COLLAPSE CONSIDERATIONS

Selection of PVC Well Casing based on Hydraulic Collapse Considerations

PVC offers many familiar advantages to the well driller, including excellent corrosion resistance and ease of assembly. Unlike conventional PVC pipe, however, the primary loading on well casing is external pressure rather than internal pressure. Because of this distinction, it is vitally important for the contractor to understand the effect of external pressure on PVC casing, and to use this information in the casing selection process.

Collapse force alone can be created by various external pressures, acting alone or in combination, including:

- Hydraulic collapse, which can occur when the fluid outside the casing is higher or heavier than the inside fluid.
- Impact or unsymmetrical loading resulting in from improper placement of gravel pack.
- Sudden release of bridged gravel pack.
- Expanding clay or formation shifting.

Of these, only hydraulic collapse can be readily evaluated and predicted. The others, which are often influenced by construction practices, are best evaluated by experience and familiarity with the local geology.

The procedure for selecting PVC well casing based on Hydraulic Collapse Considerations is very straightforward and consists of the following steps:

1. Calculate external pressure, P_e at the bottom of the casing.
2. Calculate offsetting internal pressure, P_i at the bottom of the casing.
3. Calculation of SDR ration = OD / wall thickness.
4. Calculate $P_d = P_e - P_i$ to arrive at the net external collapsing pressure acting at the bottom of the casing.

Note: If cement grout is being used, RHCP value may have to be derated based on temperature effects. See section on Grouting PVC casing.

TABLE 1
RESISTANCE TO HYDRAULIC COLLAPSE PRESSURE (RHCP) OF PVC WELL CASING

SDR RATE PIPE				
STD SDR	RHCP	SIZES (INCHES)	RHCP	(PSI)
41	14	2	13.5	471
32.5	28	3	13.5	471
27.6	49	4	21	115
26	59	4.5	21	115
21	115	5	21	115
17	224	6	21	115
13.5	471	6.5	21	115
		7.5	21	115
		8	21	115
		10	21	115
		11	27	60

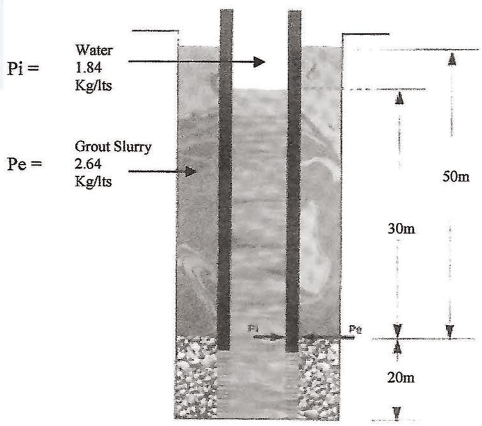
Notes:

- *For SDR rated casing, RHCP values apply to all sizes.*
- *Minimum RHCP values shown above regardless of joint type.*

Example: 8" Casing and screen in a 12" drilled hole

The following example will be used to illustrate this procedure. Emphasis here is on the solid casing, as hydraulic pressure will tend to equalize across the open screened section prior to backfill, and the slotted casing or screen will be virtually immune to collapse after the gravel pack has been properly placed. It is always a good idea to draw a profile of the well showing fluid heights and weights as an aid in calculating collapse pressures.

SDR 21 CASING TYPE 8"
RHCP = 115 psi



External Pressure: Pe = 50 * 2.64 * .052 = 68 psi
Internal Pressure: Pi = 30 * 1.84 * .052 = 38 psi
Pd = 68 – 38 = 40 psi Net

RCHP ON SDR 21 = 115/40
= 2:88

Factor of Safety: 2:1

Note: Our example of 2:88 is above the Safety Ratio of 2:1 therefore the casing selection is adequate under these conditions.

Cement grouting, as illustrated above, generally creates the highest collapsing pressures that the casing must withstand. However, collapse pressures must also be evaluated for any well which is constructed with an unconfined open annular space that will eventually fill with fluid, especially if this space is adjacent to the submersible pump. Submersible pump motors can become quite hot, particularly if the pump is allowed to run under zero flow/pump shut-off head conditions.

A reduction in collapse strength due to a hot motor in close proximity to the casing ID, in combination with hydraulic pressure directly outside the casing, can lead to premature failure. This problem of a pump getting stuck in a well due to motor – heat related collapse can generally be solved by simply using casing that is large enough for the pump and properly confining the casing to eliminate hydraulic pressure.

Collapse pressures also must be evaluated during well development, if this is performed to confinement. Collapse pressures during well development can result from:

1. Rapid injection of air, which can create excessive net collapsing pressure brought about by the reduction of the internal fluid level and density. The greater the rate of air injection into the casing, the greater the pressure differential. Therefore, care must be exercised in determining this rate.
2. Rapid removal of a bailer full of drilling mud, which reduces internal pressure through the suction effect.
3. Extreme drawdowns caused by over-pumping during some well development procedures.

So how low can you go?

It should be evident from the preceding discussion that there is no one recommendation for the maximum depth at which a particular size and class of PVC well casing can be used. It is possible to use thinner wall casing at significant depths as long as steps are taken to control collapsing pressures and heat. Conversely, thick wall casing may fail even at shallow depths if the designer does not place enough emphasis on hydraulic collapse considerations.

Basically, there is not substitute for an accurate collapse evaluation as part of the well design process.

GROUTING PVC CASING

One method used for filling the annulus between well casing and the borehole is to pour grout into the void, typically with a tremie pipe. When first installed, grout is a liquid slurry mixture that can create potentially excessive external hydraulic collapse pressures. However, when grout is cured or set to a semi-rigid state, the collapse pressure caused by the slurry is eliminated. Cured grout provides lateral support and holds the casing firmly in place, and also seals the borehole against water infiltration from the surface or from undesirable aquifers.

It is important to note that when portland cement based grouts cure, the hydration reaction produces heat that can be transferred to the casing.

The resultant temperature increase will reduce the collapse strength (RHCP) of PVC casing.

Temperature rise in cement-grouted wells are dependent upon three major factors:

1. Grout thickness: Temperatures increase with grout thickness. Particular care must therefore be exercised to avoid creating caverns in the formation during drilling which, when filled with cement slurry, could create excessive heat.
2. Fluid inside the casing: Water circulating inside the casing removes the heat of hydration most effectively. Standing water inside the casing would be the next most effective means of temperature control. An air-filled casing will result in the highest temperature increase for a given grout thickness.
3. Type of cement grout: For portland cements, only standard Type 1 is generally used with PVC, subject to the limitations discussed herein. Do not use concentrated quick-setting portland cement for wells cased with thermoplastic materials due to the excess heat that is released in a short period of time.

If calculations show that the hydraulic collapse factor of safety is falling below 2:1 or a modified target established by the engineer, the following corrective actions must be considered:

- Use a heavier wall casing with a higher RHCP
- Grout in stages
- Pressure grout through the inside of the casing instead of pouring grout into the annulus with a tremie pipe. Further details on this procedure can be obtained from the grout supplier. Note that while this operation virtually eliminates collapsing pressures at the bottom of the casing, a potentially high internal pressure is generally created at the top of the c casing, which must be compared to the pipe's short term pressure rating.
- Consider using a bentonite grout. Cement/bentonite mixtures may also be an option. The use of bentonite grout totally eliminates heat and significantly reduces slurry weight as compared to standard portland cements. When properly used, bentonite makes an excellent flexible grout and is generally recommended for PVC casing. However, the contractor is encouraged to consult with the bentonite supplier for any limitations on the use of this particular type of grout.

Please note:

As no two wells are the same, the information provided herein should be used by the drilling contractor and/or designer as reference material only. The designer and/or contractor has responsibility for the specification of casing and for installation procedures.

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