ExxonMobil

Santa Ynez Unit

Offshore Power System Repair: Amended Project
OPSR:A

Cable Retrieval Risk Assessment
(Analysis of Risk of Damage to Existing Components from a Dropped Cable During Retrieval)

Supplement 1: Shallow Water Addendum
(Supplementary findings Italicized)

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Study Summary

PMBCI examined the risk of physical damage to the active SYU cables and pipelines from the dropping of the failed "C" cable with or without the recovery tools attached during retrieval from the seabed. The study evaluated two water depths and three locations: 1) seaward of the shelf break in about 450 feet of water depth and 2) at two gas pipeline crossings of the "C" cable west of the Harmony platform each in about 1250 feet of water depth. The study methodology included the following three steps: 1) analysis of the falling cable dynamics; 2) analysis of the collision impact dynamics and 3) estimation of pipeline or cable damage. As a result of the analysis, five cable laydown modes were examined and three were found to be plausible under study conditions.

> *A supplementary examination of damage potential at 300, 150, and 50-foot water depths was performed to consider plausible damage. The same five cable laydown modes were considered with the following summary findings:*

1) Stiff Catenary Laydown – (Very shallow water only < 50 ft) [Not considered plausible]

> *This mode and the Spaghetti Pile Without Clamp mode (mode 3) converge to the same thing when the curl radius of the Spaghetti Pile is very long. In very shallow water this would be the case. The upper bound of kinetic energy for this case may therefore reasonably be taken as the same as mode 3.*

2) Hammerhead Laydown – (Does not occur under assumptions used) [Not considered plausible]

> *This mode and the Spaghetti Pile With Clamp mode (mode 4) converge to the same thing when the curl radius of the Spaghetti Pile is very long. In very shallow water this would be the case. Although considered implausible at the 450 foot and higher water depths considered in the original study, this mode is indistinguishable from mode 4 in very shallow water and would occur. The upper bound of kinetic energy for this case may reasonably be taken as the same as mode 4 thereby eliminating the need for separate consideration.*

3) Spaghetti Pile Without Clamp – (All water depths)

> *This mode, and mode 1 which is identical for very shallow water, will occur at the supplementary study water depths of 300, 150 and 50 feet. The kinetic energy at impact will be the same as for deeper study depths. The impact kinetic energy is the same as the falling cable reaches terminal velocity for transverse motion in a very short distance. The distance to reach terminal velocity is small with respect to even the shallowest supplementary study depth of 50 feet.*

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4) Spaghetti Pile With Clamp – (All water depths)

This mode, and mode 1 which is identical for very shallow water, will occur at the supplementary study water depths of 300, 150 and 50 feet. The kinetic energy at impact will be the same as for deeper study depths. The impact kinetic energy is the same as the falling cable reaches terminal velocity for transverse motion in a very short distance. The distance to reach terminal velocity is small with respect to even the shallowest supplementary study depth of 50 feet.

5) Plunging Stalk – (Deep water only > ~400 ft)

For the base study this mode was considered as requiring a water depth of 400 feet or more to develop. The reason for this is best understood by considering the mechanism by which this mode develops. If an arbitrary length of cable is falling at an arbitrary angle, being neither perfectly horizontal nor perfectly vertical, it has a component of motion transverse to the cable and another longitudinal with respect to the cable axis. The longitudinal motion is trivial if the cable is nearly horizontal. The transverse motion becomes trivial as the cable axis approaches vertical. The hydrodynamic forces resisting these two motions are very different in character. The transverse drag forces can be very large and terminal velocity can be reached in less than one foot when cable submerged weight is the only driving force. The longitudinal drag force is very much smaller and a vertical segment may accelerate for approximately 100 feet to reach terminal velocity.

As the falling cable reaches lateral terminal velocity very rapidly, but it requires a considerably longer time (and distance) to reach longitudinal terminal velocity, then the axis of the falling cable will rotate from nearly horizontal to nearly vertical during this acceleration. This mode is also predicated on the assumption that a kink, defect, or point of local damage in the cable exists at the lower end of the developing plunging stalk. Sufficient falling time and falling distance exist for the original study water depths of 450 feet or more.

At the supplementary study depths of 300, 150, and 50 feet these conditions are not met.

At 50 feet the development of a plunging stalk cannot have proceeded significantly. The seabed impact geometry would closely approximate mode 3.

At 150 feet a shorter plunging stalk could develop but there would not be sufficient time and distance for it to reach longitudinal terminal velocity. It is estimated that a stalk of quarter the mass of that considered by the original study could reach one-third the original study velocity. This means that a developing plunging stalk in 150 feet of water might impact a target with approximately one thirty-sixth (2.8%) of the energy of a deep water plunging stalk.

At 300 feet, if the stalk length were one-third that of a deep-water plunging stalk and the impact velocity was two-thirds of terminal velocity then the impact kinetic energy would be 4/27ths (14.8%) of the deep-water plunging stalk.

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These reduced kinetic energy impacts were evaluated in the same way as the original deeper water cases and added to the tabulations below.

The plausible damage to either a pipeline or a power cable was determined using elastic collision impact analysis. The results of this analysis obtained the following conclusions:

a) None of the pipelines or submarine power cables can be damaged by stiff catenary laydown mode *at any water depth.*
b) None of the pipelines or submarine power cables can be damaged by the hammerhead laydown mode *at any water depth.*
c) None of the pipelines or submarine power cables can be damaged by the spaghetti pile without clamp laydown mode *at any water depth.*
d) None of the pipelines can be damaged by the spaghetti pile with clamp laydown mode *at any water depth.*
e) All of the submarine power cables can be damaged by the spaghetti pile with clamp laydown mode *at any water depth.*
f) All of the pipelines, *in water depths exceeding 450 feet* can be damaged by the plunging stalk mode. *At the shallow water depths considered by this supplement:*
   a. In 50 feet of water a plunging stalk mode cannot be expected to initiate.
   b. For the partially developed plunging stalk mode in 150 feet of water the force exerted on the target is 8.3 kips. As this is less than the 14.2 kip maximum safe load for the weakest of the pipelines, no pipeline damage from a partially developed plunging stalk mode impact will occur in 150 feet of water.
   c. For the partially developed plunging stalk mode in 300 feet of water the force exerted on the target is 19.2 kips. As this is more than the 14.2 kip maximum safe load for the weakest of the pipelines, but less than the 35.8 kip maximum safe load for the strongest pipeline, some of the pipelines could be damaged by a partially developed plunging stalk mode impact in 300 feet of water.
g) All of the submarine power cables can be damaged by the plunging stalk mode *at any water depth.*

As shown above, a plausible risk to the operating pipelines and power cables exists at each of the study locations, specifically in the deeper water. It should be noted that the spaghetti pile mode would more easily impact a long linear target such as the submarine cable. For the spaghetti pile with clamp or the plunging stalk modes to damage a pipeline or power cable, they would have to have a direct hit on the component. A tabular summary is provided *below to include the supplementary locations at 300, 150, and 50 feet of water.*

A summary tabulation of plausible damage is shown in the following table:

location – water depth	Item	Plausible damage during retrieval operation from dropped "C" cable				
		stiff catenary laydown mode (mode 1)	hammerhead laydown mode (mode 2)	spaghetti pile mode without clamp (mode 3)	spaghetti pile mote with clamp (mode 4)	plunging stalk mode (mode 5)
1 - 450	12 inch POPCO	no	no	no	no	yes
1 - 450	"A" cable	no	no	no	yes	yes
1 - 450	"B" cable	no	no	no	yes	yes
2 - 1250	"A" cable	no	no	no	yes	yes
2 - 1250	"B" cable	no	no	no	yes	yes
2 - 1250	"D" cable	no	no	no	yes	yes
2 - 1250	20 inch oil emulsion	no	no	no	no	yes
2 - 1250	12 inch treated water	no	no	no	no	yes
2 - 1250	14 inch oil emulsion	no	no	no	no	yes
2 - 1250	12 inch sales gas	no	no	no	no	yes
3 - 1250	"E" cable	no	no	no	yes	yes
3 - 1250	12 inch gas	no	no	no	no	yes
3 - 1250	20 inch oil emulsion	no	no	no	no	yes
4 - 300	*12 inch POPCO*	*no*	*no*	*no*	*no*	*no*
4 - 300	*"A" cable*	*no*	*no*	*no*	*yes*	*yes*
4 - 300	*"B" cable*	*no*	*no*	*no*	*yes*	*yes*
4 - 300	*"C" cable*	*no*	*no*	*no*	*yes*	*yes*
4 - 300	*12 inch treated water*	*no*	*no*	*no*	*no*	*no*
4 - 300	*20 inch oil emulsion*	*no*	*no*	*no*	*no*	*yes*
5 - 150	*12 inch POPCO*	*no*	*no*	*no*	*no*	*no*
5 - 150	*"A" cable*	*no*	*no*	*no*	*yes*	*yes*
5 - 150	*"B" cable*	*no*	*no*	*no*	*yes*	*yes*
5 - 150	*"C" cable*	*no*	*no*	*no*	*yes*	*yes*
5 - 150	*12 inch treated water*	*no*	*no*	*no*	*no*	*no*
5 - 150	*20 inch oil emulsion*	*no*	*no*	*no*	*no*	*no*
6 - 50	*12 inch POPCO*	*no*	*no*	*no*	*no*	*no*
6 – 50	*"A" cable*	*no*	*no*	*no*	*yes*	*no*
6 - 50	*"B" cable*	*no*	*no*	*no*	*yes*	*no*
6 – 50	*"C" cable*	*no*	*no*	*no*	*yes*	*no*
6 - 50	*12 inch treated water*	*no*	*no*	*no*	*no*	*no*
6 – 50	*20 inch oil emulsion*	*no*	*no*	*no*	*no*	*no*

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