Article 220–Construction of Gravel Feed Pipes in Wells

Adopted by the CGA Board of Directors

BACKGROUND

The gravel feed pipe in a water well functions solely as a conduit for replenishing losses in the gravel pack filling the annular space between the casing/screen and the borehole wall. Such losses occur due to the pack's settling during well development and production. The pipe is normally a 2-4 inch conduit which extends vertically from above the surface of the well's sanitary seal, past the bottom of that seal and through any other annular seals, into the top of the gravel pack filling the annular space of the well.

Generally, the need for additional gravel occurs during and immediately after well development and much less frequently thereafter. During development, fine materials left over from drilling, or which are found in the immediate surrounding formation or in the gravel pack itself, are washed out of the pack and into the well through the well screen. The gravel pack above the screen continues to drop down to fill the spaces created by this loss of fines (and the replacement is then also subjected to this washing process as it reaches the space adjacent to the screen).

If well has no gravel feed pipe, or the pipe becomes plugged, it is possible that the top of the gravel pack will fall below the level of the first screen section. The screen will then be in direct contact with the surrounding formation, and the undesired result may be that the well will pump formation sand when placed in production. Therefore, the sole requirement in constructing the gravel fill pipe is that it provides unrestricted access to the gravel pack for make up feed from the surface.

DISCUSSION

Like the gravel pack in the annular space above the well screens, any great degree of cleaning and development of the gravel pack in the fillpipe is virtually impossible. Development requires water to move through the material at a certain minimum velocity, depending on the size of the particles to be removed. While such velocities may be achieved next to the screen sections through the typical 4 inch horizontal sections of gravelpack by pumping and other development methods, the same action is impossible through the many vertical feet found in the feed pipe and unscreened well sections.

But even if there were a means to achieve such development of the gravel in the fill pipe, it would serve no useful purpose to the construction and operation of the well. For while it is important that the gravel feed pipe not be plugged, it must be remembered that the pipe's sole function is to continue to deliver make-up gravel pack from the surface down into the annular space and then to the screen sections as needed (where it is then naturally cleaned by water entering the well through the screened areas). The gravel pack used in well construction is heavy and uncontaminated enough to work its way down the feed pipe into the annular space regardless of the degree of development (as discussed below).

Occasionally a specification or an individual well inspector will assert that a gravel feed pipe is not properly constructed unless it readily takes water (in some cases even after the pipe has been used to add make-up gravel). The reasoning is that if added water backs up in the pipe, it indicates there is a clog or restriction in the pipe. This is not true for the following reasons.

A) **Mechanical reasons a gravel feed pipe may not take water.**

The primary reason that a well can accommodate "make-up" gravel but not take water through the gravel feed pipe is a matter of hydraulics. It generally relates back to the ability to thin the drilling fluid prior to adding the gravel pack during construction.

Low viscosity drilling fluid is generally preferred so that well development time can be reduced. However, there are some circumstances where a highly viscous drilling fluid must be maintained. An insufficient volume of "make-up" feed water at the site, limitations on fluid disposal restricting thinning or poor borehole stability may dictate the use of a high viscosity fluid while the gravel pack is being introduced. A percentage of this fluid remains in the interstitial space (voids between grains of gravel) and then must be removed in the development process.

During development water from the formation directly around the screened intervals is flushed and purged at a high velocity through the gravel pack. This agitation forces the drilling fluids out of the interstitial space and jostles the grains of the gravel pack to "reorganize" into a more compact orientation. As the gravel pack compresses due to development it becomes necessary to add more gravel to the top of the pack via the gravel feed pipe.

As an example, the uppermost screen is approximately twenty feet below the gravel pack/sanitary seal contact so that cement from the seal does not migrate down and clog the screen. During well development a zone around the screens is cleared of drilling fluid and fine grained material. However, it is virtually impossible to flush the gravel pack adjacent to blank casing. The gravel feed pipe supplies gravel directly into this undeveloped location of the annulus.

The weight of the gravel in the feed pipe is more than sufficient to move down the annular space and replace the volume lost due to settling during development. However, water fed down the gravel feed pipe lacks sufficient hydraulic head to flow through the interstitial spaces (voids between gravel grains) because they are filled with a heavy, impermeable drilling fluid. The water cannot flow through or displace the fluid and therefore backs up in the pipe.

B) **Quantitative reasons a gravel feed pipe may not take water.**

Water should not necessarily be expected to move through even a gravel feed pipe. This can also be shown quantitatively. The permeability of the materials in a vertical conduit, such as the gravel feed pipe, even under ideal conditions is very slow. All water movement through a porous media is governed by Darcy's Law, an equation that considers the hydraulics involved with fluid flow.

Darcy's Law for vertical flow through gravel inside the feed pipe is as follows:

$Q = PIA$

Where:

Q = Vertical flow through pack in gallons per day (gpd)
I = Hydraulic gradient causing the vertical flow
A = The cross sectional area of the pipe
P = Coefficient of permeability of the porous material

Example:

- The hydraulic gradient is unity, or 1.
- Cross sectional area of a 3.5 inch diameter pipe is 0.068 ft^2
- Permeability of 6 X 12 gravel with drilling fluid in the interstitial spaces is 500 gpd/ft^2.

Therefore: Q = (500 * 1 * 0.068) = 34 gallons/day = 1.5 gallons/hour.

Darcy's Law proves that this is a very slow rate of water movement. A typical garden hose running at 3-5 gpm would fill the pipe and cause it to overflow quite quickly. By solving simple hydraulic flow equations, it is evident that a gravel feed pipe may not accept water due to the physical characteristics and parameters governed by its construction. But again, this does not affect its ultimate use, which is to supply gravel to the subsiding gravel pack.

In conclusion, the ability of the gravel feed pipe to take water also has no bearing on whether the well has been successfully completed and developed. Even if a gravel feed pipe takes water, this does not indicate that the gravel pack adjacent to the screened intervals is free and clear of heavier drilling fluid. If water does flow freely through the feed pipe, it need only find a flow route into the surrounding formation to exit the gravel pack. Therefore this movement has no bearing on development in the screened production areas of the well.

RECOMMENDATIONS

The CGA recommends the following practices with regard to the purpose of gravel feed pipes:

1) The sole purpose of the gravel feed pipe is to replenish the volume of gravel pack lost due to development and/or future production use.
2) Specifications or inspection requirements that the gravel feed pipe be able to take water are not relevant to proper construction techniques.
3) As long as the gravel feed pipe will take additional gravel, the well can be considered to have been constructed properly.

REFERENCES

Refer to Ground Water and Wells, 2nd Edition, 1986, Dr. Fletcher Driscoll, published by Johnson Division, St. Paul, MN, pages 443-446 for further detailed information about the "cleanness" of the upper portion of the gravel pack above the screens, the estimated low yield from this zone, vertical conductivity equations and calculations, and the ability of well development to clear this area of residual drilling fluid.

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