Perforating Shock Loads

I've perforated with several different BHA's on the tubing. The shock transmission from a 7" perforating gun loaded with big hole charges at 12 spf tubing right at the gun has been measured at an instantaneous (peak) inertia load of about 497,000 lb-ft2 (my memory of the result from 15 years ago) - BUT - the force lasted only about a millisecond, and dropped extremely quickly. We measured this at Baker Perforating in the mid 1980's during an investigation of whether to use shock absorbers between large TCP guns and the packer. The direction of the instantaneous force was not predictable, it could be either tension or compression. When it was in tension, we never saw damage. When the force was in compression, you could yield the tubing under the ideal conditions, producing corkscrewed (permanently deformed) tubing. The problem was related to the size of the explosive load in the gun and the proximity of the gun to the packer. It the packer was more than three joints of tubing from the gun, we rarely saw damage. I've seen corkscrewed tubing three times, a split gun and two stuck packers in 30 years of perforating, so damage is rare. If you are using large guns, with high density loading, and big hole charges, the potential problem is more severe than with small guns (<4") at 1 to 8 spf.

In any event, you can use a clamp-on rubber shock absorber and damp out most of the force from the gun or move the MWD tool back from the gun 4 or 5 joints and probably prevent damage. If you'll work the tubing through the zone a few times, you should release most of the stored torque and get the guns in the same alignment as the MWD. Use both distance from the gun and a clamp-on shock absorber if possible.

I've used Sperry Sun gauges, GR detectors and other devices over the gun - no damage. I believe Halliburton has a electronic gun positioner for avoiding the long string when perforating in tubingless completions - this may be a secondary possibility instead of the MWD tool.

George E. King

Regarding your comments on packers, with either underbalance or overbalance, I have found it has a lot to do with the actual packer
designs, and people do not have a good understanding of the changing
pressures and acceleration verus SHORT time periods to Dynamically rate
their equipment. If you ask a packer company if their Statically rated equipment, such as a packer rated to 5,000 psi will hold 20,000 psi for 5 milliseconds... We have strong evidence a lot of packers will hold, and data to prove it, but certainly this is not true for all products, and is a function of the individual tool's mechanical design; but the typical mechanical engineer will be extremely non-committal. This is generally due to the fact they have never studied the subject or measured dynamic wave events. Your company, and several others, now
have both the software and the pressure recorders (100,000 data points
per second, which will withstand 100,000 g's of shock load) to measure
the events and start dynamically rating equipment. I think the industry is going to slowly move towards requesting the service companies to provide dynamic ratings, as it is critical to various underbalance and overbalance designs. We can already predict the pressure versus fast time responses for the perforating and highly overbalanced or underbalanced events. Ed Vansickle in your company may be a good contact to access the technology to start acquiring data to begin dynamic rating. Without naming specific companies or products, I would comment that the abilities of some tools to handle dynamic events are a lot better than others, and this comes from data on several hundred propellant stimulations.
regards

Phil Snider, Marathon Oil

I completely disagree with Phil's comments. The vast majority of packers that are used with TCP are designed the same...that is double grip high pressure frac packers. Who would select anything different? The issues, as Andrew has illuminated stem from the reaction of the shock wave from the gun system and the reservoir and the other downhole equipment. Tight reservoirs tend to reflect the shock wave from gun detonation more than ones with large permeabilities. Read the literature and this is quite easily understood. Two waves are created by gun detonation, one moving upwards toward the packer and one downward to the bridge plug. When these two waves reflect off of both the packer and the bridge plug, they often cross in the tailpipe assembly or near the packer mandrel (depending on the relative distances). This creates a wave that is often many times greater than the original shock wave and easily crushes tailpipe and packer mandrels.

Phil is correct nonetheless that most mech engineers are non-committal on the issue of dynamic ratings. If any of these operating company engineers can predict the exact nature of the shock wave reflection phenomena we would be more than happy to come up with some dynamic performance ratings. In most cases the cost of such a science project is much greater than replacing a few crushed packers and washing over a few perf guns.

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