Rocksteady V
Quick Connection System

WES Quick Connection Systems Stage 1
Public Report

Subsea Riser Products Ltd.

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1 Project Introduction

SRP developed the Rocksteady V connector in response to industry demands for a quick mooring connector that could accommodate pull-in lines and wet-mate connectors. The design is based on SRP's field proven and qualified Rocksteady subsea mooring connector and was further developed in the Wave Energy Scotland QCS phase 1 project and assessed for use with a variety of existing WECs currently on the market.

In conjunction with InterMoor, an experienced marine contractor, the proposed installation methods were described and investigated for potential use. The connector's concept design allows for integration of the wet mate connector, and based on design data from Carnegie, it was found that the commonly used Gisma connector could be incorporated into the base concept design. The connector can be adapted for use with larger capacity wet mate connectors in development, such as Deutsch's P6-LW connector. Carnegie Clean Energy and CorPower also provided input into the connector adaptation for use with alternative WEC designs and provided some preliminary design data for concept evaluation.

The connector design considered installability, integration of services, reliability, survivability and disconnection. The installation procedures were developed and compared with a traditional WEC installation, in this case, Pelamis was used as a base. Pelamis was selected as a strong design challenge, as a bespoke QCS was developed for this system enabling comparison with a field proven method. The design concept was assessed with an eye on integration with other WECs currently in development and in service. Cost and manufacture underwent preliminarily assessment.

2 Description of Project Technology

Rocksteady V is a collet connector based on inverted geometry from SRP's Rocksteady connector.

Like a collet connector, Rocksteady V comprises a ring of latching fingers that tilt outwards and then spring close around a central mandrel which is pulled in hard to a shoulder in the connector. The lead-in tapers on the fingers are designed to permit pull-in at high offsets and approach angles.

The fingers also feature a tapered load shoulder utilising Rocksteady geometry, which close under a mating shoulder on the mandrel. A locking ring is then forced over the fingers, compressing them around the mandrel to lock it in place. The locking ring is engaged and disengaged via a set of hydraulic cylinders. The tapers on each component generate preload in the connection, which can be used to enhance fatigue life enhancement and so ensure survivability. The preloaded connection resists motion allowing motion sensitive services to be integrated, in this example a suitable readily available and proven wet mate connector is integrated to the connector. This integration means that the cable and mooring are installed in one operation.

Actuation of the locking mechanism is via a set of hydraulic cylinders equipped with an accumulator and is designed with 100% redundancy to ensure reliability. The hydraulic system also used to actuate the mating of the wet mate connector so reducing operational steps. The actuation is controlled using readily available remote-control systems.

The connector can be scaled to increase capacity and can be adapted to a number of mounting arrangements.

3 Scope of Work

The scope of work covered can be briefly outlined as follows:

Mechanical Design	The concept design was developed to a point where the design could be integrated into existing WECs, and installation procedures drafted for review. Initial sizing and material selection allowed an initial costing and manufacturability review.
Electrical System selection	Using typical electrical and communication requirements as a guide, an existing suitable wet mate connector was chosen and integrated into the connector design. Actuation methods were developed and reviewed. Higher capacity connectors currently in development were also assessed for integration with the connector
Installation procedure	An installation procedure for the connector was developed and assessed. The installation procedure was assessed against a baseline procedure utilising a conventional connection system, in this case, Pelamis's connection system.
Initial Assessment	The connector's design was driven by requirements common to many WEC developers. The initial assessment identified the benefits provided by the connector and how those benefits were achieved in the design.
Novelty appraisal	Review of connector characteristics commonly requested by WEC developers was carried out. The data from a number of RFQs issued by various WEC developers over the past 6 years was used to create a master list of WEC connector requirements. Rocksteady V was designed in response to these requirements and is expected to fulfil all of the technical requirements for many devices.
Feasibility assessment	The connector's potential use in existing WECs and those under development were identified to demonstrate the applicability of the design to various systems. An assessment of the QCS's expected performance, operability, manufacturability and cost was carried out.

Table 1 – Scope of Work

4 Project Achievements

The concept design was progressed and integrated into the Pelamis design as a baseline wave energy connector. Installation storyboards were produced and optimised. The connector design was shown to be capable of integration with at least two alternative WECs that have been developed – CorPower's HiWave and Carnegie's CETO.

Assessment of the Rocksteady V and installation method showed it to be a viable and potentially cost saving connection system. SRP's experience with traditional Rocksteady connectors provide a high level of confidence in the connector's survivability and performance in extreme conditions. The integration of the mechanical and electrical connections mean that the installation process can be simplified and made cost effective. The study identified areas for further investigation, these are in the connector's effect on the motion characteristics of the WEC, further optimisation of the mooring system and installation method and cost engineering to reduce the relatively high capital cost of the Rocksteady V.

5 Recommendations for Further Work

With the connector design based on our existing connector, there is a high level of confidence in its survivability and performance. A number of test cases were identified to demonstrate survivability in extreme conditions and to demonstrate flexibility over a range of mounting and mooring arrangements. A baseline test case will analyse a traditional connection system for use as comparison for the Rocksteady V test cases.

The test cases described in Table 2 below aim to demonstrate the connector's suitability for existing WEC devices and their mooring systems. A typical range of wave and current data will be considered to ensure applicability. The metocean data will come from known data from locations around Scotland.

Test Case	Description	Focus
1	Point absorber device using traditional chain mooring system with pinned H-Link connection.	Establish a baseline for comparison of the proposed QCS
2	Point absorber device using traditional chain mooring system with Rocksteady V connection	Assess the QCS against the defined inputs using the baseline case as a basis for comparison
3	Floating tension leg wind device using diver installed pinned H-link	Establish a baseline for comparison of the proposed QCS in a different device type
4	Floating tension leg wind device using Rocksteady V QCS	Assess the QCS in an alternative device against the defined inputs using the baseline case as a basis for comparison

Table 2 - Recommendations for further study

In addition to demonstrating survivability, the test scenarios listed will be used to optimise mooring and installation systems with a view to reducing cost. Further study in reducing the capital cost of the connector itself is also recommended through detailed material selection studies and optimised design for manufacture.

6 Communications and Publicity Activity

None

7 Useful References and Additional Data

1. SRP – Quick Connect System Detailed Report
2. SRP – Baseline WEC Installation Storyboard
3. SRP – Rocksteady V WEC Installation Storyboard
4. http://www.corpowerocean.com/technology/
5. https://www.carnegiece.com/technology/