Proactive Maintenance in the Context of Integrated Operations Generation 2
Ulf Skytte af Sätra, SPE, FMC Technologies; Rebecca Christensen, SPE, GDF SUEZ E&P Norge AS and Adrian Tanase, SPE, IKM Operations AS; Ingvar Koppervik, SPE and Espen Rokke, SPE, FMC Technologies

Abstract

With increased requirements to improve production availability; and to have a continuous updated overview of the condition status of subsea production systems (SPS), oil and gas operators have increased focus to reach beyond the current practice of integrating onshore and offshore centers and processes for continuous onshore support. Integrated Operations (IO) generation 2, is a further extension to integrate operation centers of the operator and their vendors with heavily automated processes and digital services in a 24/7 operation.

In order to reach IO generation 2, Proactive Management as foundation for operations with a preemptive maintenance program giving an early insight of coming abnormal issues is essential. Focusing on knowledge and understanding of how the equipment and installed base performs is essential and will be empowered by a management system which takes a holistic approach and an automatic integrity diagnoses functionality. To achieve IO generation 2, work processes which promote collaboration and continuous improvements and visualization of the equipment will be necessary to facilitate a common awareness and maintaining an optimum field operation.

By continuous monitoring of the integrity of the SPS in an IO generation 2 context, the Condition and Performance Management (CPM) system enables preemptive maintenance leading to maximum production at minimum maintenance cost. Increasingly important and supported by the CPM system, is the enforcing of health, safety and environment as stipulated in company goals and in national and international regulations.

The CPM system facilitates enhanced collaboration, and it is configured to support the identified IO generation 2 work processes regarding work interfaces and roles. The agreed work processes for an IO generation 2 set-up make the base foundation of the CPM system, from day-to-day monitoring and collaboration to in-depth analysis and improvement of the installed base performance.

Introduction

Wear and tear is an unavoidable part of normal use and aging of equipment and components. Maintenance is therefore of key importance to maintain equipment availability and performance. The approach to reach operational excellence in maintenance has been presented by Dunn, [1]. The maintenance program that has developed has a coupling to the amount of data that could be collected and analyzed. The first level in development of maintenance programs was performance of repairs when the equipment failed or could no longer run. This type of maintenance is characterized as being reactive. Over the last few years maintenance practices have significantly changed, progressing to a time-based maintenance, level two, referred to as preventive maintenance and later on to predictive maintenance, level three, relying on monitoring of the condition of equipment to determine the most cost effective frequency. The fourth and latest level is the proactive maintenance based determining causes of failure through monitoring of root causes. Maintenance development has walked hand in hand with the increase in level of data acquisition and data processing, see Figure 1. Roadmap to Operational Excellence.
As maintenance is one of the largest controllable expenditures in a production plant, in the effort to reduce operational expenses, maintenance practices will continue to develop over time focusing on extending the lifetime of installed assets and extending service intervals through condition based maintenance. One such possibility is the application of process models, where a model based process is continuously updated with real time data from the production process. The use of process models also facilitate prediction of remaining time to reduced performance or even failure. This will be a very powerful tool for maintenance planning.

The means for an oil and gas operator to increase productivity and efficiency is to have a high level of automation and an efficient maintenance program. An operator’s maintenance program has four objectives according to Nolan and Heap, [2]:

- To ensure realization of the inherent safety and reliability levels of the equipment
- To restore safety and reliability to their inherent levels when deterioration has occurred
- To obtain the information necessary for design improvement of those items whose inherent reliability proves inadequate
- To accomplish these goals at a minimum total cost, including maintenance costs and the costs of residual failures

In addition, concerns for health and the environment have come to be important issues in today’s maintenance program. Typical objectives in a maintenance program for health, safety and environmental (HSE) issues mirror traditional objectives.

- To ensure realization of the inherent HSE and operation availability levels of the equipment
- To restore HSE and operational availability to their inherent levels when deterioration has occurred
- To obtain the information necessary for improvement of those items whose inherent HSE and operation availability proves inadequate
- To accomplish these goals at a minimum total cost, including maintenance costs and the costs of residual failures

Prime measures in offshore operations are HSE and production availability where it is desirable to maximize both simultaneously. In the case of a SPS, being complex, remote and subsea, a high degree of automation is necessary in order to reduce maintenance cost and achieve a higher degree of production availability. A holistic
approach in the maintenance program by utilizing the CPM system will enable insight to the integrity, health and performance of critical components of the SPS. It takes integrity monitoring beyond traditional Key Performance Indicators (KPI) by utilizing all relevant data and information, encapsulating criticality, availability, process knowledge and operating philosophy of the production system. This indicator for integrity, health and performance is called Technical Condition Index (TCI). Having detailed knowledge of the true status of the facility is the first step in enabling a proactive and condition based maintenance approach and achievement of a higher grade of HSE and production availability.

A program for improvement of the value creation on the Norwegian Continental Shelf (NCS) through implementation of IO, was initiated by The Norwegian Oil Industry Association (OLF), [3]. IO was defined as “real time data onshore from offshore fields and new integrated work processes”. IO is a concept combining people, technology, and work processes to interact across disciplines, distance and companies. Traditional operations of yesterday had limited integration where the fields were self sustainable and periodic support was provided by specialized, onshore units. IO has developed over two generations. Today many field operations are in generation 1 integrating offshore and onshore centers for continuous support. Generation 2 is an extension from generation 1, integrating vendors to operators in operation centers to provide uninterrupted service and utilizing heavily automated processes, see Figure 2.

Figure 2. Integrated operations – development from traditional processes to generation 2. Ref. [3].

The advantages of the implementation of IO include improved decision making from simultaneous access to real time information and earlier improvement of performance management. As a result there is positive impact on health, safety and environmental issues and improved production rates and availability.

As Ringstad and Andersen presented from their study, [4], the implementation of IO will influence the work processes in at least four ways - work sequence, discipline sharing, physical location and decision making. In traditional working forms the tasks are performed in a serial work sequence, one by one. IO allows for multitasking and parallel processing allowing more tasks to be addressed at the same time. The focus in traditional working forms is normally restricted to a single discipline. IO utilizes multi discipline teams, which have the capability to get both a better overview of the production system and also power to focus on specific areas of interest or problem hot spots. Traditional working forms are dependent on a common physical location. In an IO context, participant’s physical location might be multiple and relies on the use of telecommunications, which are necessary to connect personnel offshore and onshore, including 3rd party vendors and other expertise in order to solve problems quickly. In traditional work forms decisions are based on experience and historical data. The availability of real-time data
and deduced knowledge for appropriate personnel resources irrespective of location presents a significant opportunity for gathering the necessary resources together. This will result in proactive decision making rather than correction of failures, and cost effective interventions to maintain integrity and performance of productions systems as well as HSE and operational targets.

Field Development on the Norwegian Continental Shelf, Setting the Context for IO Generation 2

New field developments on the Norwegian Continental shelf are within water depths of 300 meters and deeper. Developments typically consist of subsea templates and manifolds tied back in a daisy chain configuration or in clusters to a floating production unit via one or more production flow lines.

Depending on the reservoir size, the selected production strategy will either be pressure maintenance or depletion, utilizing horizontal drilling technology to access the reserves. Production techniques for maximize tail-end production are employing gas lift, Electrical Submersible Pumps (ESP), ejectors and topsides pressure reduction.

A typical field development utilizing four slot templates would include a manifold including four wing hubs for support of four wellheads and x-mas trees for each template. Communication between the x-mas tree (XT) and the manifold header is via a choke bridge module that incorporates subsea chokes for production and gas lift, multiphase meter/wet gas meter (mass flow meter in combination with a water fraction meter), sand detector and pressure and temperature transmitters. Gas lift injection volumes shall be measured for each individual oil wells using measurement from a V-cone meter. The four slot templates would be connected to the surface, for example a floating production unit, via one or two production flow lines tied back to riser bases located on the seabed in the vicinity of the floater.

An electro-hydraulic multiplexed control system located on the floating production unit would provide the hydraulic operation for all seabed valves and chokes and would monitor and relay output from all seabed instrumentation to the topside control room. A subsea control module (SCM) for distribution of hydraulic and electrical signals will be located on each XT. Communication will be transmitted through an integrated electro-hydraulic umbilical containing electrical quad cables, fiber optic cables and conduits for high and low pressure for control fluid and chemicals. The control system is designed with the flexibility to accommodate the addition of inflow control devices at any phase of the field life with the minimum of intervention, production downtime and pre-investment.

The overall operation and maintenance philosophy for any production facility is to ensure safety for personnel, environment, equipment, increase production and reduce operational costs, and achieve high regularity, based on use of suitable equipment and early warning systems, use of inspections, and quick response when failure occurs. Repairs of defects and failures are typically based on cost/benefit evaluations.

All field developments are faced with the challenge of managing communication in organizations placed in up to 3 locations, the platform, the main organization location, and the onshore operations location. In addition many operators are increasingly utilizing vendor expertise as extensions of their management of operations and maintenance. Operators are increasingly looking at integrated operations philosophy as a means for integrating disciplines and functions and organizations to close geographical distances allowing work teams to interact and cooperate more directly, using relevant and up to date information. As opposed to the discrete or batch focus of today, integration should result in an approach continually focusing on improved performance, placing the operation team in an early position to proactively and dynamically plan. This requires seamless right time data transfer, translation of data to information solutions, common communication platforms for information sharing, appropriate collaboration tools and competencies, and changes in traditional organization and work processes.

Field operators are establishing frameworks of collaboration solutions that seamlessly integrate or links vendor simulation, optimization, planning, and asset management tools to achieve speedier decision making. Integration of tools will make it possible to automatically determine operational results and deficiencies freeing up personnel to focus on optimizing and improving performance. The dynamic asset management environment will rely heavily on right time data transfer from down hole sensors, subsea instrumentation, topside facility equipment, translation of data to information solutions and visualization tools both offshore and onshore. Technical information maintenance management systems are being built for optimal support to the offshore and onshore organization. Condition monitoring is an essential tool to facilitate maintenance management. Information from these systems will be available both offshore and onshore, and will be made accessible to specific vendors of the equipment and systems.
Proactive Maintenance using CPM system

Allmendinger and Lombreglia describe a smart service as a service which gives a new kind of value, [5]. The value are removing unpleasant surprises from the activity operated by the customer and depending on “machine intelligence” gives the managers and decision makers much more visibility to the operation. The machine intelligence may consist of the gathering of real time data, from subsea and topside, to a data collector and processing and analyzing them for faster and better decision support and for maintenance planning and reduce the operational expenditures (OPEX).

Some success factors for reducing OPEX are:

- Cooperation between all relevant parties, onshore and offshore, using the collaboration rooms and tools to address problems or investigate operational or maintenance issues, when accessing and utilizing the same data which is made commonly available (historical, real-time, live audio etc.)
- Condition and performance management of critical subsea and topside systems and equipment
- Conversion of real time data to appropriate information for analysis and decision making
- Well defined work processes
- Knowledge management and best practice improvements

CPM is a smart service system. CPM takes a holistic approach to integrity monitoring, offering aggregated equipment response which embeds the system health, integrity and performance, maintenance philosophy and criticality into the monitoring system. The CPM system is a decision support system, which performs real time diagnoses and is not an alarm system. To implement the system, CPM system has a three step built-in path for decision support. The three steps are:

- **Equipment Response** where data could be extracted from a high number of subsea sensors applying online, real-time statistical analysis, signal processing, mass balance calculations etc.
- **Response Quality** where the data quality (good vs. bad) is evaluated
- **Information Aggregation** to understand the impact of the change in response quality on the overall plant integrity, production uptime, HSE etc.

The first step, equipment response, is implemented in the mathematical algorithms in the CPM system. The second and third step is embedded in the CPM system after extensive discussions between operator and contractor. In this way the CPM system encapsulates expert knowledge, criticality and operation and maintenance philosophy in the system. Only when the last step has been performed it is possible to plan and prioritize the maintenance work to be performed; what should be taken care of immediately, what can wait and what should be planned for at the next intervention campaign.

The CPM system focuses on providing diagnosis of technical condition and development trends in performance of the SPS as well as the process itself in order to avoid unintended downtime and loss of production. The indicator for integrity, health and performance is the TCI. The TCI is presented from the lowest level on a sensor or instrument and aggregated through the system to a top level which can be a platform or a field or an operator. The TCI is divided in three areas by the colors, green, yellow and red. The colors indicate the following:

- **Green**: fully functional and operation as intended
- **Yellow**: degradation has an impact to reduced integrity, health and performance, with reduced functionality and performance
- **Red**: severe degradation with malfunction and failure that inhibit operation

An example of how proactive and condition based maintenance will differ from reactive maintenance is shown in Figure 3. Time to plan during yellow light.
If the trend is slowly developing, there is time enough to plan ahead and make corrective actions to avoid a shutdown. One important property of the CPM system is the information aggregation. This means that a highly complex system as a SPS will have an overview of the total integrity on any desired level at any time and could be presented anywhere it is needed. If the trend for degradation moves into the yellow zone, a notification is notified through appropriate channels, and the operator has the opportunity to make an informed decision on how to approach the alert, or alternatively dismiss the alert. Without a proactive monitoring system, the state of processing system shows an alarm, shifts directly from green to red, on a later time and maintenance is reactive instead of proactive with increased maintenance costs and potentially loss of production as a result.

CPM system generates added value on different levels:

- When CPM system notifies of a deviation in performance or integrity, this notification will be input to the maintenance planning system to initiate planning of maintenance or intervention; e.g. replacement of an eroded choke.
- When CPM system notifies about a deviation in performance or integrity, a decision to alter the operational parameters to reduce the strain on the identified component or sub-system may be taken enabling continuation of production until the next planned intervention campaign.
- When a maintenance campaign is undergoing, CPM system will give a full overview of components and sub-systems with reduced integrity, ensuring all identified components are being replaced during this campaign; e.g. failed sensors on a XT.
- Proactive use of built-in redundancy. CPM will advice operator to switch to redundant system before a potential fail-safe shutdown is initiated by the topside control system.

CPM system will also contribute to improve the HSE performance:

- As a vital part of Integrated Operations. Operational teams will be performing monitoring and maintenance planning onshore. This means less travel to offshore installations.
- Less unscheduled maintenance
- Enable better planning of scheduled maintenance, safer maintenance
- Detect environmental spills. Detect leakage of chemicals and fluids (hydraulic fluids) by applying mass balance calculations
- Provide track record of hydrocarbon (HC) leakage detectors

**IO Generation 2 Work Processes**

To be able to achieve the objectives of IO generation 2, technology and people have to be accompanied by appropriate work processes. The IO generation 2 work processes for proactive maintenance of a SPS have been divided in six main processes whereas four of them are running in a continuous loop, as illustrated in Figure 4.

![Diagram of IO Generation 2 Work Processes](image)

Figure 4. The IO generation 2 work processes for proactive maintenance of a SPS.

The work processes for proactive maintenance start with determine of goals and requirements, which are inputs for establishing the CPM Service. Then there is a continuous loop containing four processes; (1) monitor and report, (2) diagnose and report and alert, (3) recover and maintain and (4) manage and evaluate. The monitor and report process covers the day to day monitoring processes and regular meetings. The diagnose, report and alert processes covers all processes related to diagnosing an identified problem and decisions for corrective actions. A full situation analysis and diagnosis is performed in order to investigate the root causes of a confirmed problem, such as an unwanted trend development, and to conduct a diagnosis of the appeared situation. The process may also provide a recommendation on further action needed in the form of interventions and/or maintenance needs. This process can also establish collaboration sessions with the Operator's environment using off-the-shelf collaboration tools like video meeting in order to reach the correct diagnose. The recover and maintain process covers the processes normally conducted by the traditional customer support. The manage and evaluate process covers the processes to maintain the models of the CPM system best practise updates, feedback to product groups and maintaining subsea documentation.

**CPM system, Visualization**

Visualization is the most exciting tool for collaboration Bamford states, [6]. It provides the involved people with a common mental picture, which brings people together (common awareness). In problem solving, which involves interaction between different people at different locations and entities, it is important to have a common mental picture in order to reach a correct, better and faster decisions. To illustrate how 3D visualization can be applied to improve the understanding and perception of a SPS, a typical case has been constructed for a choke that is degraded by erosion. The choke internals is eroded, due to a sand production, and reached the defined level for alert (yellow color of the TCI). The affected zone in the choke is being presented in the visualization tool. A zooming takes place, from an overall view by four steps A to D, into the choke where the erosion affected item is
showed, see Figure 5.

Figure 5. Zooming, from an overall view, into an eroded choke.

Traditionally, an operator will be presented a figure for the flow coefficient $C_v$ of the choke. If the sand load has increased heavily and internals of the choke has been eroded, the $C_v$ value will increase accordingly. For an experienced operator with knowledge about choke design an interpretation of $C_v$, the degradation of the choke would be obvious. But if the operator is less experienced in choke design or the person is a new operator in learning modus, a visualization of the result will be most helpful. Figure 5 present zooming in four levels, from a top level for the whole SPS down to the eroded choke internals. The operator has an overall view of the SPS, in this case a semi submersible vessel and some templates in the upper left picture in figure 5. If a choke in the nearest template got erosion, with reduced performance as result, this is alerted by the yellow color on the whole template due to aggregation of data from lower levels. To examine the cause, a further zooming, following arrow A, will show which choke module that is affected on the template. Going further, following arrow B, shows the choke inside the choke module. The tree list in lower right picture in figure 5 has a yellow tick for $C_v$ deviation in accordance with the choke. Zooming deeper, following arrow C, will show the choke in a 2D drawing and the last zooming, following arrow D, present the choke cage that is subject to erosion also in a 2D drawing. If the degradation due to sand load has been worse and put the choke, with malfunction, in an alarm modus the presented color for the actual template and choke would be red. This also imply for the tick for $C_v$ deviation in the tree list.

Once the problem has been identified, the operator will be able to pull up a menu for the particular sub-system to get additional information. For the choke, this will be:

- The historical trend curve for the $C_v$ deviation
• Nominal and estimated C_v curves
• A list of associated sensors for this choke
  o Upstream/down stream pressure sensors
  o Multiphase flow rates
  o Density used in C_v calculation
  o Other if applicable
• Hyper links to relevant documentation

The sensors associated with the choke C_v calculation will again let the operator see the historical raw values for the sensors, as well as the CPM calculated integrity number (TCI) for each sensor. This way, it will be very easy for the operator to decide if the indicated erosion of the choke is real, or if it is caused by a faulty sensor, or by applying wrong flow rates or density numbers (if these are entered manually).

Result and Discussion

GDF SUEZ E&P Norge AS’ Operations focus is to maintain safety, intended function of their facilities and improve hydrocarbon recovery though improved production facility availability. The Operations organization relies on utilizing contracted maintenance support and vendor expertise, connecting organizations through common work processes and collaboration facilities. The long term operations and maintenance strategy is based on reliability centered maintenance and will extensively utilize condition monitoring of facilities based on real time information as a tool to understand the integrity of equipment and to proactively perform maintenance when need. The information out of the CPM system will enable relevant elements of the overall organization to estimate the status and actual degradation of different parts enable evaluation and prediction of potential failures, and enable better planning for offshore interventions.

Root cause parameters will be monitored to follow any aberration from the normal situation resulting first in a material deterioration followed by performance degradation and finally resulting in a total loss of component and / or system functionality. In order to appreciate component failure characteristics it is important to become familiar with the service life parameters and life sustaining conditions that are typical of various components. This characteristics stem from a controlled root cause condition and progress to a conditional failure state and finally to a totally dysfunctional state. The most important factor is to know and understand exactly how the system is working. To achieve this, it will be necessary to consider all operation parameters. The results will be a part of the TCI’s, for different system levels, but can also be used as KPI for the system itself.

During normal operations the activity will focus on continuous estimation and evaluation of the indicators which are compared with the design values. This will give a holistic view of the performance of the system and will be used to help maintaining the performance stability. Proactive maintenance using the monitoring systems will follow systems health status and will detect abnormal conditions that could eventually lead to failure conditions and will be used to assist in taking necessary actions to correct aberrant conditions. TCI’s will focus on performance degradation and equipment and system parameters will be monitored to obtain operational symptoms and to show the grade of stability for the systems. Continuous monitoring of these parameters combine with better understanding of each system will be used to determine the root causes of failure and are consider to be the basic requirements for a proactive maintenance strategy.

The human factor is very important in this situation. All the indications shall be evaluated and human factor will take the proper decisions during normal operations for better planning of all interventions. Using of common visualization tools will provide better collaboration between offshore personnel, onshore support team and the Contractor, all of whom will have access at the same time stamped information and will provide a basis for better diagnose.

Proactive maintenance as a strategy together with condition monitoring systems is considered to provide a better frame work in the hands of Operations personnel to ensure efficient and stable production. Implementing a proactive maintenance strategy is anticipated to extend the service life time for the equipment, contribute towards better planning of offshore maintenance campaigns, reduce the costs for interventions, and increase the benefits regarding reduced shut down times and extend production. These can be considered just few rewards that can be gained from this strategy.
While operating the SPS with the CPM system will new knowledge and insights be a natural result. All information’s that give system knowledge are stored in the CPM system. This could give benefits in several ways as; on the actual field, on other green and brown fields and on new field developments. In the actual field would it be easier and faster to introduce and learn new staff and reduce the knowledge drops which could occur when highly experienced staff is retiring. In green and brown fields would the gained experience be useful to increase their oil and gas recoveries. Also future field developments would get gain from how a field could be operated, with a higher degree of HSE excellence and process equipment availability, to be able to develop the operations beyond IO generation 2.

The CPM system is designed to meet the IO generation 2 needs and has the following properties;

- An in house vast subsea experience embedded in the solution that perform automatic integrity diagnose
- Can predict field production that leads to less operational surprises and also increase overall field production
- Gives an early insight to evolving integrity issues with the possibility to spot and understand and react before a critical situation is triggered
- Proactive management of the subsea installation powered by an early insight and therefore gives time to evaluate different solutions
- Facilitates Integrated Planning which moves health awareness and good housekeeping of what should be done to a higher level

Conclusions

In order to reach proactive maintenance in the context of IO generation 2, beneficial activities would be;

1. Lay a Proactive Management as foundation for the operations
2. Implement a monitoring system with a holistic view and an automatic integrity diagnose functionality
3. Use a Proactive Maintenance program giving an early insight of coming abnormal disturbances
4. Introduce work processes which promote collaboration across regions and entities and continuous improvements
5. Establish a visualization tool, which easy relieves the internal parts of the equipment that are exposed to reduced integrity. The visualization tool will create common situation awareness across different disciplines and locations, which enhance the troubleshooting activities; hence reaching better and faster decisions.

Acknowledgements

Acknowledgement and thanks are given to the Licensees of PL153 – Petoro AS, Statoil ASA, A/S Norske Shell, and RWE Dea Norge AS.

Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2D</td>
<td>Two Dimensional</td>
</tr>
<tr>
<td>3D</td>
<td>Three Dimensional</td>
</tr>
<tr>
<td>AG</td>
<td>German; Aktiengesellschaft (public corporation)</td>
</tr>
<tr>
<td>AS, A/S</td>
<td>Norwegian; Aksjeselskap (public corporation)</td>
</tr>
<tr>
<td>ASA</td>
<td>Norwegian; Allmennaksjeselskap (public corporation)</td>
</tr>
<tr>
<td>billion</td>
<td>prefix; 1,000,000,000</td>
</tr>
<tr>
<td>CPM</td>
<td>Condition and Performance Management</td>
</tr>
<tr>
<td>CS</td>
<td>Customer Support</td>
</tr>
<tr>
<td>Cv</td>
<td>Flow Coefficient</td>
</tr>
<tr>
<td>DC</td>
<td>Data Collector</td>
</tr>
<tr>
<td>e.g.</td>
<td>Latin: exempli gratia, for example</td>
</tr>
<tr>
<td>E&amp;P</td>
<td>Exploration and Production</td>
</tr>
<tr>
<td>ESP</td>
<td>Electrical Submersible Pump</td>
</tr>
<tr>
<td>etc.</td>
<td>Latin: et cetera, and other things</td>
</tr>
<tr>
<td>FMC</td>
<td>Food Machinery Corporation</td>
</tr>
</tbody>
</table>
GDF  Gaz de France
HC    Hydrocarbon
HSE  Health, Safety and Environment
IO    Integrated Operations
KPI   Key Performance Indicators
million prefix; 1,000,000
NCS   Norwegian Continental Shelf
OLF   Norwegian; Oljeindustriens Landsforening (The Norwegian Oil Industry Association)
OPEX  Operational Expenditure
PL    Production License
PMV   Production Master Valve
PWV   Production Wing Valve
quad  Quadruple, 4
RWE Dea Rhenish-Westphalian Electric Deutsche Erdöl AG (power company)
SCM   Subsea Control Module
SPCU  Subsea Power and Communication Unit
SPE   Society of Petroleum Engineers
SPS   Subsea Production Systems
TCI   Technical Condition Index
V-cone Flow meter with a V shaped cone
vs.   Versus
XT    X-mas tree

References


