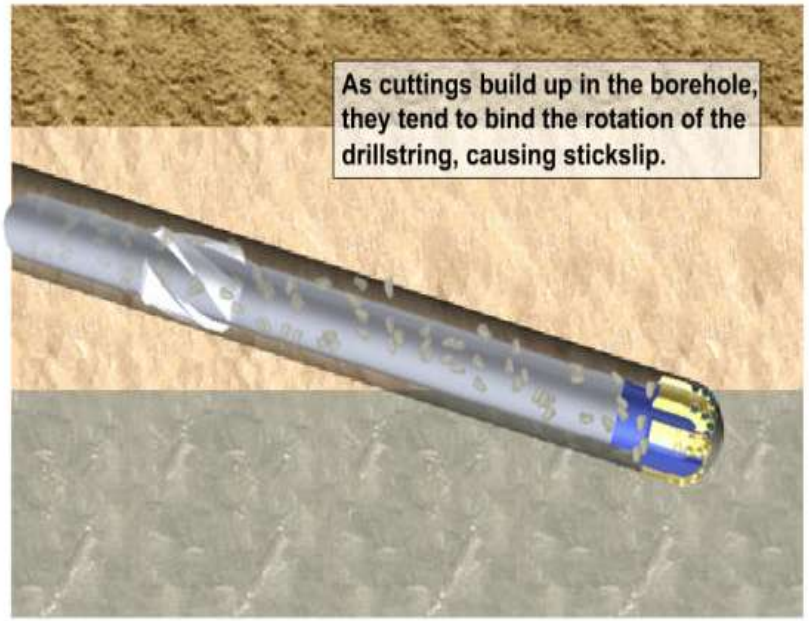
Actions to Address Drill String Vibrations				
Condition	RPM	WOB	Flowrate	Complete Action and Comments:
Shutting Down for a Connection.	Reduce RPM to between 60 to 80.	Drill off to 50% of drilling WOB	Shut Down Pumps.	1. Reduce RPM to between 60 to 80. 2. Drill off to 50% of Drilling WOB, and 3. Stop Rotary and Lift Off Bottom. 4. Make the Connection.
Starting Up after a Connection.	Start the rotary between 60 and 80 RPM.	Slowly Increase WOB to target drilling value	Bring Pumps up gradually to drilling value	1. Start the rotary between 60 & 80 rpm. 2. Place the bit on bottom. 3. Slowly increase WOB to target drilling value. CAUTION: Take Care not to initiate Stick / Slip. 4. Increase RPM to the target drilling value.
Reaming Guidelines	Use low RPM	Use minimal WOB	No Change	1. Use minimal WOB while reaming. 2. Control reaming penetraton rate to below 50% of the normal drilling penetration rate. 3. Ensure the bit torque does not exceed 50% of the normal drilling torque for that bit and formation. 4. Keep reaming speed below 35 fpm, and 5. Use low rpm to minimize vibration levels while monitoring RT shock measurements.
Bit Break-in Procedure	Start the RPM at half the target drilling rate	Begin drilling with low WOB <6K for 2 to 3 feet.	Target Drilling Flowrate	1. Start the RPM at half the target drilling rate. 2. Tag Bottom. 3. PU 1 foot off bottom & circulate for 5 minutes. 4. Begin Drilling with low WOB & drill 2 - 3 feet. (no more than 500 psi of bit diameter -- 6K WOB) 5. Increase the WOB to target drilling value, then 6. Increase the RPM. CAUTION: Take Care not to induce Stick Slip or Axial & Lateral Vibrations

Hole Cleaning

- **Poor hole cleaning, especially in wells with angles of 35-65 degrees, can help induce stick-slip**

- **Cuttings can build up around the BHA, especially the stabilizer blades, binding the drillstring and causing stick-slip**

Stick Slip caused by borehole cleaning



Mud Lubricity

- **Increasing the lubricity of the mud will help “slick up” the hole and reduce stick-slip tendencies**
  - ✓ **Try to use liquid lubricants where possible, in water-based muds – avoid solids such as beads to avoid any downhole tool jamming issues**
  - ✓ **Increasing oil percentage can help**
  - ✓ **In some cases with oil-based muds, stick-slip can be accelerated by the extreme “slickness” of the mud system**