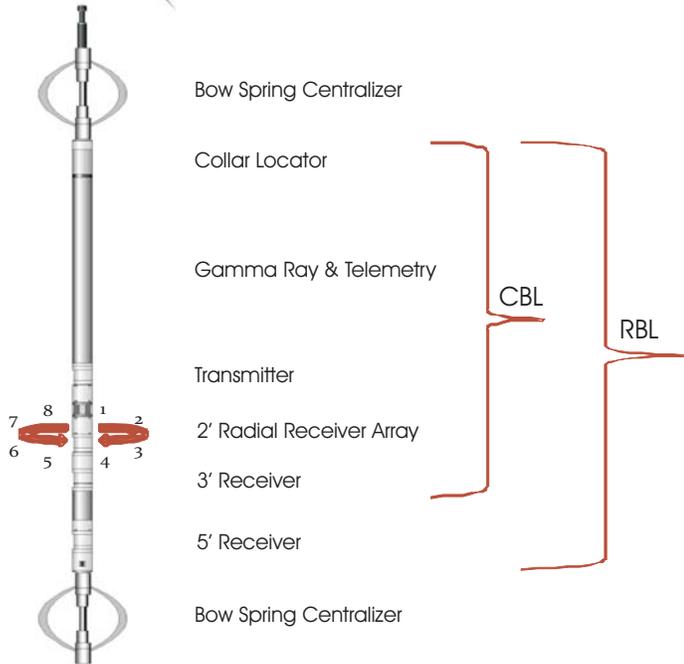




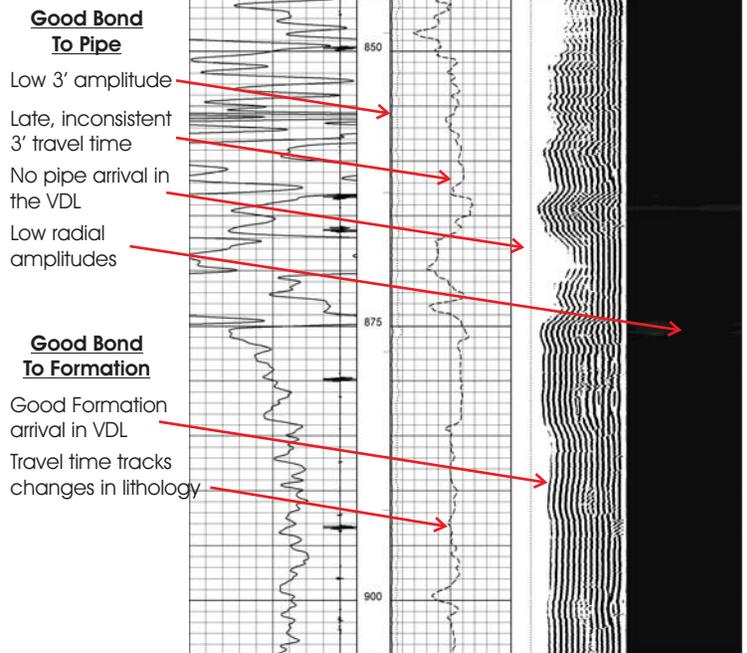
Cement Bond Log Quick Reference

Example Bond Tool



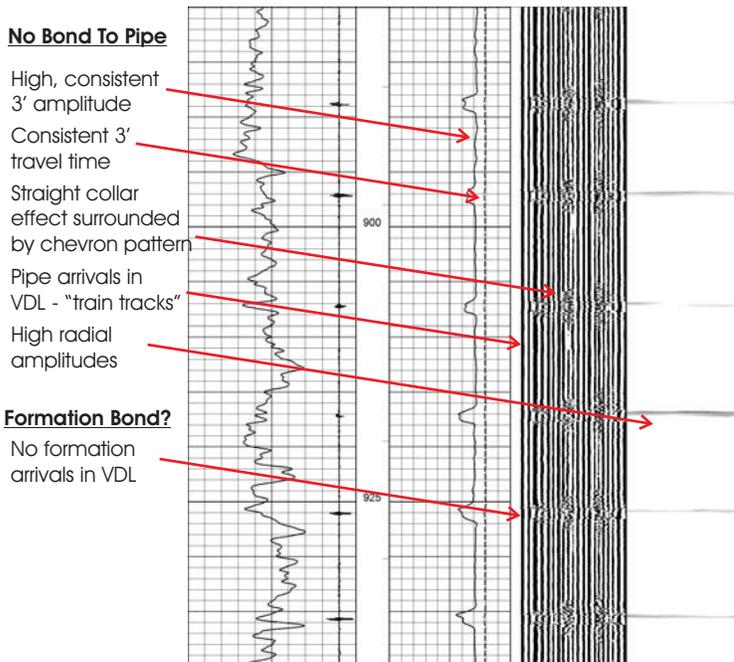
CBL - Cement Bond Log (GR-CCL, 3' & 5' receivers)
 RBL - Radial Bond Log (CBL + Array of 8 Radials)

Good Bond To Pipe & Formation



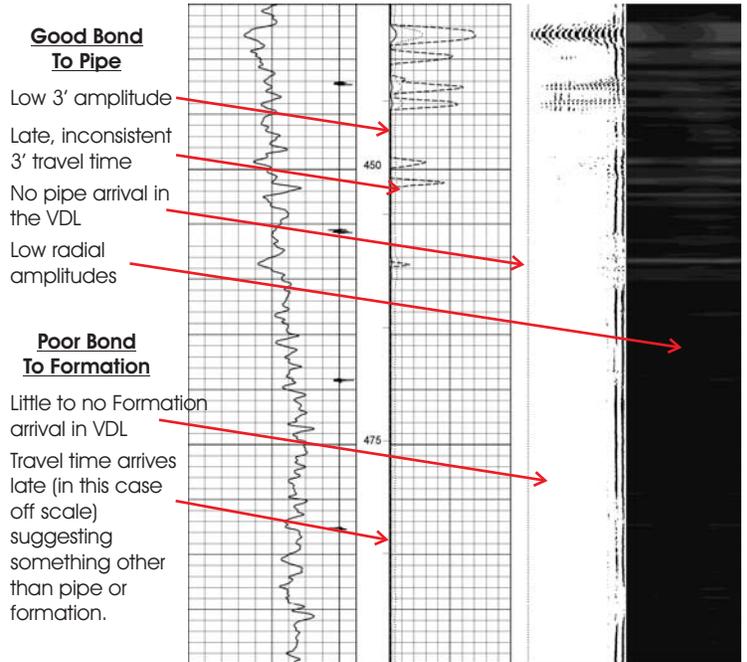
Good Bond To Pipe & Formation - Good bond to pipe is characterized by a low 3' amplitude, transit times of something other than pipe arrivals (which are consistent), lack of pipe arrival in the VDL and low 2' radial amplitudes (if RBL). Good bond to formation can be assumed if the VDL exhibits strong formation arrival suggesting good acoustic coupling between cement and the surrounding formation. Travel time will also track lithology.

Free Pipe



Free Pipe - No bond to pipe (free pipe) is characterized by a high, consistent 3' amplitude, consistent 3' travel time, high radial amplitudes, strong pipe arrivals (train tracks) and chevron patterns in VDL. No formation arrivals are present in the VDL as no cement is present to carry acoustic signal to formation and back to the receivers.

Good Bond to Pipe & Poor Bond to Formation



Good Bond To Pipe & Poor Bond to Formation - Good bond to pipe is characterized by a low 3' amplitude, transit times of something other than pipe arrivals (which are consistent), lack of pipe arrival in the VDL and low 2' radial amplitudes (if RBL). Poor bond to formation may be assumed if the VDL does not exhibit strong formation arrivals (may not be present at all). Must be aware if VDL is from 3' or 5' as mud may be confutes with formation.



Cement Bond Log Quick Reference

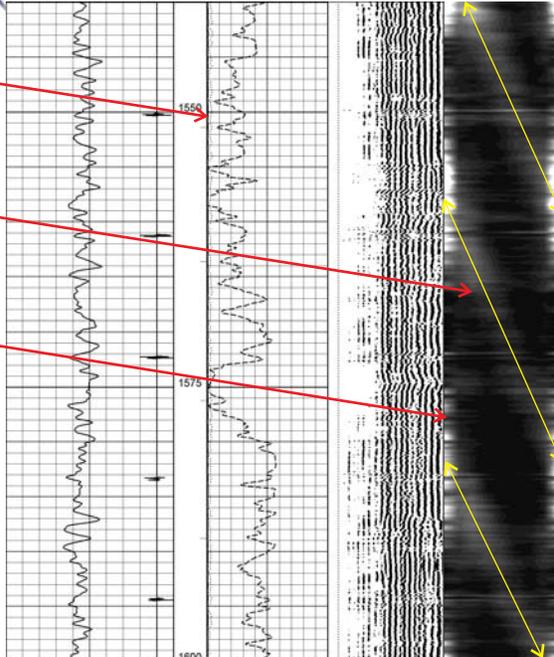
Channel

Channel

Channel may not be identified on 3' amplitude (average of 3' section).

Mapping of 2' radials identify channel.

Channel may appear as a spiral due to the tool spinning out of the hole.



Channel - a channel is a potential conduit for formation fluids from one zone to communicate with another, contaminate groundwater or allow for fluid/gas communication to surface in the form of surface casing vent flow or gas migration. Radial bond logging allows for the identification of channels not readily identified on basic cement bond logs.

Fast Formation

Fast Formation

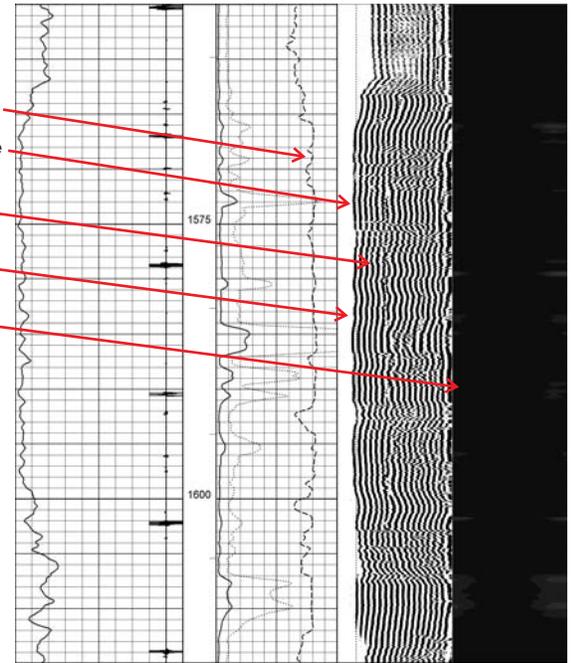
Earlier-than-pipe arrival time

Earlier arrival time on the VDL

Wavy VDL

No chevrons in VDL

Low radial amplitudes



Fast Formation - to get formation arrivals there must be good bond from cement to pipe and cement to formation. Thus, if there is fast formation arrival there is good bond on both sides of cement. The problem arises when the formation arrival appears like pipe arrival. Look for clean GR (hard rock - carbonates) earlier arrival times in VDL and travel time, wavy appearance in VDL and lack of chevrons in VDL. 3' amplitude may be high or low.

Light Weight Cement

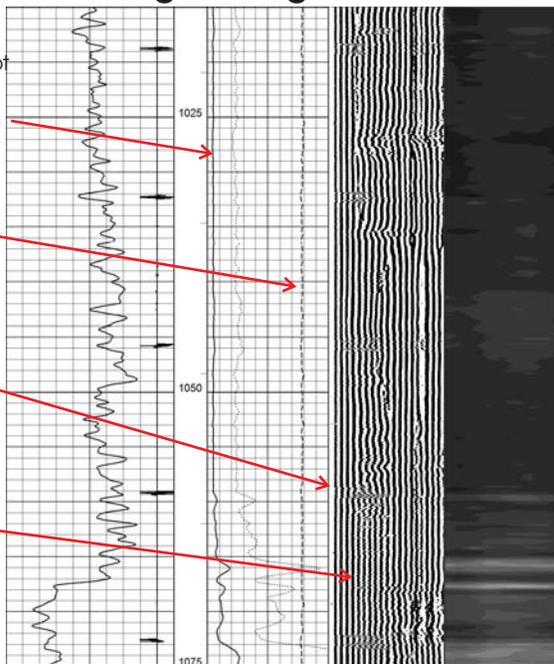
Light Weights

Amplitude may not reach 0 mV but will "flat-line" at a new 100% bond - up to +/- 10 mV.

First arrival in VDL and travel time will be pipe as signal not fully attenuated.

No chevrons present. Under good bond collars show straight-line collars patterns.

Formation arrivals may be weak or not present at all.



Light Weight Cement - VDL exhibits a "straight line" collar effect with no chevron patterns. First arrival in VDL and 3' Travel Time is pipe as cement does not fully attenuate signal. 3' amplitude may baseline up to 10 mV (new 100% bond). Formation arrival may be weak if present.

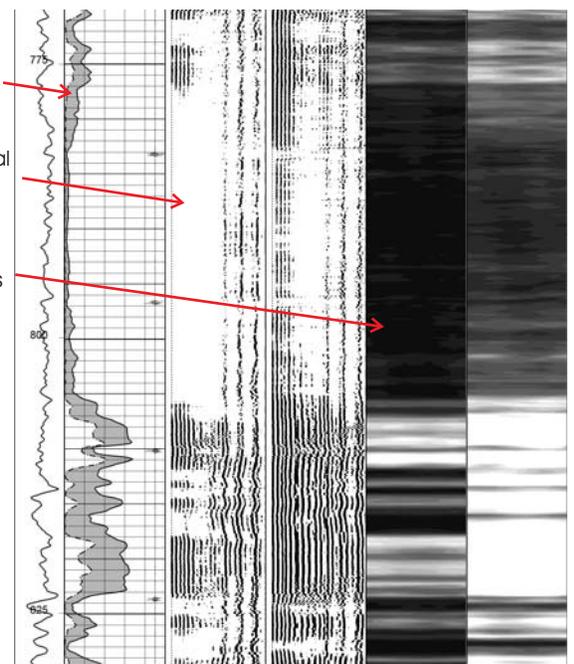
Microannulus

Microannulus

Reduction in 3' amplitude under pressure.

Loss of pipe arrival in VDL under pressure

Reduction in 2' radial amplitudes under pressure



Microannulus - Micro-separation of pipe from cement that reduces the cements ability to support the pipe in shear and thus allows for some pipe ring. To test for a microannulus, the pipe is logged under pressure to see a reduction in 3' amplitude, loss of pipe arrival in VDL and improved radials. The presence of a microannulus indicates cement present.