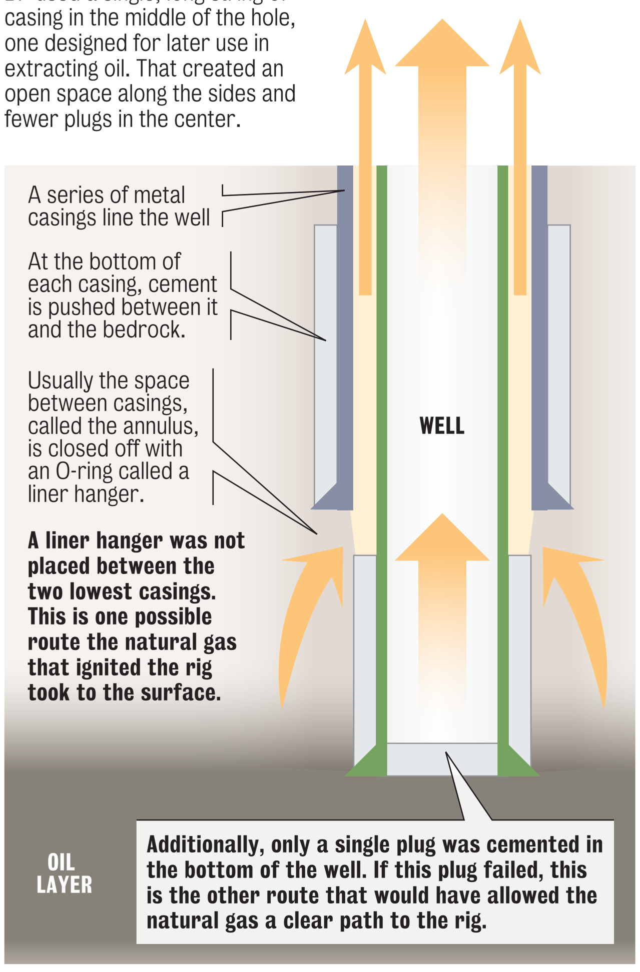
SIX STEPS THAT DOOMED THE RIG

The blowout of BP's Macondo oil well on April 20 was the result of a string of five human errors and one final, colossal mechanical failure, when the blowout preventer failed to close off the exploding well. The choices were made in the final hours before the exploratory well was to be completed and the Deepwater Horizon removed. BP engineers knew they had an especially tough well, but repeatedly made quicker, cheaper and ultimately more dangerous choices. They seemed to consider each danger in a vacuum, never thinking they could all add up to 11 dead rig workers, a sunken rig and millions of barrels of crude fouling the Gulf.

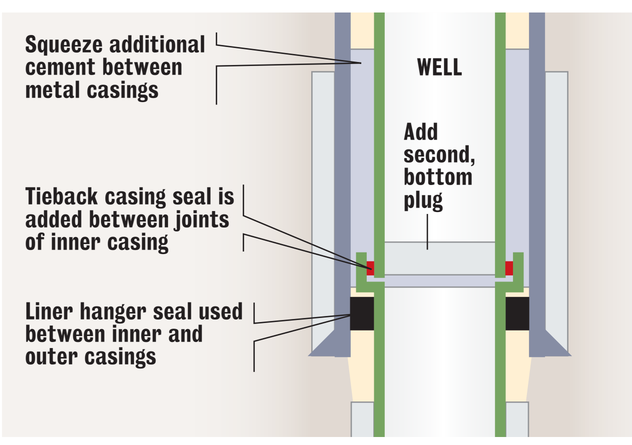
1 FEWER BARRIERS TO GAS FLOW

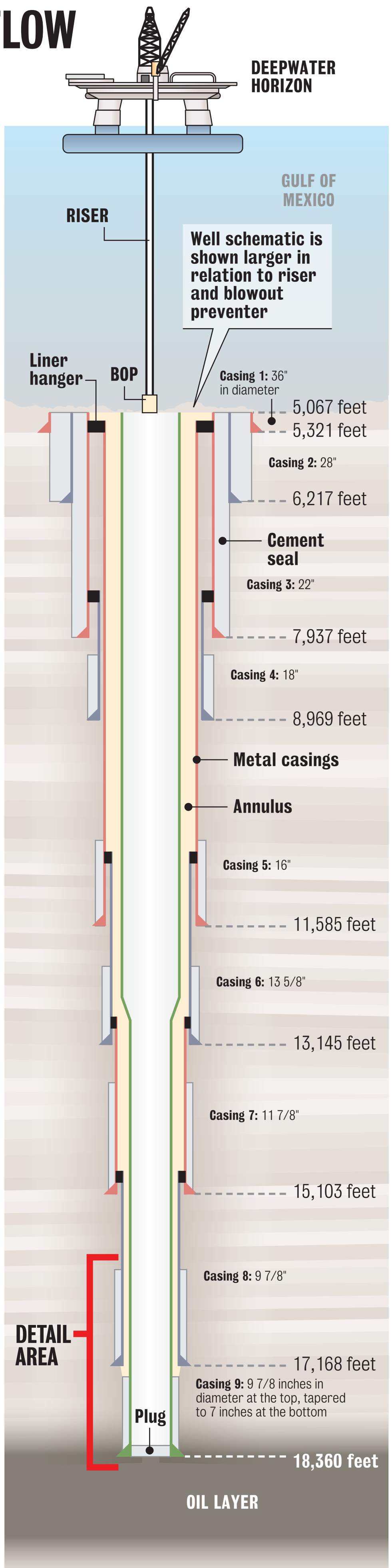
BP had two choices of how to line the well with metal tubes and cement seals. Its engineers considered using a typical industry practice of a short liner at the bottom, with additional seals. But they ultimately chose a method that saved the company up to $10 million.

THE BP METHOD:
BP used a single, long string of casing in the middle of the hole, one designed for later use in extracting oil. That created an open space along the sides and fewer plugs in the center.



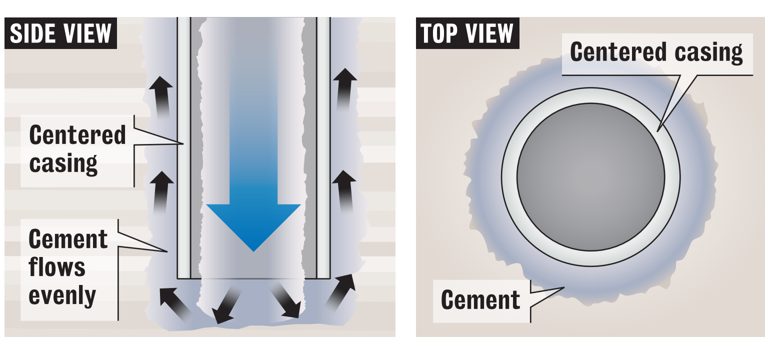
A BETTER WAY:
Common industry practice is to use a shorter tube called a "liner" at the bottom of the hole, then a separate tool called a tie-back. These would have created an additional barrier, as well as the addition of a second plug in the middle of the well, but it would have cost millions of dollars more and BP chose not to do it.





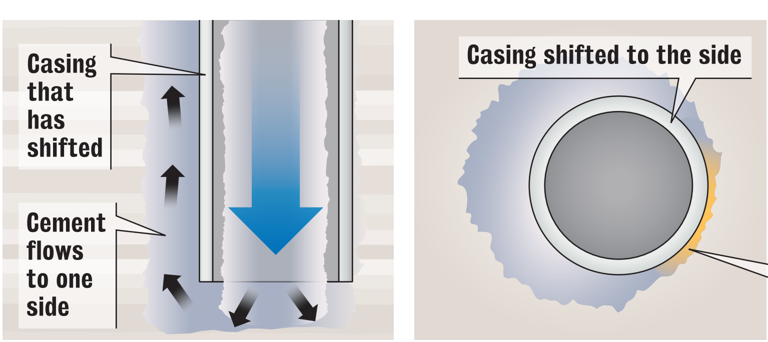
2 FEWER CENTRALIZERS TO KEEP CEMENT EVEN

BP chose to use six of the devices for keeping tubes centered, ignoring Halliburton models calling for 21. It's important to have the telescoping tubes centered in the hole because that's where cement is poured. If a tube is sitting to one side, the cement slurry will follow the path of least resistance and set unevenly, leaving weak points where gas could seep in.



THE RIGHT WAY:
Cement is pumped down the metal casings and is then forced up into the spaces between the outer casing and the sediment wall of the well.

If the casing is centered in the hole, the cement can harden around it completely and seal it to the surrounding earth.



THE WRONG WAY:
Problems arise during the cementing process if the casing has moved closer to one side of the well hole.

An uncentered casing prevents the cement from fully surrounding it. These gaps are potential pathways for oil and gas.

Poorly cemented area where gas can leak through

3 NO BOND LOG TO TEST CEMENT INTEGRITY

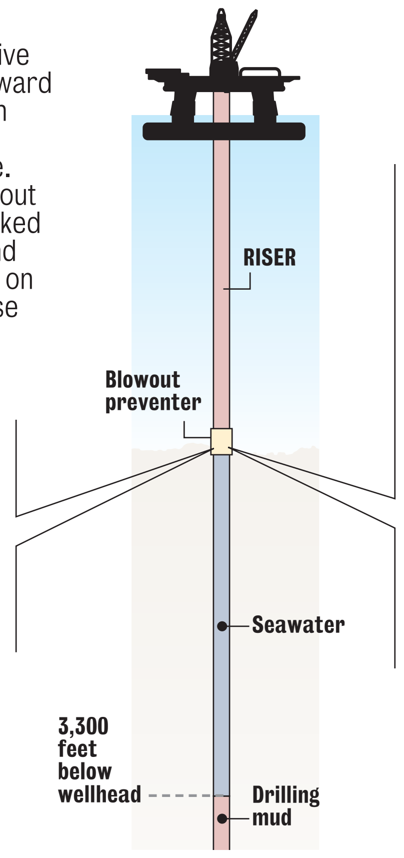
BP had hired contractor Schlumberger to run tests on the newly cemented well. But BP sent Schlumberger's crew home on a helicopter without having it run the test, called a cement bond log. It would have cost $100,000 more, taken time and required a month of remedial work if it found problems, like an uneven cement job, at a likely additional cost of $30 million.

Note: Drawings are schematic and not to scale.
Source: Times-Picayune investigation, Halliburton, BP e-mails, testimony

4 PRESSURE TEST MISINTERPRETED

Rig workers reported confusion over the negative test, which measures upward pressure from the shut-in well. It is a key test of whether the well is stable. Material used in the blowout preventer may have masked the test's true results, and heavy pressure readings on the drill pipe failed to raise red flags.

DOUBLE AMOUNT OF SPACER FLUID ADDED:
An extra dose of heavy fluid called spacer is pumped into the blowout preventer so BP won't have to pay to dispose of it. The higher density of the additional spacer may have obscured key test readings.

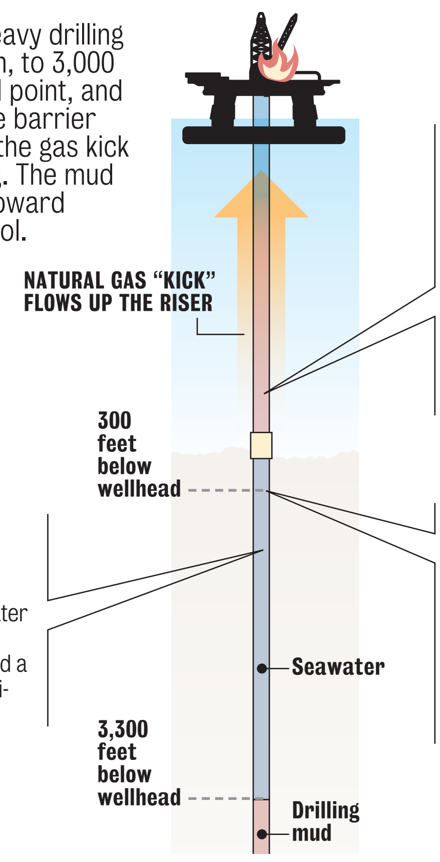


FIRST PRESSURE TEST:
A valve is closed on the blowout preventer to pressurize the drill pipe for testing. During the test 15 barrels of drilling mud leak from the valve. The mud was a sign that there was gas pressure in the well.

SECOND PRESSURE TEST:
Another test is run with more pressure on the blowout preventer valve. No mud escapes during the second test, which is deemed a success. But 1,400 pounds per square inch of pressure is recorded on the drill pipe when it should have been zero. That red flag was dismissed.

5 MUD BARRIER REMOVED EARLY

BP decided to take heavy drilling mud out of the system, to 3,000 feet below the normal point, and earlier than usual. The barrier wasn't there to stem the gas kick that destroyed the rig. The mud is used to keep any upward pressure under control.



SEAWATER BELOW BLOWOUT PREVENTER NOT HEAVY ENOUGH:
The larger amount of seawater left below the BOP from the pressure tests is not as good a barrier when the well experiences a natural gas "kick."

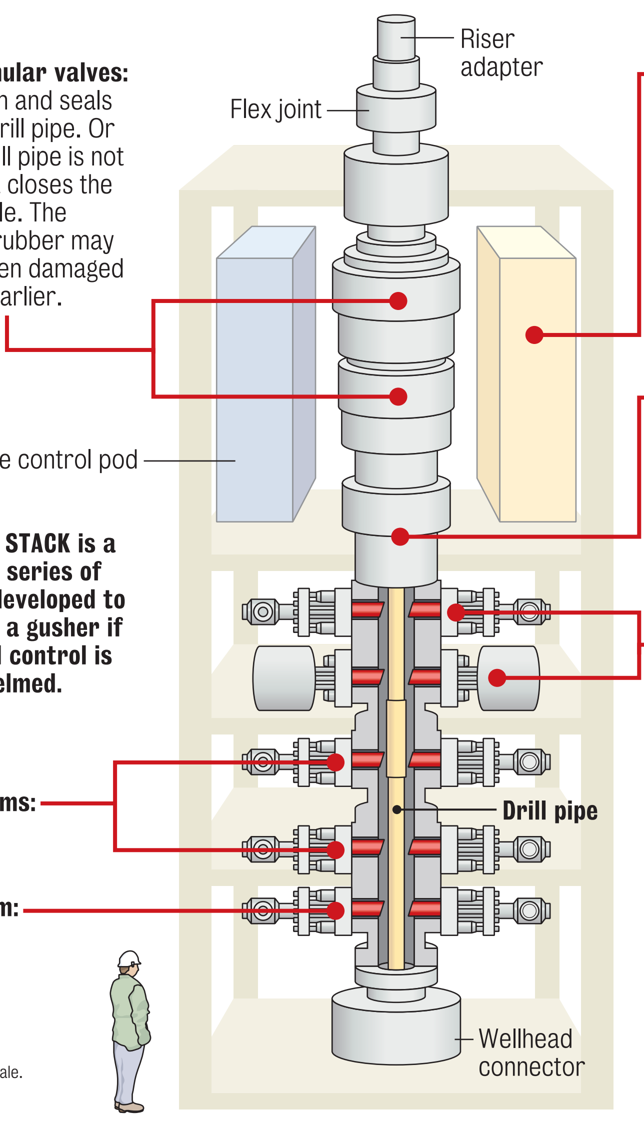
MUD IN THE RISER WAS BEING REPLACED WHEN RIG EXPLODED:
Lighter seawater was being put into the riser as the Deepwater Horizon was preparing to disconnect from the well. The pumping of the oil from the drilled well was to be handled by a production platform or pipeline.

BETTER WAY ESCHEWED:
BP engineers actually had a fallback plan to use the industry-standard 300 feet of seawater in the well, and to set a final top plug before removing mud from the riser. But federal regulators allowed them to use the quicker way.

6 BLOWOUT PREVENTER FAILED

It's unclear exactly why, but the last line of defense to close in the well never worked. A hydraulic leak could have been the culprit, or a plumbing issue, or debris could have fouled it up, or there may have been more pipes running through it than it was designed to cut.

Two annular valves: Closes in and seals on the drill pipe. Or if the drill pipe is not in use, it closes the open hole. The valves' rubber may have been damaged weeks earlier.



The BOP STACK is a 300-ton series of valves developed to prevent a gusher if the mud control is overwhelmed.

Blind rams:

Test ram:

Note: Man is shown for scale.

Yellow control pod: Recieves messages from rig to control blowout preventer valves and rams. Had a hydraulic leak and was placed in neutral to prevent fluid from leaking.

Lower marine riser package disconnect: Should have disconnected the rig from the blowout preventer after the accident, but it didn't work.

Shear rams: The final fail-safe, it is designed to close the well by cutting through and sealing the drill pipe. But they are not designed to cut two drill pipes or through joints where two pipe sections connect. The shear rams were unsuccessful.

EMMETT MAYER III / THE TIMES-PICAYUNE