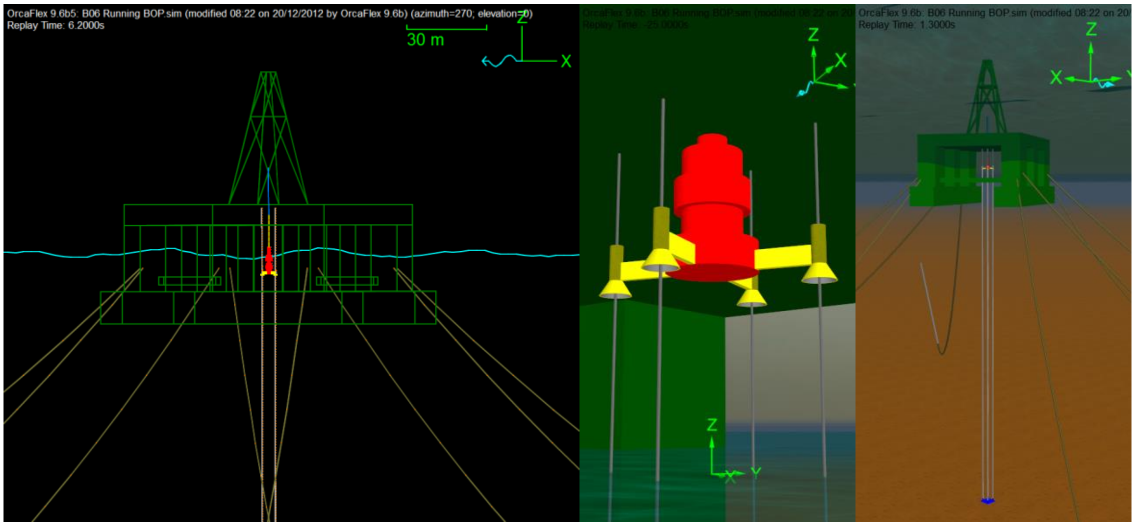
B06 Running BOP



A blow out preventer (BOP) stack is lowered to the seabed for connection to the wellhead. Guide wires are used to restrain the BOP while it is lowered.

Building the model

The drilling vessel uses displacement RAOs while the lowering is simulated in a low seastate. The BOP is modelled using a 6D spar buoy (shown in red in the model). A wave packet including the maximum expected wave has been applied to the system.

The BOP hydrodynamic properties are set on a cylinder-by-cylinder basis. They are intended to give a reasonable impression of the environmental loads on the buoy – although it will be restrained quite strongly by the guide wires and winch. Slam loads are also applied by means of a slam coefficient applied to lower-most cylinder in the stack. Open the data form for the *BOP* 6D buoy, in the *BOP Group*, to see how these properties have been assigned. In this example, the slam force exit coefficient is left as zero, as we are only interested in the lowering operation.

We are using a winch for lowering the BOP through the water column. The winch object has no mass, displacement, drag or added mass, therefore we will not capture all of the loading on the lowering gear. The BOP should be sufficiently restrained by the guide wires so that this approximation will not cause too much inaccuracy.

If the winch wire properties are significant then it can be changed to a winch-line hybrid. Part of the wire would be modelled by an OrcaFlex line object. A winch would then be attached to the free end of the line to provide the length that pays out.

The guide wires are long OrcaFlex lines, which run from the semi-sub down to a template on the seabed. At the seabed end of each line, a section is modelled with a variable outer diameter profile to represent the guide spike on the template. The BOP has four guides (coloured yellow) that slide down the guide wires and ultimately locate on the template spikes. *Line contact* is used to model this, with the *inside* relationship being used in this instance. The guide lines are *inside* the guides, which means that the penetrator 'balls' are located on the guide lines and the guides themselves are fitted with smooth spline surfaces (see the OrcaFlex Help section *Modelling, data and results | Lines | Line contact | Data* for further explanation of these terms). In this model the *around* relationship could also have been used which would have switched which line of each pair was splined and which had penetrators. Each relationship has its pros and cons and which one is best to choose depends on a number of factors, however often either relationship is suitable.

In this particular model, the guide wires have high axial stiffness but very low bend stiffness, which is typical for a wire; however this combination can result in some strange spline behaviour! If the *around* relationship was used then the spline would be fitted between the nodes of the guide wires. If the segmentation is quite coarse and a force is applied to the spline by the penetrator pulling on it (as happens in this model if the BOP moves sideways) then the nodes of the splined line can turn (due to the low bend stiffness) which forces the spline itself to deflect away from the line that carries it. The spline is forced to fit through each node, aligned with the node directions. This phenomenon is undesirable and is clearly visible in the screen shot below: -

The solution to this is to shorten the segment length, however on a line that is 250m long this could mean a lot more segments, which would subsequently increase the run time. An alternative is to do what we have done in this model, which is to use the *inside* line contact relationship instead. The segments on the guide wires still need to be fairly short and the penetrators (located at the nodes) need to be positioned close enough to ensure that there is always at least one penetrator in contact with the spline surfaces of the guide tubes, but they can be longer than they would need to be with the *around* option. See example *B01 Drilling riser* for further explanation of this type of line contact relationship.

Open the *line contact data form* from the model browser to see the line contact relationships. Note that *containment is enabled* is ticked for all the relationships. The guide tubes are free flooding so OrcaFlex will calculate which parts of the guide wires are shielded by the guides, and will calculate the fluid forces acting on them accordingly.

The line contact relationships also sort out the line positions for us in statics; line contact is active during statics, therefore the penetrator lines are forced inside their respective splined lines, as required.

Elastic solid shapes are used to model the guide cones located on the bottom of the guide tubes; usually we recommend that thin-walled shapes are made thicker to reduce the risk of nodes accidentally picking up the outer surface of the shape rather than the inner. However in this case the contact between the wires and guide tubes sufficiently restrains the motion of the BOP and prevents this from happening, therefore the cones can be modelled with their 'real' dimensions.

During dynamics, the winch payout is ramped up to a maximum speed, and ramped down again when the BOP is near the seabed. You can view a graph of the payout rate by looking at the *variable data* item *BOP Lower Rate* in the model browser. Click the *profile* button to see the graph. The purpose of this ramping is to avoid sudden shock loads in the Winch, and to give a gentle set-down for the BOP on the template.

Results

Open workspace *B06 Running BOP lowering.wrk* and watch the replay of the whole simulation. Note the vertical line on the time history of BOP Z. It shows where the animations have reached. The impact of the waves passing the buoy as it enters the water can be seen in the top right-hand view.

Now open workspace *B06 Running BOP results.wrk* and note how the BOP X and Y positions vary with time. While the BOP is lowering on the guide wires, it is loosely aligned with its final position. Once the guides come into contact with the alignment spikes, the BOP is finely aligned before it finally comes to rest on the template.