Blast Vibration Limits on Pipelines

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Limits on blast effects are properly imposed for many of our blasting projects, but there are instances where some of them really aren't appropriate. For example, it has become far too easy for specification writers to simply insert some arbitrary limit (usually 2 inches/second of peak particle velocity) into all manner of contracts where blast effects need to be controlled, sometimes totally ignoring the fact that, (1) the vibration from blasting may not be the potential damage-causing mechanism, and (2) that the inappropriate limit imposed could make the project economically unfeasible or in some cases impossible to accomplish.

A conservative limit on blast vibration is usually not appropriate for massive concrete structures, many steel structures, buried concrete vaults, buried pipelines, etc. These are usually highly resistant to damage from vibration and limiting it severely will serve no useful purpose. These structure types should be examined on a case by case basis before blast effect limits are established.

In other instances, it may not be practical to apply vibration limits to structures when the blasting is to be accomplished in very close proximity to them, even though the structure might be quite sensitive to blast vibration from more distant sources. The actual mechanism for damage would be ground rupture or rock block movement rather than vibration.

In 1994 I was contacted by a petroleum company in Texas and asked if I would be willing to help them on a pipeline looping contract in New Mexico. They were installing a new pipeline parallel to an existing one that ran from Amarillo to Albuquerque. The second line used the same right of way, being situated some 20 feet from the existing line. At intervals, the two lines were to have cross connections and associated valves. This allowed them to take portions of either line out of service for maintenance and, when no maintenance was being done, the use of two pipelines increased their total capacity.

The blasting specification on the pipeline had been adapted from the report done for the American Gas Association in 1981. (A copy of the AGA report resides in the Golden West Chapter library if you are interested in researching it.) The owner's on-site engineers were concerned about the potential for damaging the existing pipeline and wanted to tighten the specifications, while the blasting contractor was afraid that he couldn't adequately fracture the rock if he followed the existing specification. They had pretty much reached an impasse and I was requested to assist in resolving their differences.

The specifications allowed an "adjusted" (more on this later) 5 lbs per delay at 20 feet, gradually falling to 1 lb per delay at 10 feet. This was quite conservative for protecting a buried pipeline and would have been acceptable if the blasting could have been done with small diameter holes with tight spacing. The production schedule wouldn't allow such cautious blasting and the blaster wanted some relief. He had been involved with blasting for the Pacific Gas Transmission line near Alturas California and intuitively felt that he wouldn't damage the pipeline with higher charge weights.

The "adjusted" part of the specs meant that the weights would have to be adjusted to take into consideration energy release factors that favored using AN/FO over a cartridge explosive. This meant reducing the weight of a 60% rated dynamite to about 90% of the equivalent AN/FO weight. The different energy factors were included in the specifications. The fallacy with this thinking was that, while it was based on total energy release factors, it didn’t consider the way in which different explosives work. AN/FO may have a lower energy release, but usually accomplishes its work through higher gas generation. Higher gas generation means more backbreak. Not only would a cartridge product such as dynamite probably result in less backbreak, the amount loaded could be more easily controlled. It is almost always better to use a cartridge product in close-in, critical blasting situations. The blaster wanted to use cartridge explosives rather than AN/FO and didn't like the penalty that was being imposed upon him.

Fortunately, the owner's engineers knew something had to be done and were open to suggestions. I tried to avoid criticizing the AGA report excessively, although I explained that it was based upon flawed modeling and that the strains that the report predicted had never been reached in numerous field measurements that had been done since the study was published. I also expressed the aforementioned thoughts regarding energy release vs. using the correct product. I suggested that we do a series of test blasts starting with small charges and work up to larger ones. In all instances, all holes would be detonated on individual delays. After each blast, the zone between the blast and the existing buried pipe would be inspected carefully to determine how far the surface cracks extended toward the existing pipe. Vibration would continue to be recorded, but because of equipment range limitations, the seismographs were placed at a constant 40 feet beyond the pipe and the results extrapolated to the pipe's distance. (I anticipated vibration at the pipe's location to be somewhere in the range of 12 to 15 inches/second, possibly higher.) We established an arbitrary maximum distance for cracking and backbreak at 50% of the distance from the ditch center line to the pipe. Basically, we wanted to keep the edge of any crater zone (inelastic zone) from encroaching on the existing pipeline.

After the third test blast, charge weights were up to 10 lbs per delay, backbreak was still only about 1/3 of the distance to the existing pipe and everyone was satisfied that the work could be done safely and efficiently.

My recommendations were: (1) limit backbreak to a maximum of 50% of the distance to the pipe, (2) measure cracking and backbreak after every blast and adjust loading accordingly if it approached 50%, (3) continue to record vibration and compare vibration levels and backbreak to see if there was a correlation between the two, (4) conduct conservative test blasts again whenever the rock changed appreciably and, (5) use cautious test blasts and similar ground control limits if blasting were to be required at distances less than 10 feet. I also highly recommended the use of cartridge products, with no adjustment because of energy ratings.

I had a chance to talk with the same engineers a year later when I worked with them on another pipeline project near Roswell NM and they said the job had proceeded smoothly to completion. Apparently they had moved the location of some of the cross connections so that blasting up to the pipe was not required, thus eliminating one potential problem.

Another example of an incorrectly applied specification occurred about 8 years earlier at the Sweetwater water treatment facility expansion project east of San Diego. Due to the proximity of the adjacent dam at Sweetwater reservoir, all blasts had to be designed or approved by a blasting consultant. In addition to that capacity, I did the pre-blast surveys and vibration monitoring for the contractor. A vibration limit of 2 inches/second applied at the nearest structure for all blasts. The bench-type blasting for excavation of the sedimentation basin was relatively straight forward. Vibrations were low and the blasting crew was well qualified.

Prior to completion of the project, the contractor was asked to put in some additional drains and ditches that were not included in the original contract. These would be in very close proximity to (and twice occurred underneath) a 36 inch pipe carrying all the water for Chula Vista and National City. In one instance, a trench for a drain line had to be blasted within 2 feet of the corner of a brick storage building. The owner's intent was that the vibration limit of 2 inches/second would apply to this blasting as well. Although the owner's consulting engineer never did back away from his 2 inch limit, on-site personnel recognized that the blasting could not be done with such a limit and relented. The work proceeded successfully with no damage done to any of the structures or facilities. Decked charges were used and plenty of relief was provided so that breakage would be sure to occur in the direction intended. I estimated that the corner of the brick building probably experienced vibration levels exceeding 25 inches/second, yet it wasn't damaged. The frequency was very high and displacements were probably down to several ten-thousandths of an inch or less from the close-proximity blasts, one of which exposed a corner of the foundation. I was more worried when we were blasting 20 feet from the building. At that distance, the frequency was lower and displacements could be considerably higher (and the blasters might get complacent being farther from the building).

The added blasting on this project should have had a ground control specification rather than a vibration limit. In actual practice, that was what we did. Rather than concern ourselves with the vibration levels, we concentrated on designing blasts with reduced burdens that minimized back-break. We did monitor vibration from most of the blasts, but usually at a point which was a bit farther away than the protected object. (I wish at that time I would have had ready access to one of the more modern recording units and accelerometers in order to measure the close-in effects. The data collected would have made for interesting reading, considering the fact that no damage occurred.)

As an aside, there was one instance of damage during the extra work. A driller accidentally put a 3 inch hole in a pressurized pipe that was quite some distance from where the as-built plans said it should be. I'll never forget the look on his face when he struck a geyser.

When faced with these close-proximity blasting situations, it is always wise to conduct conservative test blasts to determine safe loading schemes. One should also make sure that there aren't other considerations such as sensitive equipment, fragile structures, etc. in the area that would indeed require a tight blast vibration limit.

Perhaps we will see the day when specification writers will carefully analyze where the potential for damage really lies and adopt limits accordingly, rather than choosing a conservative vibration limit that was intended to prevent minor cosmetic damage to a fragile, non-engineered structure. On several projects with which I'm familiar, design engineers took the easy way out and precluded any blasting at all. That certainly saved them from doing additional research and analysis, but weren't they doing their client a disservice by increasing his project's cost?