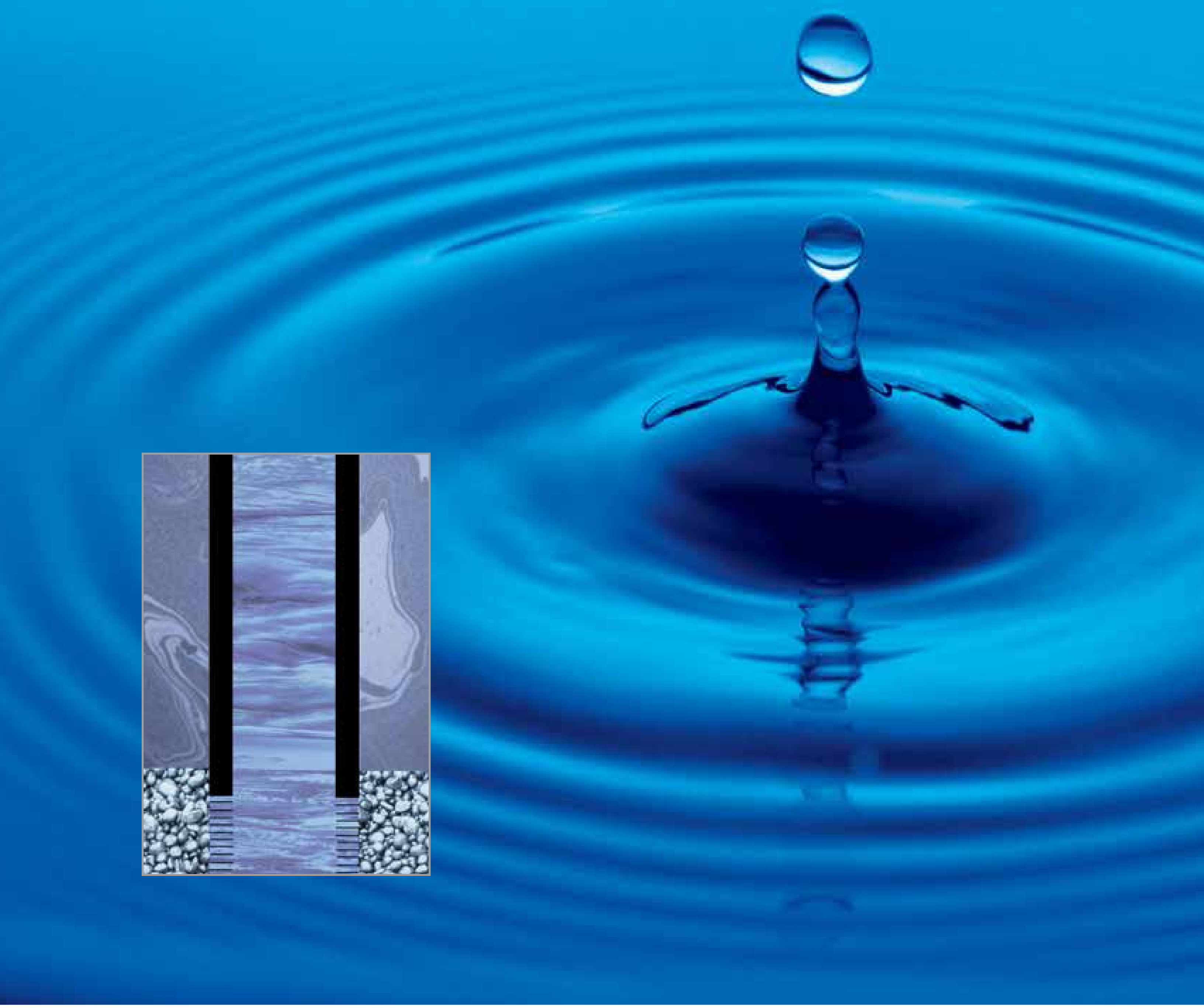
Selection of PVC Well Casing

Based on Hydraulic 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. However, unlike conventional PVC pipe, the primary loading on well casing is external pressure rather than internal pressure. Because of this distinction, understanding the effect of external pressure on PVC well casing is vitally important, as is use of this information in the well casing selection process.

Collapse force 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 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 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. Calculate $P_d = P_e - P_i$ to arrive at the net external collapsing pressure acting at the bottom of the casing.
4. Compare this value to the published Resistance to Hydraulic Collapse Pressure (RHCP) of the PVC casing (see Table 1). Casing must be selected so that its resistance to hydraulic collapse is greater than the applied net external pressure loading; a 2:1 factor of safety (F.S.) is generally recommended.

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

Table 1
Resistance to Hydraulic Collapse Pressure (RHCP) of PVC Well Casing

SDR Rated		Schedule Rated		
	RHCP		RHCP (PSI)	
SDR	(PSI)	SIZE	SCH 40	SCH 80
41	14	2"	291	877
32.5	29	3"	250	704
27.6	48	4"	152	459
26	58	4½"	130	
21	111	5"	103	329
17	215	6"	77	297
13.5	443	8"	52	205
		10"	39	176
		12"	32	163
		14"	30	160
		16"	30	152

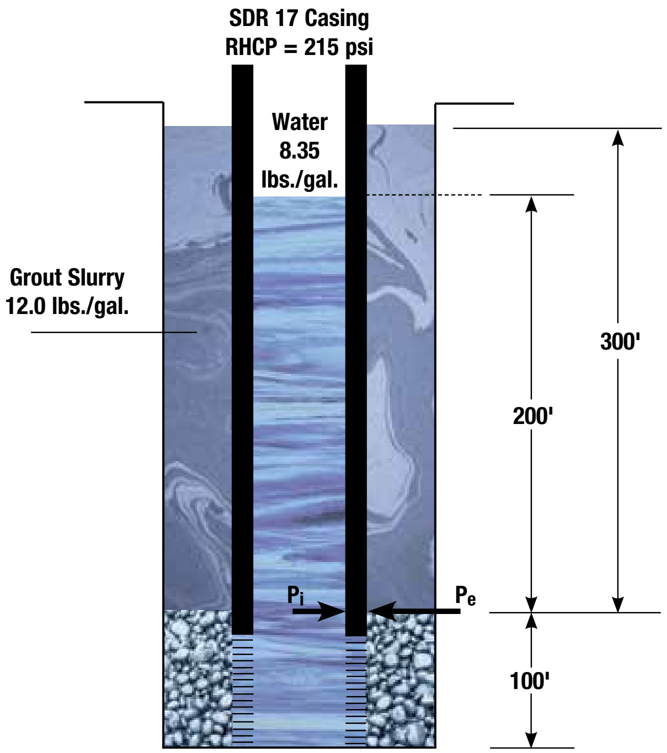
NOTES
- For SDR rated casing, RHCP values apply to all sizes.
- Minimum RHCP values shown above apply regardless of joint type (solvent weld or Certa-Lok®).
- RHCP values are predicted failure points; the engineer or contractor must apply a factor of safety to the design.
- Not all sizes and classes shown in the table may be commercially available. See North American Pipe Corporation well casing literature for standard product listing.
- Decrease in RHCP = 0.6 psi per ˚F increase in temperature over ambient.

In the above calculations:
- Pressure (psi) = H * W * .052
  where H = Height of fluid column (ft.)
  W= Weight of fluid (lbs./gallon)
    - Water = 8.35 lbs./gallon
    - Other fluids used in well construction, such as muds, drill cuttings and grouts, can range from 9 to 15 lbs./gallon or more.

Example

The following example will be used to illustrate this procedure. Emphasis here is on the solid casing, as hydraulic pressures will tend to equalize across the open screened section prior to backfill, and the slotted casing or screen should be virtually immune to collapse after the gravel pack has been properly placed. However, care must be taken when placing the gravel pack in order to avoid bridging or excessive settling that can create unpredictably high radial and/or tensile forces on the casing, screen, and joints.

It is always a good idea to draw a profile of the well showing fluid heights and densities as an aid in calculating collapse pressures.



External Pressure: $P_e = 300 * 12.0 * .052 = 187$ psi
Internal Pressure: $P_i = 200 * 8.35 * .052 = 87$ psi
$P_d = 100$ psi **Net External Collapsing Pressure**

Factor of Safety = 215/100 = 2.15

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 I.D., in combination with hydraulic pressure directly outside the casing, can lead to a 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 must also be evaluated during well development if this procedure is performed prior to confinement. Collapse pressures during well development can be caused by:

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 overpumping 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.

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 according to the following relationship:

Decrease in RHCP = 0.6 psi per ˚F increase in temperature over ambient.

Temperature rise in cement-grouted wells is 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. It is also good practice to utilize centralizers to keep the casing centered in the borehole, which will prevent excessive grout build-up on one side of the casing.

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. Circulating or standing water inside the casing serves a dual purpose, providing temperature control and an offsetting internal pressure.

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.

In our example, using a 20˚F temperature increase:

Decrease in RHCP =	0.6 * 20 = 12 psi
RHCP (SDR17) =	215 psi - 12 psi = 203 psi
F.S. =	203/100 = 2.03

In this example, the factor of safety is still above 2:1, even taking into account temperature effects.

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

- Use a heavier wall casing with a higher RHCP.

- Grout in stages (unless prohibited by local regulations).

- 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 casing, which must be compared to the pipe's short-term pressure rating.

- Use a bentonite grout. Cement/bentonite mixtures may also be an option. The use of bentonite grouts 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; in particular, the planned use of bentonite should be carefully evaluated to ensure that it will adequately shield the casing from any ground movements or forces, and not create any excessive long-term compressive loading on the casing due to its swelling properties.

NOTE: All applicable state or local regulations governing grouting materials and procedures take precedence over the recommendations presented herein.

IMPORTANT: 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. Need more information on protecting PVC well casing against collapse? Contact NAPCO technical support at the number shown below.

NAPCO
PIPE & FITTINGS

1.855.624.7473 | napcopipe.com

NAPCO
2801 Post Oak Blvd., Suite 600
Houston, TX 77056

 WW-BR-001-US-EN-0119.3