Article 219–Minimum Thickness of Seals within the Annular Space in Wells Having Gravel Fill Pipes

Adopted by the CGA Board of Directors on July 18, 1998

BACKGROUND

Wells must be constructed in a manner that prevents the introduction of pollutants from the surface down into the production aquifer. Poor quality aquifers are also sealed off to prevent the migration of contaminants from one aquifer to another.

In gravel packed wells, the seal is placed between the casing and the borehole wall, or if a conductor casing is used, between the conductor and the borehole wall. As a general rule, the thickness of the seal is a minimum of two inches or not less than three times the largest coarse aggregate in the sealing material.

In many wells, however, this annular space is penetrated by a gravel fill pipe tube. This tube is commonly three inches in diameter or more, and thus would entirely fill the sealed annular space unless allowance is made for the pipe in the course of constructing the well. Unfortunately, DWR Bulletins 74-81 and 74-90 as currently written provide conflicting guidelines in this particular area. Therefore, the purpose of this Standard is to highlight the conflict and present the groundwater industry's preferred method of construction.

DISCUSSION

History of Bulletin 74. Bulletin 74-81 originally addressed the problem of seal thickness in Chapter II, Part II (Well Construction), in Section 9.B.5.b. (Sealing Gravel Packed Wells without Conductor Casing):

> "An oversized hole at least 4 inches greater in diameter than the production casing, shall be drilled to the depth specified in Part A of this section and the annular space between the casing and the drilled hole filled with sealing material. If gravel fill pipes are installed through the seal, the annular seal shall be of sufficient thickness to assure a minimum of 2 inches between the gravel fill pipe and the wall of the drilled hole" (emphasis added).

The only other reference to the thickness of the seal is found in Section 9.E.:

> "Thickness of Seal. The thickness of the seal shall be at least a nominal 2 inches,2/ and not less than three times the size of the largest coarse aggregate used in the sealing material. (footnote 2/ adds 'In other words, the borehole shall be nominally 4 inches larger than the nominal casing diameter (thus creating a 2-inch annular space)')."

In January 1990, DWR issued the "Final Draft" version of an update to Bulletin 74 (subsequently called Bulletin 74-90). That draft did not change Section 9.B.5.b., but did modify section 9.E for greater clarity although eliminating the requirement that the minimum thickness be three times the aggregate size:

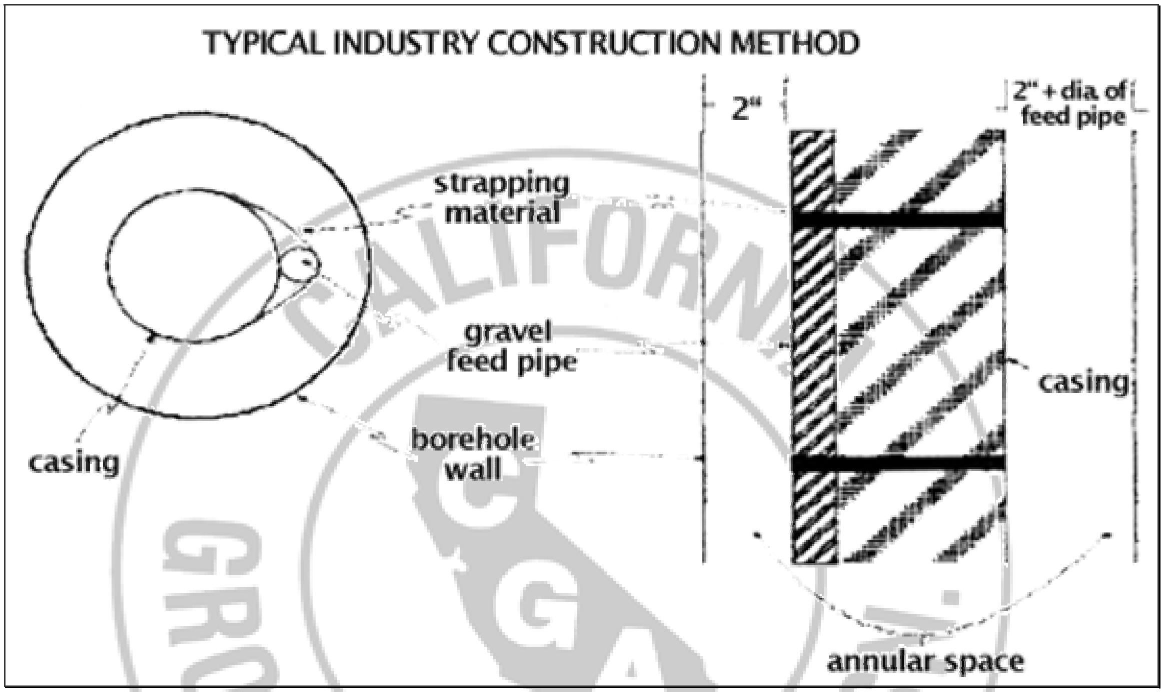
> "Thickness of Seal. The annular seal shall be a minimum of 2 inches in radial thickness. The borehole diameter shall thus be at least 4 inches larger than the outside diameter of the well casing." In June 1991, a new version of Bulletin 74-90 was published. The cover stated that this Bulletin is a supplement to Bulletin 74-81. It also deleted the term "draft," but a flier inside the cover stated "This Bulletin is temporarily considered a draft. The California Department of Water Resources plans to adopt this Bulletin as a final after a public review and comment period. The Department will announce in the future when this Bulletin is final."

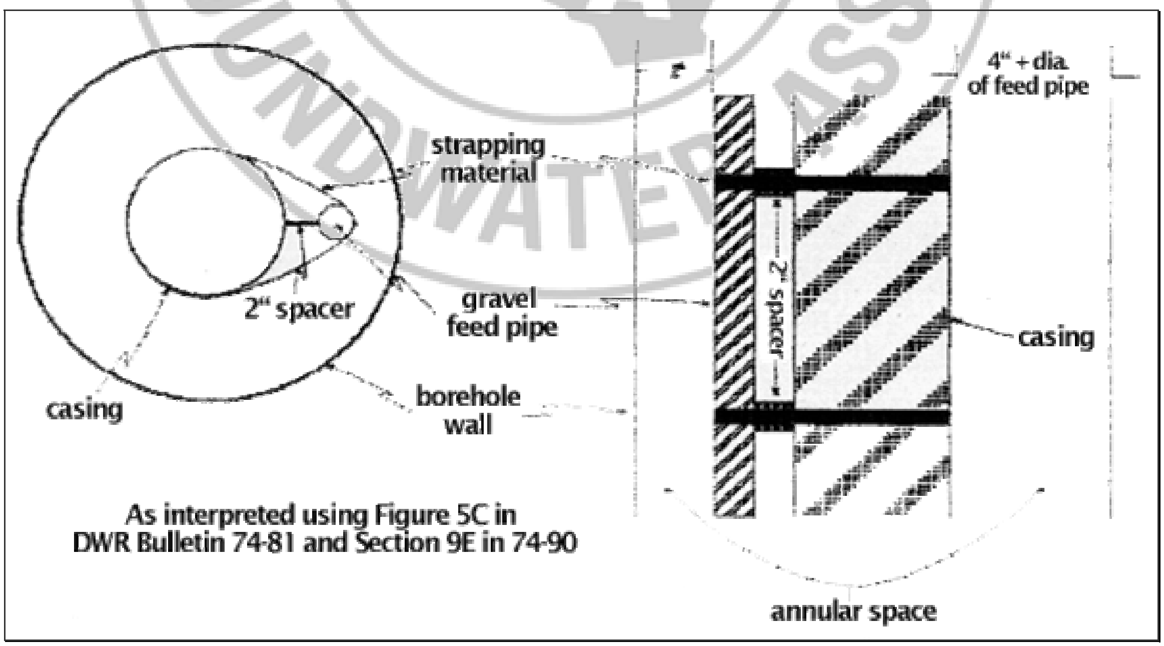
Unfortunately, the formal adoption never occurred, and Bulletin 74-90 remains in limbo. However, many agencies use both publications in making decisions about regulations and permits. The process becomes all the more unwieldy in that only portions of existing Bulletin 74-81 were actually replaced, and the two documents have never been integrated into one publication. Thus to determine a particular standard, the reader must first find the sections that apply in Bulletin 74-81, then consult Table 1 in Bulletin 74-90 to see if any of the sections have been replaced, and finally consult the applicable portion of Bulletin 74-90 to determine what has been added.

This has created considerable confusion in trying to interpret the operative standard. Sealing around gravel fill pipes is a good example. As now written, Bulletin 74-90 does not amend Section 9.B.5.b., meaning that the 2 inch minimum thickness between the borehole wall and the casing (or the borehole wall and the gravel fill pipe if one is used), remains in effect. However, Section 9.E., which in the initial draft of Bulletin 74-90 had previously been limited to setting the minimum thickness of the seal, was replaced by the following:

"A minimum of two inches of sealing material shall be maintained between all casings and the borehole wall, within the interval to be sealed…. A minimum of two inches of sealing material shall also be maintained between each casing, such as permanent conductor casing, well casing, gravel fill pipes, etc., in a borehole within the interval to be sealed, unless otherwise approved by the enforcing agency. Additional space shall be provided, where needed, for casings to be properly centralized and spaced and allow the use of a tremie pipe during well construction (if required), especially for deeper wells" (emphasis added).

Several interpretations have arisen regarding Section 9E. One interpretation is that there must be a 2 inch interval between the borehole and the pipe closest to the borehole but not a two inch interval between pipes. This is the typical industry construction method. The other interpretation is that Section 9E requires a 2 inch sealing interval between each pipe placed in the borehole. The following graphic shows the difference between these interpretations.





Construction Problems Caused by the Interpretation of 2-inch Interval Between All Pipes. While sections 9.B.5.b. and 9.E are not in direct conflict, they do present radically different well construction philosophies if Section 9E is interpreted to add an additional sealing thickness between the gravel fill pipe and both the borehole wall and the well casing. This interpretation presents very practical problems in both the construction and development of the well, and significant extra material costs, without adding any measurable benefit insofar as seal integrity.

Cost. Well boreholes are typically drilled to a single uniform diameter from top to bottom. This is important in getting the borehole thoroughly cleaned prior to casing. By using the same bit size for the final passes, all remaining cuttings and debris can be completely removed from the borehole.

Section 9.E, by requiring a centralized well casing and minimum 2 inches between all casings and other pipes, increases the ultimate diameter of the borehole necessary to accommodate the arrangement by a minimum of four inches (2 inches on each "side" of the casing). This more than doubles the volume of gravel pack and sealing material necessary for completing most common diameter wells.

Well Development. More importantly, the development of a gravel pack well is a function of the thickness of the gravel pack surrounding the screen.

> "The thickness of the filter pack has considerable effect on development efficiency. This happens for two reasons. First the filter pack reduces the amount of energy reaching the borehole wall. The thinner the filter pack, the easier it is to remove all of the undesirable fine sand, silt, and clay when developing the well. Second, a filter pack is so permeable that water may flow vertically in the filter pack envelope at places where the formation may be partially clogged, rather than move into or out of the natural formation." Fletcher G. Driscoll, Groundwater and Wells 2nd ed., page 502.

Groundwater and Wells 2nd ed. also notes that a properly graded gravel pack of only ½ inch successfully retains formation particles regardless of water entrance velocity. Due to the difficulty in achieving that uniformity, however, it therefore recommends the gravel pack be approximately 3 inches, and never more than 8 inches in thickness (p. 443).

The typical gravel fill pipe is 3 and occasionally 4-inch pipe (or 3.5 and 4.5 inch OD). When attached directly to the casing, the bit diameter is generally 12 inches larger than the nominal casing size (i.e. a 28-inch borehole for a 16-inch casing). Borehole walls are never uniform in diameter, as wall material sloughs off during the drilling of the well. This means that in the typical well construction, the filter pack thickness is already approaching the maximum size for effective well development.

Adding an additional 2 inches to this thickness to accommodate the extra spacing between the casing and the fill pipe means that the gravel pack thickness will equal or exceed the maximum recommended development width. Thus it can be anticipated that this method of construction will greatly decrease well efficiency due to incomplete development, and result in considerably higher pump wear and energy costs from higher pumping lifts and longer pumping cycles.

Other Problems. The final problem with a two-inch spacing construction technique is the difficulty in inserting the fill pipe itself. In normal construction, the fill pipe is strapped or welded to the casing, and thus is somewhat protected from damage by the casing itself.

To achieve the two-inch spacing however, requires that the pipe be attached to the casing by spacers or be inserted separately using its own centralizers. Either way, the pipe with spacers attached is relatively flimsy in comparison to the casing next to it, and the chances of damaging the fill pipe are greatly increased. This also complicates the insertion of the tremie pipe for the gravel pack and grout seal. Finally, the extra spacers and/or centralizers offer further opportunities for the gravel pack to hang up and bridge, particularly if it is not placed by tremie pipe.

Given all of these distinct possibilities of significant well degradation in providing the two-inch spacing between the casing and the fill pipe, one would expect that there would be a large return in terms of the quality and integrity of the seal achieved by using this method. But there isn't. There is not one technical guide that recommends a two-inch grout seal between the various pipes and casing in a well, and in fact the procedure has never been used in the groundwater industry.

RECOMMENDATIONS

The CGA recommends the following practices with regard to sealing around the gravel fill pipe:

1. That the gravel fill pipe (and any other utility pipes) in the well be attached directly to the well casing in construction to insure integrity of the pipe and enhance well development.
2. That the minimum two-inch thickness of the well seal be measured radially between the borehole wall and the nearest pipe or casing.
3. That the minimum thickness requirement be applied within the total depth of the surface sanitary seal as provided in Bulletin 74, or within any other zone where a seal is placed to prevent the migration of contaminants from one aquifer to another. No minimum spacing shall be required within other intervals of the annular space. Wherever a seal of a minimum thickness is required, the seal shall be placed from the bottom to the top of that interval in one continuous pour.

REFERENCES

Refer to Ground Water and Wells, 2nd Edition, 1986, Dr. Fletcher Driscoll, published by Johnson Division, St. Paul, MN, for further details on proper well construction and development techniques.

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