The Consultants Collection is a new monthly WWJ feature. In its pages you'll hear from a rotating group of professional hydrogeologists on their favorite subject-ground water-in a way that will interest both drillers and hydrogeologists.

Our collection includes Don Keech, chief of the ground water quality control section of the Michigan Department of Public Health; William Skinner, hydrologist with Dames and Moore; Tyler Gass, president of Bennett & Gass and Brad Caswell, water resources director for Wright Pierce Architects/Engineers.

We hope you'll enjoy reading and learning from our new monthly offering for you.

CONSULTANTS COLLECTION

Methane in Water Wells

by Donald K. Keech and Michael S. Gaber

Methane gas can occur naturally in water wells and when it does, it presents unique problems for water well drilling contractors. The major concern relates to flammable and explosive hazards associated with methane gas (see Figure 1). However, with the treatment discussed in this article, methane and other dissolved gases can be effectively removed from the water system.

Methane (CH_4) is the first member of the paraffin series of saturated hydrocarbons. Methane is a colorless, odorless gas and has an explosive limit between 5 to15 percent by volume in air. Since it is lighter than air it rises; in a fire, it will be at the ceiling. Methane stays in solution below 42^0F and evolves out of the water between 42 to 58^0F. Above 58^0F, methane is a gas and will not stay in solution. Methane is known as "fire damp" in the coal mining industry and presents an explosive hazard in underground mines. Methane can also be generated by the decomposition of carbonacious matter in swampy or marshy areas and is often called "marsh gas."

The gas that causes problems in water wells can occur in either bedrock or overburden wells. Methane is generated in source rock, then "stored" in a reservoir with some type of cap rock or impervious layer to contain the gas underground. In Michigan, these wells generally occur in areas underlain with Antrim or Coldwater shale formations of the late Devonian or early Mississippi period. These two shales are carbonacious in nature and serve as the source rock. Gas from these sources may contain methane or may be nearly all nitrogen. A high nitrogen content gas can cause problems in pump operations but it is not an explosive hazard.

Production type natural gas may also be occasionally encountered in water wells. This higher Btu gas may escape from an oil/gas well blowout or from a failure at an underground gas storage field.

Table 1 lists some characteristic analyses of dissolved gas from well water These analyses are all from wells in Michigan drilled no deeper than 120 feet and illustrates the variability in composition of dissolved gas that can be anticipated from a well with typical gas problems such as milky water, pulsations at the faucets or flammable conditions.

Sampling procedures

A simple qualitative test for methane can be done with the use of a plastic, narrow-mouthed milk carton and a book of matches. Use the following procedure:

1. Fill the gallon container up to the bottom of the narrow neck. Place hand over the mouth of the bottle. If methane is present, it will collect in the upper portion of the container.

Table 1
Gas Composition – Percent By Volume

Well Location	Methane	Ethane	Butane	Oxygen	Carbon Dioxide	Nitrogen	Hydrogen
Harrison Twp. - Macomb Co.	87.0	0.0	0.0	2.4	0.0	10.6	0.0
Pontiac Twp. - Oakland Co.	0.0	0.0	0.0	6.0	6.0	88.0	0.0
Wilson Twp. - Charlevoix Co.	30.1	0.0	0.0	11.3	0.1	57.8	0.3
Goodwell Twp. - Newaygo Co.	71.3	2.8	trace	trace	0.2	24.6	trace
Goodwell Twp. - Newaygo Co.	28.7	1.3	trace	2.5	0.7	66.8	trace
Whitewater Twp. - Grand Traverse Co.*	84.5	6.0	.6	trace	.23	4.69	

*Analysis also indicated traces of propane, isobutane, pentane, heptane and helium.

2. Bring a lighted match to the mouth of the bottle and quickly move hand away. The presence of methane will result in a brief wisp of blue or yellow flame.

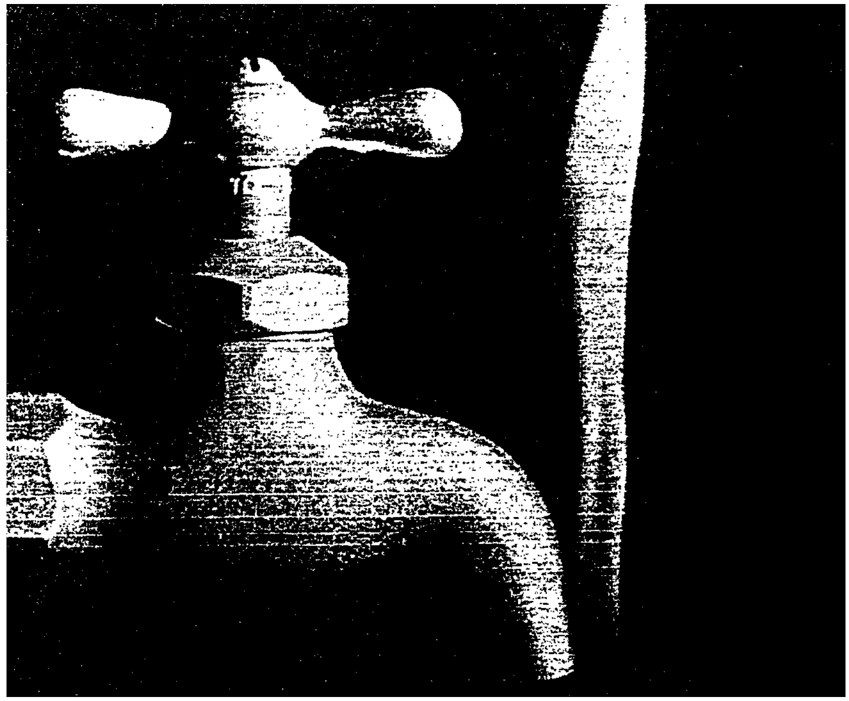
Note: It is important that a plastic container be used rather than glass because of possible breakage. This test should be performed outdoors and away from flammable materials.

The Michigan Department of Public Health uses the bubbler pail method for collecting gas samp-les from water supplies. The bubbler pail can be constructed easily from a small pail (see Figure 2). Water enters the pail through an inlet near the bottom of the pail and rises up through a standpipe. The pail is filled with water during the sample collection. A sample collection bottle is filled with water and inverted over the standpipe and gas will accumulate by displacing the water in the sample bottle.

By recording the flow rate, length of test and volume of gas collected, the percentage of gas-in-water can be determined. Labora-tory analysis of the gas is performed to determine composition and presence of methane or other combustible gases. Portable combustible gas meters can also be used for field determinations of methane levels. A percent meth-ane-in-water figure can then be established for the individual water supply. An example of calculations from a typical gas sample collection using the bubbler pail are as follows:

1. flow rate = 3 liters/minute
2. length of test = 5 minutes
3. total water volume sampled = 3 x 5 = 15 liters
4. gas volume collected = 750ml or 0.75 liters
5. percent gas in water = $\frac{0.75}{15}$ =0.05 = 5%
6. methane (CH_4) concentration in gas sample (determined by laboratory) = 30%
7. percent methane in water = 5% x 0.30 = 1.5%

The Michigan Department of Public Health, Occupational Health Division, considers less than 1 percent methane-in-water (by volume) as being safe from explosion hazards. If levels are above 1 percent, it is usually recommended that a methane removal system be installed on the water supply.



Gas in water-bearing formations is sometimes emitted directly from household faucets.

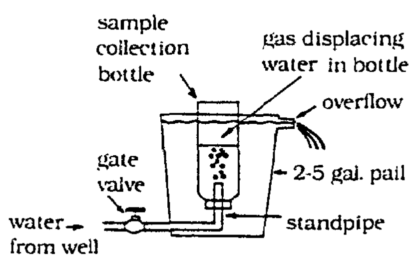


Figure2. Bubbler pail method for collectinggassamplesfrom water supplies

Well venting

Proper venting at the well head is essential. Methane gas is lighter than air and will exit through a vented well cap. The upward movement of water in the casing when the well is recovering after pumping will push the accumulated methane gas out the top of the well. If large amounts of combustible gases (methane, ethane, butane, etc.) are present, the well vent should terminate above a person's head level to avoid ignition of the gases by lawn mowers, barbeque grills, cigarettes, etc.

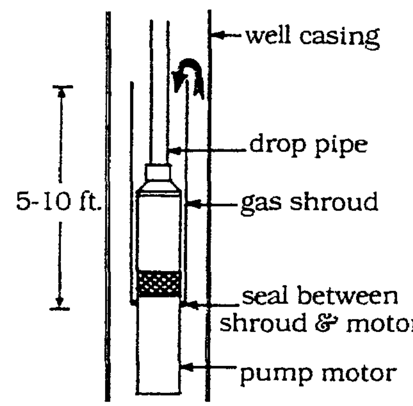


Figure 3. Details of gas shroud on submersible pump

Gas shrouds

One method which has been successful in several gaseous water wells involves the installation of a gas shroud on the submersible pump (see Figure 3). The shroud will usually eliminate substantial amounts of gas and help prevent air locking of the pump, which is a common problem in gas producing wells. In some cases, the installation of a shroud on the pump has reduced the gas levels enough so that further treatment was not necessary.

The shroud seals to the top of the submersible pump motor, below the intake, and extends 5 to 10 feet above the top of the pump. The water must then travel upward and over the top of the shroud and downward to the pump intake. The dissolved gases will have a tendency to continue upward rather than following the water to the intake, allowing gases to escape from the well vent.

If the casing is 5 inches or larger with a 4-inch submersible pump, a gas shroud can be easily fabricated from 4-inch thin wall plastic pipe. A few submersible pump manufacturers have shrouds available for 4-inch wells. A 3-inch submersible pump with a thin wall plastic shroud can also be used in a 4-inch well. It is important that a tight seal be made between the pump motor and the bottom of the shroud since leakage will cause gaseous water to enter the pump intake. The bottom of the shroud must seal at the top of the motor to allow for proper motor cooling. Drillers have sealed the shroud to the motor by wrapping tape around the shroud or by slitting the thinwall plastic near the bottom and clamping the shroud to the motor.

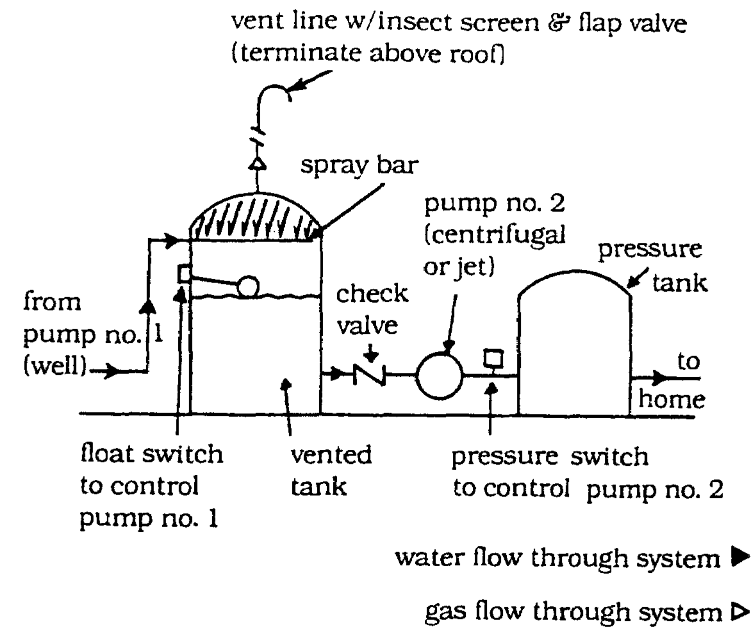


Figure4. Vented tank method for gas removal

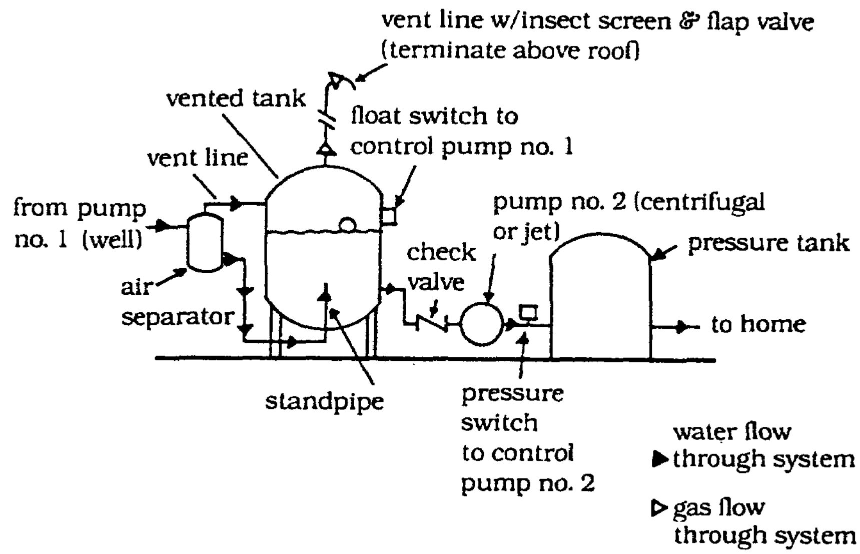


Figure 5. Air separator method for gas removal

Vented tank method

A gas removal system that has worked effectively on several installations in Michigan uses a vented storage tank with a spray bar mechanism (see Figure 4). The spray bar is a length of pipe with small holes drilled in it to disperse the water. Agricultural spray noz-zles may also be used for this purpose.

Water from the well is sprayed upward through the spray bar into the vented tank and gas is liberated and exits through a vent pipe at the top of the tank. A float switch is used in the vented tank to control the well pump. A shallow well jet or centrifugal pump is then used to pump water from the vented tank into a precharged pressure tank to provide pressure for the distribution system.

If methane or other combustible gases (e.g. ethane, butane, pentane, hexane) are present, the vent line which eliminates gas from the system should terminate above the roof line of the building. The vent should be screened and downturned to prevent insects and debris from entering. It is recommended that a flap-type check valve be installed on the vent line to allow the tank to vent to the outside only. This will minimize the intake of airborne bacteria, spores, pollen. etc., into the vent line. In addition, the check valve will place the tank under negative pressure when the second pump is operating, further increasing the liberation of gas from the water.

Water retention time in the vented tank is critical. The tank should be adequately sized to allow the water to remain in the tank for several minutes to optimize gas liberation. Also, the location of the tank inlet and outlet should prevent short circuiting of water flow through the tank.

Air release valve method

Another system involves the use of an air release valve on a galvanized storage tank. Gas is released from the air release valve when the liquid level is lowered to a predetermined point due to the accumulation of gas in the upper part of the tank. The vent line from the air release valve is terminated above the roof line of the building.

Since the tank remains pressurized, gas liberation does not occur as readily as in those systems using a vented tank. Several systems using air release valves tested by the Michigan Department of Public Health have not been effective in removing large amounts of gas.

Air separator method

In the summer of 1981, a newly constructed high school in northern Michigan was found to have more than 1 percent methane-in-water in its 6-inch, 165-foot, 150 gpm well. When the water supply was put into service, school personnel noted the effervescent, milky appearance of the water. One custodian reported that a flame shot across the room when he lit a match and opened a faucet simultaneously.

The Michigan Department of Public Health recommended that a methane removal system be installed. A local engineering firm designed a system utilizing a device called an air separator (see Figure 5). Air separators have been used for several years for removing air from hot water systems, but had never been used for removing gas from on-site water supplies. The system was installed in the fall of 1981.

The air separator is a cylindrical device with an inlet near the top, outlet near the bottom and air vent on top. Water flowing through the unit creates a centrifugal force which causes heavier, gas free water to move toward the outside. Lighter, gas-entrained water moves toward the center due to a low velocity vortex being created within the air separator. The gas rises and exits through a vent line into the top of a vented tank. A vent from the tank terminates about a foot above the roof line of the building.

Water from the air separator enters the bottom center of the vented tank through a smaller diameter standpipe. The smaller diameter of the standpipe lowers the pressure and increases water velocity and turbulence in the tank, which induces further gas-water separation.

A centrifugal pump is used to pump water from the vented tank into the school's pressure tanks. A float control on the vented tank controls the submersible pump in the well, and a standard pressure switch located downstream from the centrifugal pump controls the repumping operation.

The Michigan Department of Public Health evaluated the operation of the air separator methane removal system by collecting several gas samples from water before and after treatment. Raw water samples showed gas-in-water concentrations ranging from 7 to 9.8 percent and methane-in-water concentrations of 1.3 to 1.5 percent. Analyses of gas samples showed it to be 20 percent methane. Samples collected after treatment through the gas removal system showed a 95 percent decrease in gas and methane-in-water levels. The gas-in-water concentration fell to less than 1 percent and the methane-in-water concentration was less than one-tenth of 1 percent

Conclusion

Methane and other dissolved gases can be removed from water supplies; however, the additional equipment and space necessary may be prohibitive for small domestic systems. Whenever vented tanks are used, oxidation can cause turbidity problems in certain ground waters which may make further treatment necessary. Additional field research is needed in the area of methane removal so that low cost treatment methods can be developed.

Well drilling contractors, engineering firms or other regulatory agencies that have had experience with other methane removal systems are encouraged to share their experiences. Write to: Consultants Collection, c/o Water Well Journal, 500 W. Wilson Bridge Rd., Worthington, OH 43085.

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