Article 400–Drift and Alignment Testing

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BACKGROUND

Many new well construction specifications contain standards of acceptability for drift (sometimes called plumbness) and alignment (or straightness) of the borehole. Typically, failure to meet these standards can result in rejection of the well at the Contractor's expense. While drift and alignment testing may appear as an abstract concept to be justified to insure proper installation and operation of the pumping equipment, in practice it suffers from a number of practical limitations. These include:

(1) The standards are not uniform, and some specifications seem to be written on the basis that if a published standard such as AWWA or EPA are acceptable, a much tighter standard will be even better.

(2) Often the standard is much more restrictive than required by pump manufacturers for acceptable operation of their equipment (some manufacturers, in fact, do not want their pumps in a perfectly straight well).

(3) The standards are sometimes found in wells for which they were never intended (such as hard rock and small diameter domestic wells).

(4) The potential range of errors in measuring drift and alignment are not considered in setting standards, yet in some instances may actually exceed the range of acceptable results (meaning a perfectly straight well may fail the test because of inherent measuring inaccuracies).

(5) The test is often extended to depths in the well beyond where the pump is intended to be placed.

(6) Frequently the specification will in fact be a drift (plumbness) standard only, when in fact alignment (expressed as a change in the rate of drift per successive casing sections) is the far more critical measurement.

(7) The most practical measure of alignment in a well is the ability to insert a dummy of the same approximate size as the intended pump, yet this test is rarely accepted by project engineers.

DISCUSSION

A. TERMS.

Drift or plumbness is the amount a given borehole deviates from true vertical. Alignment is the measure of straightness, or conversely the lack of excessive twists or doglegs. A well can be straight but not plumb, but a perfectly plumb well will always be straight. Alignment is the more important factor in a well, since a pump (particularly turbines) cannot be installed if the well is crooked beyond a certain amount. Lack of plumbness by itself does not affect pump installation and only at extremes may impact pump life and operation; therefore, insufficient plumbness (or excessive drift) is rarely a problem encountered in modern well construction.

B. STANDARDS.

The AWWA standard allows a drift deviation of two/thirds the well's inside diameter per one hundred feet of depth. The EPA standard is a deviation from plumbness of one degree per fifty feet of depth (Johnson, Groundwater and Wells 2d. page 333). It is not uncommon, however, to see requirements as tight as three inches per hundred feet in recent projects. Note that the problem with each of these standards is that a well which is sufficiently straight to accept the pump may fail the test. Conversely, a well can meet the drift standard yet still have a tight enough bend in the casing to prevent the installation of the pump.

C. MEASUREMENT.

1. While the oil well industry has developed sophisticated instrumentation to measure drift (such as wireless gyrocompasses and multishot recorders), these techniques are quite expensive and therefore rarely used in the groundwater industry to date. Discussions with manufacturers also suggest these instruments may have an unacceptable error rate (one-half to one degree) for use under current water well standards.

2. The standard test for drift in the well industry involves the use of a plummet which is one/quarter inch smaller than the inside of the well casing. The plummet is stretched by a cable from a fixed point exactly ten feet above the top of the casing. The cable guide is adjusted horizontally to center the plummet in the casing. The plummet is then lowered into the well, and the distance the wire has moved off center is measured every ten feet (generally two measurements are recorded, in north/south and

east/west axis). These measurements can then be converted to inches from vertical at each elevation by the formula: Drift = Wire deflection X Depth/10.

3. The common alignment test is the use of a forty foot dummy (or such other length that equals at least two casing sections) slightly smaller than the inside diameter of the casing. The dummy is run to the depth of the final pump setting to insure the pump can be freely placed and removed.

D. TESTING ERRORS.

The plummet test presumes five factors for precise measurements:

(1) The guide is suspended from an immovable point at all times during the test;

(2) the suspension point is ten feet above the casing measurement point and initially centered on the casing;

(3) the cable attached to the plummet remains absolutely straight and taut at descending depths;

(4) the cable deflection can be measured very precisely, and

(5) the attachment point of the cable on the plummet is always centered in the casing. In practice, however, these factors cannot be completely controlled. This results in an increasingly large range of errors in the drift calculations as depth increases (the fact that such errors do exist rather than being merely hypothetical can be demonstrated in the field. Any time successive tests are run on the same well, the runs will yield different results; the range is even greater where different equipment or operators are employed).

1. Probably the most overlooked error is the tendency of the measured (upper) end of the cable to bow back toward true vertical with increasing depth (imagine, for example, a plummet suspended from a 300 foot building to ground level and then being moved five feet from plumb; unless the plummet was very heavy in relationship to the wire, it is doubtful that any movement would be observed in the wire at a distance ten feet below the suspension point).

Any cable bowing will be seen by the observer above the well as a gradual movement of the cable back toward center as the plummet is lowered. This effect would be calculated as a lack of alignment (i.e. bowing back to true center) even in a perfectly straight but non-plumb well. This tendency is magnified once the plummet reaches water depth, since the plummet and attached wire weigh less when submerged (and are less able to pull the cable taut). For this reason alone a plummet test is probably of no value beyond a given depth, probably not much more than 300 feet.

2. Another error will be created by movement of the suspension point. The wire is normally fed over a winch, and if the winch itself is used as the sole alignment device, the induced errors can be quite large (if the suspension point were to move one half inch while running out forty feet of cable, the indicated drift would be almost two inches in a plumb well). Even if the cable is run through a fixed suspension point, the stand to which it is affixed must also be immovable or these errors will occur.

3. A similar apparent error will develop in a plumb hole if the plummet is not properly centered at the start of the test. Centering can be particularly difficult if the casing diameter is reduced above the planned pump depth or does not extend to the ground surface. With improper centering, the cable will appear to move farther away from center as depth increases, when in fact the cable is merely moving closer to the casing's true center. This movement, however, will be calculated as drift.

4. Offsets of the plummet attachment point (such as the aligning screws being caught in perforations), will also give false readings. However, since they happen at the plummet point rather than the measurement point, the errors should be no greater than the actual amount of the deflection, and are not important in the test results (in fact if the test were truly accurate these deflections of the plummet should be observed in the calculations).

5. Errors in measuring the wire offset at the top of the casing become increasingly critical at greater depths (and as anyone who has done the test can testify, it is very difficult to get the wire to hold still). For example, if the measuring error is as little as +/- one/sixteenth of an inch on a given axis, this can result in a calculated drift of 6 1/4 inches in consecutive measurements in a plumb well at 500 feet. Whatever the actual measurement error, it can be visualized as an inverted cone centered on a hypothetically plumb well; any measurement of this plumb well can fall anywhere within this cone, and at some depth the range of indicated drift from measurement error alone will exceed the drift standard (meaning even a perfect well could be found to be out of design alignment). Even before this depth, however, the impact of measurement error can easily be sufficient to move the calculated drift far enough from actual to cross beyond the project standard and cause an acceptable well to be rejected.

RECOMMENDATIONS

The California Groundwater Association recommends the following practices with regard to drift and alignment testing:

1. Regardless of the standard adopted for individual projects, no well will be constructed or tested to specifications that exceed their intended use.

2. Current drift standards are too restrictive, particularly in light of the inherent inaccuracies of measuring technology and statements from pump manufacturers that higher deviations from plumbness will not affect pump performance or longevity. Therefore drift standards which call for a borehole to be within a certain degree of plumbness should not be utilized in new well construction except in very special circumstances. Drift standards are never appropriate for wells under 8 inches in diameter.

3. Alignment testing should never be required in those situations where the contract includes the unimpaired installation of a test pump or permanent pump of sufficient size set at the planned maximum depth. Separate testing in such circumstances is simply an added expense to prove what will necessarily be determined by the actual installation process.

4. If no pump installation is included in the contract, alignment testing utilizing a maximum forty foot dummy (or other length equal to two casing sections) should be the sole criterion for determining whether a well is suitably straight, since it is the only reliable test to determine the capability to install a pump of proper size in the well. The dummy diameter shall not exceed pump or bowl diameter or 1 inch less than the I.D. of casing whichever is larger. Other types of tests should not be used for alignment verification since the potential range of error that can be associated with successive measurements creates a substantial likelihood of false readings (both pass and fail) in marginally straight wells.

5. Regardless of the standard adopted for individual projects, drift measurements employing the tripod/plummet technique should never be utilized beyond three hundred feet due to the increasingly large range of error associated with the method below that depth.

6. No drift or alignment testing of any kind should be required beyond the top of the highest screen section in the well, since this is maximum acceptable pump setting for that well and drift and alignment has no possible bearing on well performance below that point.

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