TECHNICAL NOTE 600-11
OFFSHORE TECHNOLOGY
Part 1 – Exploration Drilling
December 14, 2009

1.0 There are two basic types of offshore operations, as shown in **Figure 1** on Page 4:

- Exploration – Drilling to locate oil and gas under the sea; this is a short-term activity, with a typical well taking 30 to 90 days to drill. After evaluation of the site has been completed, the drill rig caps the well and sails away.
- Production – Extraction of the oil and gas from beneath the sea floor and removing it to a place where it can be refined and distributed; this is a much longer-term activity, with large wells remaining in place for 20 years or more.

2.0 The syntactic foam products we make can be divided into two main categories:

- Flotation – Products, such as drilling riser modules, that provide buoyancy to support oilfield equipment; the largest use at present is in exploration drilling.
- Insulation – Products such as syntactic foam coatings on subsea flowlines that provide thermal insulation to keep the oil warm and free-flowing in production.

3.0 Syntactic foam buoyancy is normally required only on “floating” exploration drill rigs. “Fixed” drilling platforms such as *jackups* do not require buoyancy because they rest directly on the ocean floor. The two main types of “floating” rigs are shown in **Figure 2**.

- Drillship – A “ship-shaped” rig with a hull that resembles that of a freighter or oil tanker. The advantage of a drillship is that it can move quickly from one location to another; disadvantages include limited space and instability in heavy seas.
- Semisubmersible – A “multi-legged” vessel with the drill deck raised high above the surface of the water. “Semis” may be slow-moving rigs, but they are more stable than ships in bad weather and they offer roomier deck space.

4.0 The metal pipe that connects the rig to the ocean floor is called the *riser*. A typical joint of riser pipe is from 50 to 90 feet long, with 75 feet being the most common length. Joints are bolted together to form the riser *string* that reaches from the surface to the bottom. Most risers are made of steel, although aluminum risers have been used and composite (fiberglass) risers are being contemplated. Whatever the material, riser pipe is heavy, and the floating rig needs help in supporting the riser when drilling in very deep water. That is why syntactic foam drilling riser buoyancy modules have become an essential part of modern deepwater operations. See the diagram in **Figure 3**.

5.0 The large main tube of a typical steel riser is made of seamless or welded steel pipe. Wall thicknesses of 0.75” to 1.25” are common. 21.00” is now the most nearly standard outer diameter, but a wide range of sizes from 16.00” to 24.00” may be encountered. Centered inside the riser is the smaller diameter *drill pipe*, which actually turns the drill bit attached to its lower end. The dense drilling fluid called *mud* is injected down through the drill pipe at high pressure to keep the drill bit clean and carry the well cuttings back up through the riser main tube to the surface, where the mud is filtered and used again.

6.0 The ends of the main tube are welded to heavy steel forgings called *connectors*. There are two mating styles of connectors, one for the *pin* (male) end and one for the *box* (female} end. Connector flanges are bolted together to join the riser joints as they are stabbed on the drill deck and “run” downhole. The reason all drill rigs have derricks is so that tubulars, including risers, can be lifted up into the air one joint at a time for passage down through the rotary table en route to the well.

7.0 The function of the riser is to join the drill rig to the wellhead so that a tightly sealed connection is made, enabling the drilling mud to be retrieved and re-cycled. The weight or density of the mud can be varied so that the hydrostatic pressure inside the riser is always carefully balanced against pressures in the well. This prevents rupturing the oil-bearing strata inside the rock while guarding against a “kick,” or natural gas bubble, erupting up through the riser and possibly causing an explosion. Rigs have been lost at sea because of “blowouts” caused by unexpected gas kicks.

8.0 Arranged around the outside of the main riser tube are several other pipelines with specialized functions. Two *choke & kill lines* carry mud down to the wellhead for the purpose of controlling internal pressures. Heavier mud can be circulated in quickly if it becomes necessary to “choke” or “kill” the well. *Auxiliary lines* include hydraulic lines and booster lines. Hydraulic lines convey high pressure fluid to actuate the BOP (Blowout Preventer) stack, the complex tower of valves sitting atop the wellhead. Booster lines augment the flow of mud down into the well. Multiplex (MUX) cables serve the BOP electrical control system. This multitude of pipes and lines is attached to the riser by sturdy clamps that hold them in place as they are pressurized. See **Figure 4**.

9.0 When a riser manufacturer such as Cameron, Vetco, Shaffer, or Aker designs a riser, they often perform a computerized *dynamic analysis* to determine the optimal amount of buoyancy required for the string. The software takes into account the water depth, ocean currents, riser weight, and rig tensioner capacity to confirm that the overall system will work as desired. The main goal is to prevent excessive stress on the riser. The resulting amount of buoyancy, or “compensation,” is usually between 85% to 95% of the riser weight in sea water. Compensation of 100% or more is normally avoided because of the danger of the riser rising unexpectedly to the surface if broken.

10. Flotation uplift is provided to the riser by attaching a number, typically 3-5 pairs, of syntactic foam buoyancy modules. The modules fit closely around the riser pipe and its various lines and clamps. About 90% of the riser length is covered, leaving room at the upper end of the joint for *spider dogs* and room at the lower end for *makeup tools*. To make sure the modules do not slip up or down the riser, it is often necessary to supply *stop collars* at both ends. The buoyancy modules are painted with color-coded stripes to designate their service depth rating and are identified with unique serial numbers.

11. The principal industry standard governing the design and construction is API 16F. Paragraph 13.2.2.1 of the API (American Petroleum Institute) specification calls for riser buoyancy to be calculated as follows:

- Riser joint weight in air = 11.250 lbs.
- Riser joint weight in sea water = 0.87 x 11,250 = 9,788 lbs. (steel riser)
- Desired buoyant lift = 95% of riser weight in water
- Net lift per joint = 0.95 x 9,788 = 9,298 lbs.
- Buoyancy per module = 9,298 / 6 = 1,550 lbs each (assuming 3 pairs per joint)

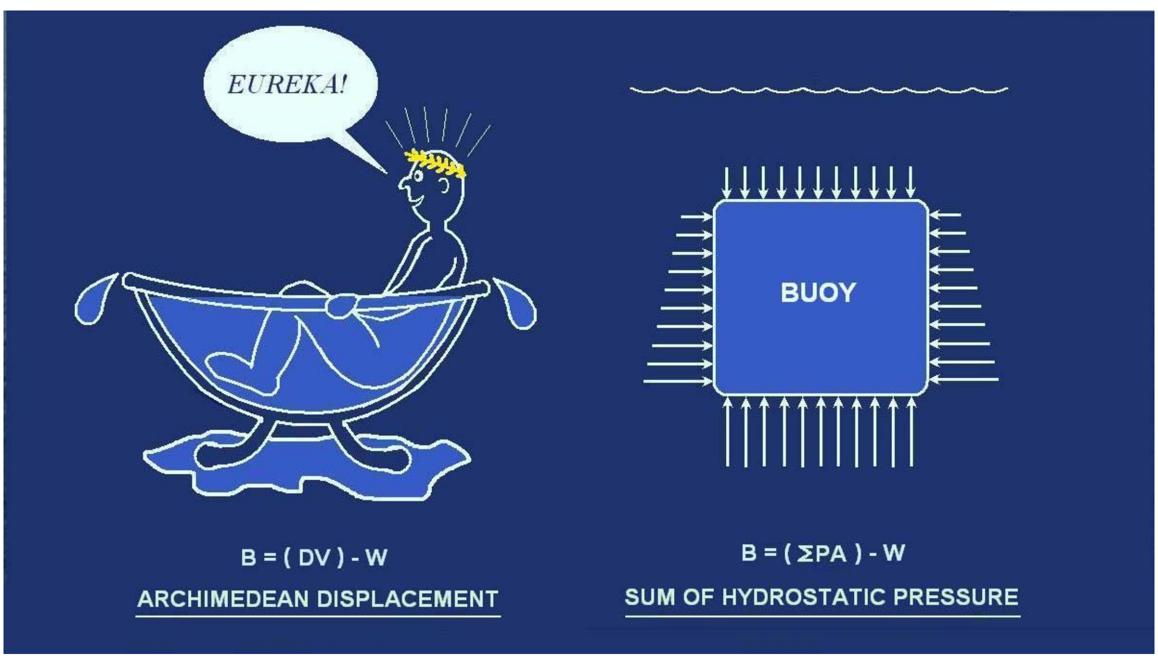
12. The 0.87 term used above in calculating riser joint weight is sea water is unique to steel, and is derived as follows:

- Weight of steel in air = 490 lbs per cu. ft
- Weight of sea water = 64 lbs per cu. ft
- Therefore, weight of steel in sea water = (490-64) = 426 lbs per cu. ft = 0.87

If the riser were made of another material, aluminum for example, the calculation would be different. Aluminum weighs 168 lbs per cu. ft, so the conversion factor is 0.62.

13. The above calculations illustrate the key principle of buoyancy: upward lift is created whenever an object is immersed in water. The <u>gross</u> amount of lift (or displacement) is equal to the volume of the object times the density of water. The <u>net</u> amount of lift is equal to the displacement less the weight of the object. The relationships are shown in the following example and in the diagram below:

- Buoy volume = 40.0 cubic ft
- Buoy density = 25.25 lbs per cu. ft
- Buoy weight in air = 40 x 25.25 = 1,010 lbs
- Weight of sea water displaced = 40 x 64 = 2,560 lbs
- Net lift or buoyancy = (2,560-1,010) = 1,550 lbs
- Net lift can also be calculated by [40 x (64-25.25)] = 1,550 lbs
- Sea water weighs 64 pcf, whereas fresh water weighs 62.4 pcf.
- A more thorough explanation of buoyancy, weight, density, and volume is given in Cuming Corporation Technical Note 100-3.
- An informal history of the offshore oil business and the early days of exploration drilling can be found in *Roughneckin'* by Robert F. Bauer, former president of Global Marine Inc.



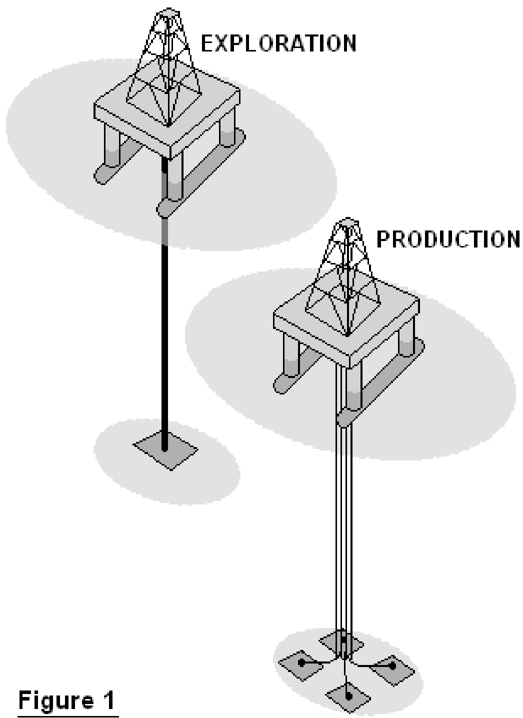


Figure 1

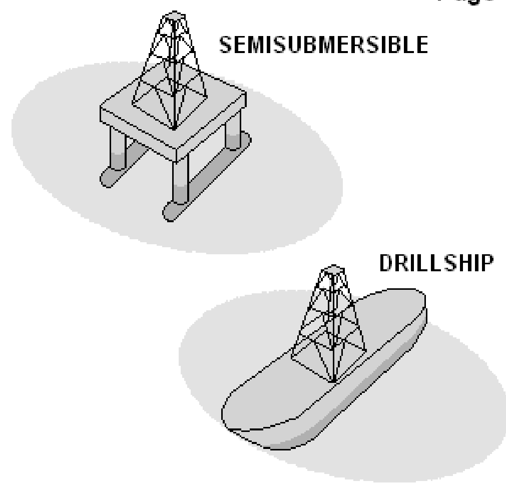


Figure 2

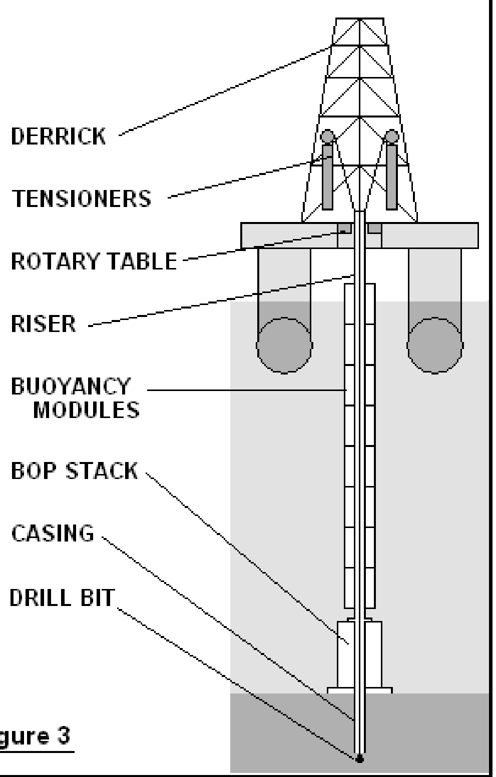


Figure 3

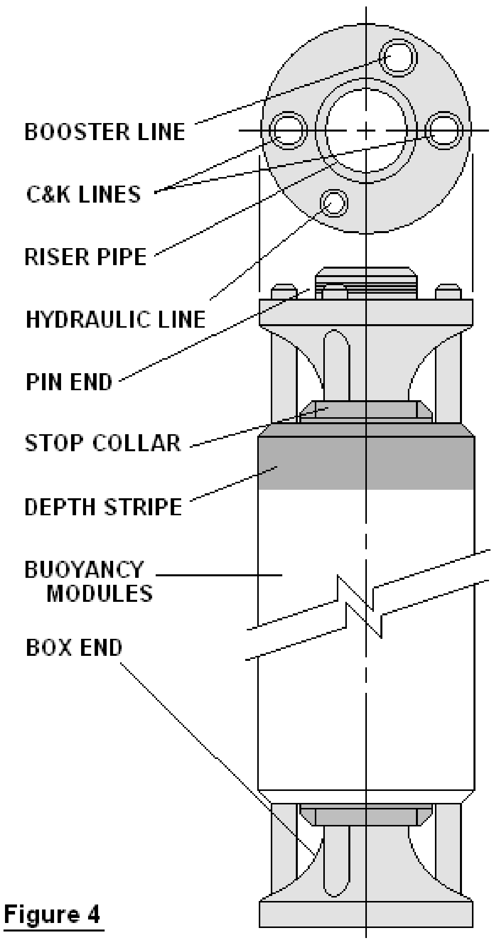


Figure 4