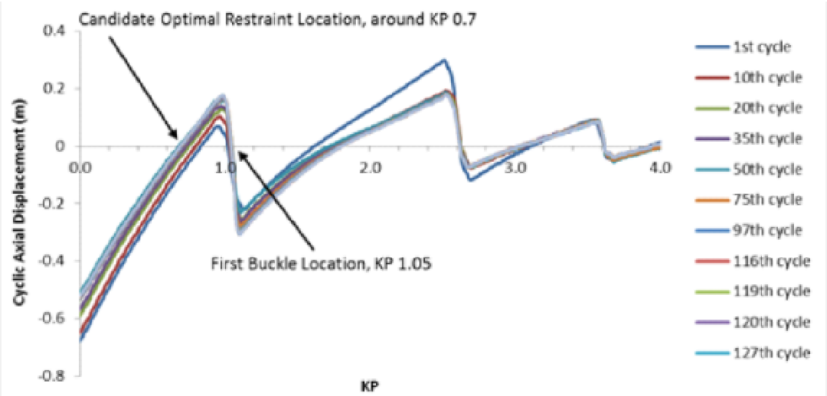
Pipe Clamp Mattress
FAQ

How does the PCM compare to rock dumping or concrete mattresses?
The key design driver of the PCM is to mobilise 100% of the anchoring weight into the pipeline using the seabed. Coefficient pipeline friction provides the walking restraint load. This greatly reduces the material required for restraining the pipeline and provides significant cost savings in materials, transport and installation. With conventional methods, up to 80% of the weight of concrete mattresses or rock goes onto the seabed, not into pipeline restraint.

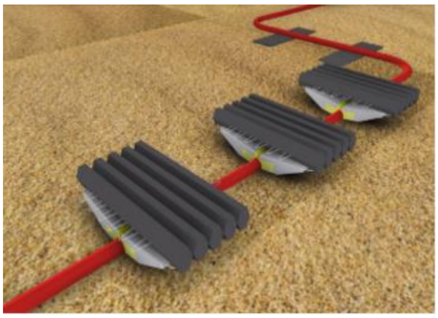
How can the PCM be optimised compared with piled solutions?
Piled walking solutions are traditionally installed at the ends of pipelines where the restraint loads are the highest. Driven or suction piles require a clamp to be installed on the pipeline and are typically attached via tensioned chains. Transfer of the high loads through the pipeline coatings are difficult to transfer.

PCMs can be installed precisely at the virtual anchor point(s). The designer can optimise the restraint load required by selecting virtual anchor points requiring the least amount of restraint load to prevent the pipeline walking.



FEA Analysis used to identify Virtual Anchor Point.

How can the PCM be used to optimise Expansion Spool Design?
Expansion spool design can be radically optimised by using PCMs to reduce feed-in expansion at pipeline terminals. By utilising PCMs to resist trigger loads at the first buckle or provide an anchor point for expansion the feed-in can be greatly reduced and in some cases removed. This reduces Z spool length, connector sizes, spreader bar design, hook heights, loadout requirements, barging requirements and installation durations.



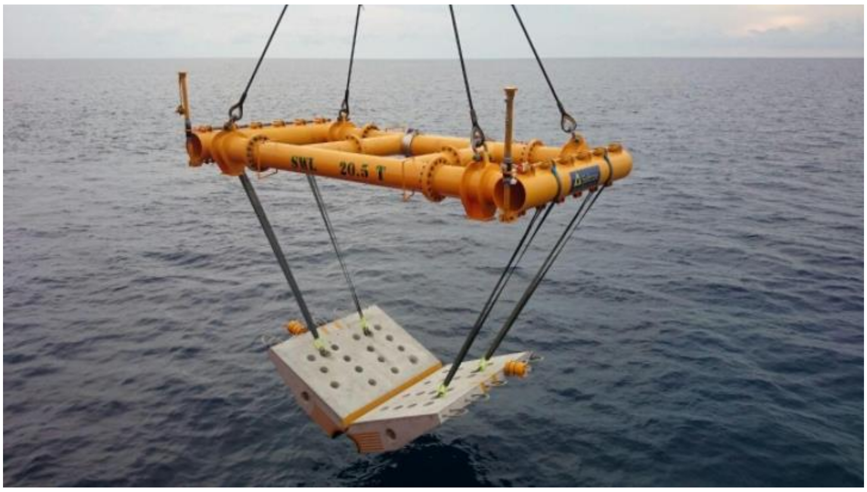
PCMs arranged to minimise Feed-In Expansion.

[Contact one of our engineers] to discuss how PCM's can be deployed to optimise your spool design.

How is pipeline burial managed during installation?
The clamping interface must be kept sediment-free during installation.

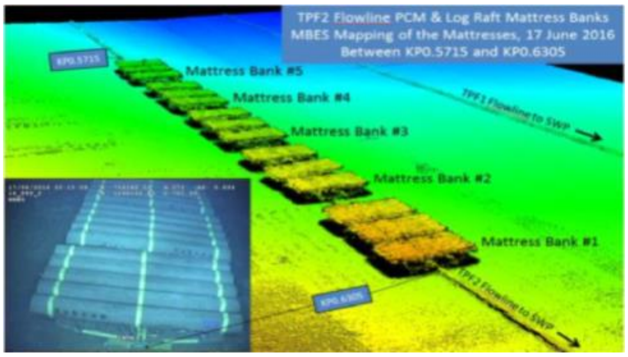
We manage this by:

- Accounting for 20% pipeline burial at installation.
- Lifting the PCM very flat to minimise embedment of the pipeline induced by the load transfer itself.



PCM lifted Flat to minimise load transfer induced embedment.

In some cases, the pipeline will bury as the PCM's are set in place. If this happens, we recommend the PCM weight is managed so that banks of the clamping section are installed, followed by the log mats to reduce installation induced embedment before clamping.



PCMs arranged in banks in soft soil to manage installation embedment.

How do the PCMs perform if they embed post-deployment?
The PCM to seabed friction coefficient depends on the drainage characteristics of the soil type. Typically, soft clays drain slowly and sandy seabeds drain quickly. We performed centrifuge testing at National Geotechnical Centrifuge Facility (NGCF) to investigate the following soil types: Kaolin Clay, Philippine Angolan Clay and Calcareous Sandy Soils from Australia's North West Shelf.

This testing demonstrated that whilst the PCM element may have a reduced undrained friction coefficient, the important response is that of the PCM-Pipeline system as a whole. The testing proved that embedment causes the axial restraint of the system to increase as the soil consolidates under cyclic loading.

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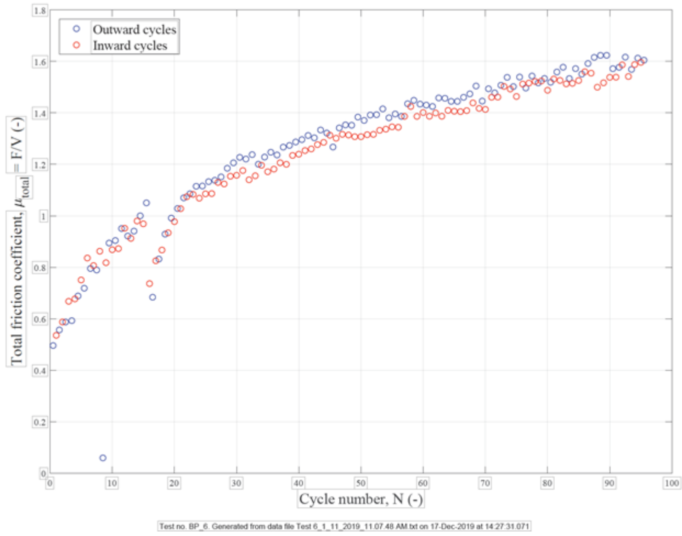
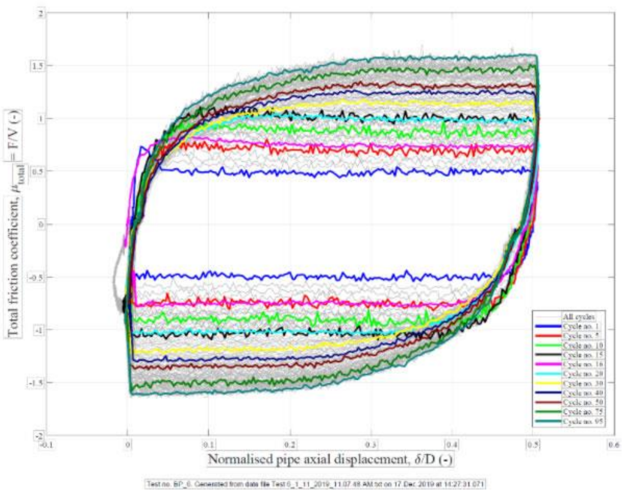
Testing at the NGCF.



Increase in soil resistance with cyclic soil consolidation.

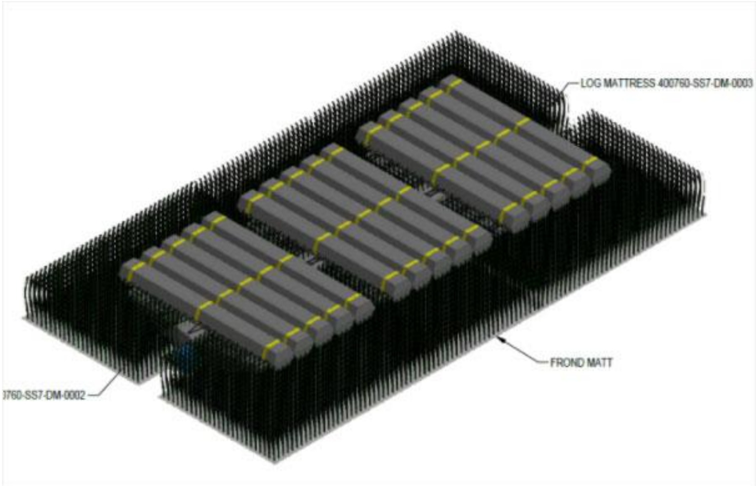


Total Friction Coefficient of the system increases with cyclic embedment.

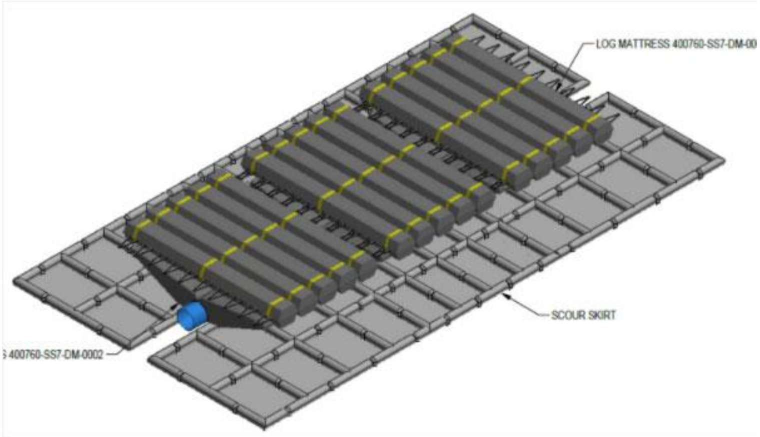
Dr Phil Watson led the research at UWA. His impact article can be read here.

For a summary of test results please contact one of our engineers here.

How is scour around the PCM managed?
Scour is a challenge in many shallower applications. Scour is mitigated by deploying a roll-out scour skirt. These can be grout inflated, stabilised with chains or fronded depending on the soil type and sediment transport conditions. Some examples are given below. To find out which solution suits your application, please contact one of our engineers here.



Fronded scour mitigation skirt.



Grout inflated scour mitigation skirt.

How does the PCM accommodate concrete weight coat or thermal insulation?
The PCM clamping surface is tailor-made specifically to suit the OD of your pipeline including coatings. The clamping surface is lined with rubber to account for any local deformations and coating OD tolerances.

Rubber Liners.

The clamping loads can be specifically designed for and are typically between 1MPa and 5 MPa. This is considerably lighter than typical tensioner and stinger installation loads.

Rubber Clamping Interface.

We recommend a full-scale FAT to be performed to ensure the clamping angles and tolerances are correct before commencing a full production run.

PCM fit up test on a test pipe joint.

To discuss which configuration would suit you clamping pressures, based on our historical results, please contact one of our engineers here.

Can the pipeline or its coating pull out from the PCM?
It is a common misconception that embedment will result in the PCM unloading and slipping on the pipeline. In fact, the clamping loads are much much greater than the pullout loads and so the PCM cannot slip or detach from the pipeline.

Firstly, the restraint is generated by the pipeline to the seabed friction, not by the PCM to the seabed (as per a traditional mattress) therefore very little axial load is applied to the PCM.

Secondly, embedment is typically driven by axial walking of the pipeline which is the very activity we are restraining. In the unlikely event that the pipeline does move, the piggyback configuration means the PCM simply moves with it. Even if the pipeline and PCM are partially or fully buried, the soil generates very little axial load into the PCM.

To demonstrate this we conducted centrifuge testing at the National Geotechnical Centrifuge Facility for several operators. This testing demonstrated that embedment does not result in any slippage. On the contrary, the axial friction coefficient (and consequently the restraint capacity) of the system increases due to the soil consolidation, making embedment less likely.

In conclusion, the PCM is effective in reducing all movement therefore no burial or axial loads would typically occur. If embedment does occur, the clamping loads ensure no slippage is possible.

To discuss MMA's PCM for your specific application please contact one of our engineers here.

How is the rubber connected to the PCM and what is its sheer strength?
The rubber clamping surface is bonded with an adhesive to the concrete jaw. This bond is only required to withstand transport and installation loads. Once in place, the PCM to pipeline connection experiences minimal sheer loads and the clamping force ensures the rubber stays in the jaw.

For more details on how the PCM piggybacks on the pipeline refer to the FAQ above: Can the pipeline or its coating pull out from the PCM?

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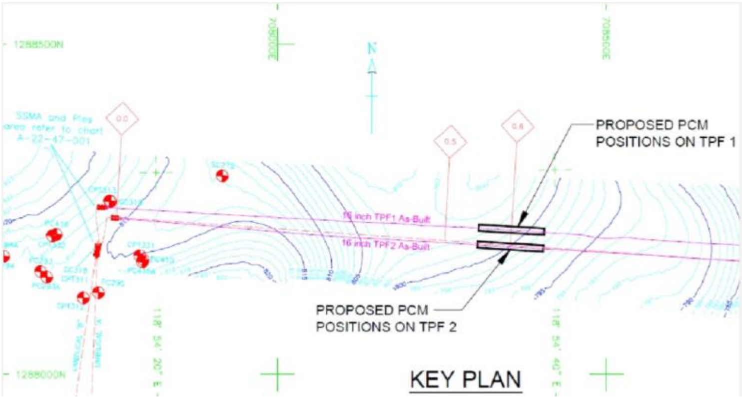
Does the seabed slope matter?
Seabed slope impacts all restraint methods. Mattresses, rock, piles and PCMs are all impacted by seabed slope. However, PCMs are unique in that they can be placed anywhere on the pipeline and in some cases they can even provide benefit from the slope. Typically, virtual anchor points do not occur on significant slopes or in steep valleys.



Pipeline Route showing Bathymetry and PCM location at Virtual Anchor Point.

Often, rogue buckles can occur where there is a change in the seabed gradient. In these cases, we look for the virtual anchor point options which invariably will be located on flat seabed at a suitable place to apply the PCM. The direction and angle of the slope may or may not act in the direction of walking.

Small angles have minimal impact, but we would look for a more optimal position for the PCMs for larger angles.

Should mitigation measures by applied pre or post-lay?
Predicting buckles and walking is a fickle business. Because not every pipeline will experience walking, MMA PCMs enable operators to take a wait-and-see approach to pipeline walking mitigation. PCMs can be readily applied to live pipelines that demonstrate pipeline walking.

Alternatively, they can be deployed during pipeline installation if required. They can also be used to restrain pipeline end expansion, thereby reducing expansion spool size and installation costs even further.

How is the PCM licence made available?
Shell holds the patents for the PCM technology and retains ownership of the intellectual property.

Shell has granted MMA the exclusive, global license to supply PCMs to market. The technology is then shared with contractors and operators on a project by project basis.

Our design innovation, project experience and test results are available to all operators so that PCMs can be deployed not only on Shell projects but worldwide for all field developments.

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