



# BaraShield<sup>®</sup>-664 LCM Standard Field Application Procedure

**Prepared for:** All Customers

**Prepared by:** Sharath Savari, Donald L. Whitfill

**Submitted by:** Halliburton

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## 1. Overview

BaraShield®-664 lost circulation material (LCM) is a proprietary, engineered particulate formulation designed to rapidly seal fracture widths up to approximately 1000 microns. With a proprietary particle size distribution and special particle properties, BaraShield-664 LCM can pack a fracture entrance efficiently with a thin layer of sealing particulates. This rapid, high efficiency sealing can be quantified by its small/controlled spurt loss, and can be measured with a slotted disc in an industry-standard, Permeability Plugging Apparatus (PPA). **As BaraShield-664 LCM is an “Engineered, Composite Solution” (one sack), it should be used on its own and is NOT recommended to supplement any other conventional LCM like BARACARB®, WALL-NUT® or BAROFIBRE®. Only, BaraLock®-666 LCM is the recommended Supplemental LCM for BaraShield-664 LCM. Consult with Technical Manager/Regional Technical Manager and if needed Global Technical Advisors for potential suggestions on other supplemental LCM if any.**

The BaraShield-664 LCM rapid sealing can be further enhanced to seal wider and unknown fractures with the “one size fits many” BaraLock-666 LCM, sized pieces of foam rubber, as a remedial solution. BaraLock-666 LCM, including BaraLock-666.F, BaraLock-666.M and BaraLock-666.C, are highly compressible and permeable. After being pumped into fractures, they can fit nicely forming a filtration bed on top of which the BaraShield-664 LCM sealing particulates then can form a rapid seal. So BaraShield-664 LCM, in combination with BaraLock-666 LCM, can also be used as a remedial solution to cure losses.

When drilling in lost circulation prone areas, it is recommended to run a BHA bypass tool (e.g., PBL Sub) in the drillstring. This equipment can be opened/closed multiple times and allows the pumping of large lost circulation material without plugging bit nozzles or small clearances in the BHA. This also insures that restrictions from the tool supplier on the size and amount of LCM that can be pumped through their downhole tools can be eliminated.

Induced fractures and mud losses are often experienced while drilling through a depleted formation or drilling an offshore deepwater well where narrow mud-weight windows are encountered. The behavior of an induced fracture is predictable. Such a wellbore can be strengthened by securely sealing the incipient induced fractures. To seal an induced fracture, it is critical that the spurt into the fracture is small and the seal forms instantaneously and further prevent fracture propagation. The “STRESS-SHIELD Engineering Method (SEM)” is a process to design and ensure the fluid spurt invasion is well controlled with BaraShield-663 LCM or BaraShield-664 LCM to prevent induced mud losses. However, when BaraShield-664 LCM is selected to pretreat the mud, due to its larger particle size, it is recommended that API 20 mesh, or coarser, shale shaker screens are used to retain the majority of the sealing particulates in the drilling fluid system, if bypassing the shale shaker is not an option.

When a lost circulation material treatment does not stop the mud loss, consideration should be given to the following:

- Were the type and sizes of particulate material appropriate for the loss conditions?
- Did the treatment have sufficient volume/concentration of material?
- Was the lost circulation material applied to the proper location?

BaraShield-664 has no built-in suspending capability and it should always be mixed with fluid with some suspending capability, preferably drilling fluid, which already has a viscosifier in its formulation.

### **Recommended BaraShield-664 LCM Applications**

BaraShield-664 LCM may be applied for prevention of losses in both induced and natural fractures. For induced fractures, the “STRESS-SHIELD Engineering Method” is applied to determine the treating concentration. For natural fractures, a nominal 40 ppb concentration is suggested in the absence of previous loss rate information. Furthermore, BaraLock-666 LCM can be added to sweeps or treating pills in case of wider fractures that may exist.

- 1) Pretreatment applications to prevent drilling fluid losses:
  - a. Add to active fluid in circulation to drill naturally fractured or highly permeable formations.
  - b. Add to active fluid in circulation to drill low fracture gradient/weak wellbores.
  - c. Add to pill to be pumped to cover a depleted interval, and to pressurize the wellbore to the strength required.
  - d. Add to pill to be pumped to cover the entire weak section of the wellbore before pulling out of the hole to mitigate whole fluid losses while running casing (especially for deepwater drilling).
  - e. Add to pill to be pumped ahead of a cement spacer fluid to cover the entire weak wellbore to prevent induced fluid losses while cementing (especially for deepwater drilling).
- 2) Sweep mud pill applications to remediate seepage losses.
  - a. Add to pill with 0.5 ppb of BaraLock-666.F. When used as a sweep pill, this may also help to detect a loss zone location if the pit and displacement volumes are monitored. The pit level should start to remain at the same level, rather than constantly decreasing, when a pill circulated at a constant pump rate seals off the loss zone.
- 3) Squeeze mud pill applications to remediate seepage to partial losses.
  - a. Add to pill with a calculated concentration of BaraLock-666.F (BaraLock-666.M and BaraLock-666.C are optional, based on the loss rates or assessed fracture width).

### **2. BaraShield-664 LCM Pretreatment and Pill Volume & Concentration**

For preventing induced fractures, the volume and concentration of BaraShield-664 LCM is defined by SEM. More details about this method can be found in the Operation Procedure for BaraShield-663 LCM. For sealing existing induced or natural fractures, the volume and concentration of BaraShield-664 LCM is defined by an empirical method.

***Contact Global Technical Advisors for support on this calculation and application of “STRESS-SHIELD Engineering Method”.***

While drilling, an API 20 mesh, or coarser, screen is required to retain the majority portion of the BaraShield-664 LCM particulates in the active fluid system and remove the larger drilled cuttings during circulation. *As with any drilling fluid with LCM in Background, it is recommended*

to run sweeps of BaraShield-664 LCM also for every stand drilled, compensating for those LCM ground down during circulation. Optionally, shale shakers can be by-passed to retain the BaraShield-664 LCM particulates.

#### **Volumes for the STRESS-SHIELD Engineering Method:**

- For drilling, it is recommended to treat the total active fluid system with BaraShield-664 LCM.
- For loss prevention while running casing or cementing, a pill with sufficient volume to cover the entire open hole, or as a minimum, a specific weak zone is recommended.

#### **Empirical Method for Curing Losses to Existing Openings:**

- For pretreatment applications, BaraShield-664 LCM must be applied to the entire volume of the active circulating fluid system. The concentration can be 40 ppb for general drilling operations through naturally fractured formations. An API 20 mesh screen (or coarser) is required to retain the majority portion of the BaraShield-664 LCM particulates in the active fluid system, while removing the larger drilled cuttings during circulation. If an interval is not too long (such as a few hundred feet), it may be possible to safely by-pass shale shakers while drilling the interval. This is particularly true when drilling with OBM/SBM drilling fluid or drilling non-reactive formations. Proper solids control equipment must be used in order to prevent any buildup of excess solids in the system. After drilling through the potential loss formations, the shale shakers can be brought back in line.
- For sweep pill applications (typically with BaraLock-666.F), a customary volume is 40-80 bbls. A general rule of thumb is to cover a minimum of 200 ft of open hole. The concentration of BaraShield-664 is typically 40 ppb and the BaraLock-666.F is 0.5 ppb in the pill fluid. Sweep pills are generally pumped at a normal drilling pump rate. When pumped at a normal drilling rate, the pill can pass regular BHAs with MWD, LWD etc.
- For squeeze pill applications, a customary volume is 60-120 bbl. Ideally, it needs to cover the entire open hole interval, but as a minimum, it needs to cover the problematic interval with a 100% excess volume. The concentration of BaraShield-664 is typically 80-100 ppb with BaraLock-666 LCM at the following concentrations (respective to the size of the supplemental material used).
  - BaraLock-666.F: 0.5 ppb
  - BaraLock-666.M: 0.25 ppb (Optional, based on the assessed fracture width or loss rate)
  - BaraLock-666.C: 0.20 ppb (Optional, based on the assessed fracture width or loss rate)

The volume of a pill mixed and pumped is many times controlled by factors other than the estimated need of what is required. It is safe to say that the initial application should be as large a volume with as high a concentration of material that is practical to mix and place on the specific drilling rig. The greatest unknown in many cases is the actual location of the loss zone. Larger volume pills have a higher probability of success when this is the case.

When pumped as a pill, the density of the BaraShield-664 LCM treatment is preferred to be the same as the fluid density in the hole. Since it is very likely that the pill is built with the fluid that is in the hole, the density of the pill should be close enough to the mud. BaraShield-664 LCM has a specific gravity of around 1.8 g/cm<sup>3</sup>. If needed, either base fluid or barite can be added to further adjust the density of the pill.

### 3. BaraShield-664 LCM General Mixing Procedure

- Using proper personal protective equipment (PPE), add BaraShield-664 LCM to the designated fluid into the mixing tank via the hopper; turn on all agitators.
- Add BaraShield-664 LCM through the hopper at a rate to distribute it throughout the entire treating volume.
- If BaraLock-666 LCM is being used:
  - Add BaraLock-666.F to the fluid directly through the hopper.
  - If the mixing jets are larger than the size of BaraLock-666.M or BaraLock-666.C, add BaraLock-666.M or BaraLock-666.C through the hopper. If the mixing jets are smaller than BaraLock-666.M or BaraLock-666.C, shut down the mixing pump to prevent plugging hopper jets. In this case, add BaraLock-666.M or BaraLock-666.C directly by dumping into the mixing tank. In this scenario, it is better to add these supplemental additives when the tank is not too full so that there is enough agitation for quick and uniform distribution of the BaraLock-666 throughout the fluid volume. Do NOT mix with any type of shear mixers.

### BaraShield-664 LCM Special Risk Assessment, When BaraLock-666 LCM is Added

S. No.	Risk/Opportunity Name	Event Description/Impact	Elimination of Risk
1	Plugging the Bottomhole Assembly (BHA), including bit nozzles	BaraLock-666 LCM may not pass through BHA at a low pump rate. Plugged BHA then must be pulled for cleaning out.	<p>When only BaraLock-666.F is added to the pill treatment, ensure that the nozzle sizes are at least 10/32" and the pump rate is higher than 2.5 BPM to pump the entire pill through the BHA.</p> <p>When BaraLock-666.M is also added to the pill treatment, ensure that the nozzle sizes are at least 13/32" and the pump rate is higher than 5 bpm to pump the entire pill through the BHA.</p> <p>When both BaraLock-666.M and BaraLock-666.C are added to the pill treatment, a drillpipe by-pass tool (such as a PBL-Sub or Well</p>



S. No.	Risk/Opportunity Name	Event Description/Impact	Elimination of Risk
			Commander – with ports of at least 1”) should be used to avoid plugging the BHA. The pump rate is at least 5 bpm. Otherwise, the pill should be pumped open-ended.
2	Plugging mud pump suction and discharge filter screens	There may be a coarse filter screen installed at the suction and discharge lines, resulting in an inability to deliver treatment slurry to or from fluid pumps.	If BaraLock-666.M or BaraLock-666.C is added to the pill treatment, the filter screens should be temporarily removed.
3	Plugging drillpipe screens	There may be a filter screen installed on drillpipe.	If BaraLock-666.M or BaraLock-666.C is added to the pill treatment, the filter screens should be temporarily removed.

#### 4. BaraShield-664 LCM Squeeze Pill Pumping Procedure (Moderate to Severe Loss)

The combination of BaraShield-664 and BaraLock-666 LCMs are designed for use in pill treatments, not background treatments. Although it may be applied via sweep, hesitation squeeze or pump-spot-soak operations, the preferred application technique is a hesitation squeeze in a pill of water based drilling fluid or non-aqueous drilling fluid.

Review Section “**BaraShield-664 LCM Special Risk Assessment When BaraLock-666 LCM is Added**” first.

- a. The lost circulation material pill should cover the entire potential lost circulation zone, if at all practical. To insure this is done, mix twice the open hole volume or, if that is not possible, mix twice the volume of the interval to be treated. Ideally, enough slurry should be available to cover all potential loss zones, as well as enough excess volume available for squeezing operations.
- b. Placement of the bit at the proper depth is critical, but many times must be done without precise knowledge of the loss zone location. Preferably, the bit will be located inside casing above the loss zone. For a long open hole interval, this may not be practical. For these cases, place the bottom of the drill pipe or bit to ensure that it is high enough above the loss zone so that the wellbore below the bit and above the top of the loss zone is large enough to contain the entire pill. To lower the probability of stuck pipe, you do not normally run the pipe into or below the loss zone. Close the annulus. Continuously pump the pill out of drillpipe at a rate of 5 bpm or above to avoid plugging the drillpipe and clear the drillpipe. The minimum pump rate can be further defined by reviewing “**BaraShield-664 LCM Special**

**Risk Assessment When BaraLock-666 LCM is Added**". Before beginning the hesitation squeeze, check the annulus. If no fluid can be seen, use the fill-up line and fill the hole.

- c. Once the LCM pill is out of the bit, continue to pump the slurry at 3~5 bpm (150~600 lpm) or above. This will direct the slurry downhole to the point of loss. If pumping pressure allows, pump 100% of the total LCM pill volume in to the treatment interval and continue to pump 10~15 bbl of the pill into formation (This is necessary to set some BaraLock-666 LCM into fractures, etc.). Shut down the pump for 10 min.
- d. Begin the hesitation squeeze by pumping at 0.25 – 0.50 bpm (40 – 80 lpm). When a pressure of 50 psi (3 bar) or 2 bbl has been pumped, discontinue pumping for 10 – 15 minutes. Repeat this procedure until 50 psi (3 bar) can be maintained, then attempt progressively higher pressures in 40 – 50 psi (2 – 3 bar) increments. With this hesitation squeeze method, there will be a pressure bleed off each time the pump is stopped. However, with each successive squeeze, the pressure should stabilize at a progressively higher level.
- e. If no pressure builds, then wait two hours – and repeat step "d" (above). If no pressure is measured, the treatment has not been successful and must be repeated with the same pill or a modified treatment selection. Experience in an area will generally dictate the exact path to follow, but this should be decided during the well planning stage.
- f. A 200 – 600 psi (15 – 40 bar) squeeze is generally considered to be very good but, if possible, it is recommended to squeeze to the equivalent mud weight (ECD) required to drill ahead in this interval or run casing and cement. When maximum holding pressure is obtained, **shut down for 4 hours**.
- g. Bleed the pressure from the annulus slowly, and then recirculate the remaining LCM pill out of the hole.
- h. Run the drill pipe back into the hole slowly, monitoring the weight indicator and checking for bridges. Wash to bottom, drilling any LCM plug – if encountered. Any remaining LCM will be removed at the shakers.

#### **Possible Failure Causes for BaraShield-664 LCM Squeeze Pills**

- *High pump rates to displace the entire pill into the formation at once:* After some BaraLock-666 LCM is pumped into fractures at a high rate, stopping the pumps is necessary to let the BaraLock-666 LCM to restore to the initial shape and size to form a seal.
- *Fractures are larger than the BaraLock-666 LCM:* In this case, a larger BaraLock-666 LCM may have to be added to the pill treatment.
- For induced fractures, fluid pumped into a fracture ahead of a BaraShield-664 LCM pill may inflate the fracture to a width wider than what the BaraShield-664 LCM can seal. Furthermore, in a wellbore breathing situation, in order to reduce the dilution effect from mud flowing back from a charged fracture during a squeeze process, a high concentration of 100~120 ppb is recommended.

#### **Limitations for BaraShield-664 LCM Squeeze Pills**

- BaraShield-664 LCM squeeze pills can only seal off loss flow-paths that are the same size or smaller than the selected BaraLock-666 LCM.
- Due to the quick fracture shut-off capability of the formed seal, BaraShield-664 LCM squeeze pills may not be able to hold a large pressure differential across a wide fracture.

When sealing can be achieved but its strength is not enough, it indicates that the high fluid loss squeeze pill, BaraBlend-665 LCM may be required which contains the same BaraLock-666 LCM.

## **5. Additional Notes**

- It is necessary to pump some pill into formations at a high rate; such as 3~5 bpm to set BaraLock-666 LCM into fractures, etc.
- Do not hurry to build squeeze pressure; patience and time are necessary to obtain a successful squeeze.
- Do not mix weighted slurry too far in advance of using it; all weighted fluids are subject to barite settling over time.
- Use a low pressure gauge to accurately measure squeeze pressure; if possible, rig-up equipment so that drill pipe and casing pressures can be monitored easily and precisely.
- No special equipment is needed to pump the slurries. The slurry can be mixed in a mud pit and pumped with rig pumps.
- Attempt to accurately determine the location of the loss zone, to increase the chances for obtaining a successful squeeze (temperature log and/or MWD). Sweep pill applications of BaraShield-664 LCM can help to locate the loss zone location.
- Always have a sufficient quantity of material on location for additional squeeze procedures.