RAPID: A New Approach for Improved Regularity and Decreased Maintenance Costs

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Norway is the world’s 3rd largest trader of crude oil, and a significant supplier of gas to the European market. Statoil is a Norwegian based oil company, with 17,000 employees, and with a number of offshore production plants, pipelines and land based facilities. As part of an improvement campaign with focus on increased production and reduced maintenance and operational costs, Statoil is working with a new initiative related to turnaround strategies and execution of maintenance that requires shutdown. This campaign is called RAPID, which stands for “Remove Activities, Prolong Intervals and Decrease durations”. The initiative was due to the fact that turnarounds are the largest single contributor to reduced production in Statoil. Turnarounds with production shutdown are conducted on a regular basis, with a typical duration of 15 days and with a 1-3 yrs. frequency for offshore facilities and 4-8 yrs. for land based facilities. It is a long-term objective to reduced lost production due to turnarounds by increased use of condition monitoring, new procedures for hot work, safety integrity verification, opportunity maintenance and improved planning. This paper describes the on-going campaign and its applied methods. The work for 2003 is focused on two main products: a new turnaround strategy for a pilot offshore installation (Heidrun) and a general Company guideline for turnarounds.
# ACRONYMS AND DEFINITIONS

<table>
<thead>
<tr>
<th>Name</th>
<th>Definition</th>
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<tr>
<td>CBM</td>
<td>Condition Based Maintenance</td>
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<tr>
<td>HSE</td>
<td>Health, Safety and Environment</td>
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<td>LNG</td>
<td>Liquefied Natural Gas</td>
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<td>NCS</td>
<td>Norwegian Continental Shelf</td>
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<td>Opportunity Maintenance</td>
<td>Execution of selected planned and corrective maintenance at opportunities generated by unscheduled production shutdowns</td>
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<tr>
<td>RAPID</td>
<td>Remove Activities, Prolong intervals, and Increase Durations</td>
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<td>Statoil home page</td>
<td><a href="http://www.statoil.com">http://www.statoil.com</a></td>
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<tr>
<td>SAP</td>
<td>Trademark. World's largest inter-enterprise software company. Maintenance administration tool used by Statoil.</td>
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<tr>
<td>Turnaround</td>
<td>Execution of large amount of planned maintenance activities during limited time related to work that requires full or partly production stop. Originally related to revision of pressurized equipment or other critical equipment with special governmental concern.</td>
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INTRODUCTION

General

Statoil is a medium size oil company, with approximately 17,000 employees worldwide. The main activities are in the North Sea region outside the coast of Norway. The company has also increased its activities in other regions such as Iran, Caspian, West Africa and Venezuela. Today Statoil is the world’s third largest trader of crude, and large amounts of gas are exported to the European Continent. The company operates several onshore and offshore facilities, both “old” installations (from late 1970s) and new installations, recently put into operation. Examples of new projects are Kvitебjørn (offshore production plant), Kristin (offshore production plant) and Snøhvit (land based LNG plant with subsea installations). In 2002, the production was in average 1074 boe/day, whereas 92% of this from the NCS (Norwegian Continental Shelf).

Statoil is daily facing challenges related to asset management, e.g. maintenance of tail end production facilities (declined fields), maintenance of subsea production equipment, and operation and maintenance of facilities abroad. A major task is to change the work culture and work processes from being repair oriented, with focus on repairing breakdowns, to being proactive, maintaining critical equipment before failures occur. Typical focus areas are turnaround strategy optimization, remote operation of facilities, improved maintenance management strategies, increased use of condition monitoring and use of mobile ICT (Information Communication Technology). Statoil is today facing competition from new companies willing to take over the operation and maintenance of small/declined fields in the North Sea. In order to compete with these new actors, Statoil have to look at ways of reducing the maintenance and operational costs. One important parameter to be a successful operator is to have sufficient control over the technical condition of the process plant and the equipment. Having control over the technical condition of the plant and equipment, being able to predict failures before they occur and estimate the residual life of critical equipment, are basic elements in a proactive maintenance philosophy. This, combined with continuous work on removing root-cause of failures, results in improved planning, increased production, reduced costs and reduced risk of hazards related to personnel and environment.

Statoil has ongoing activities and utilize extensive effort to develop methods and tools that define and monitor the technical condition both on the lowest level as well as on the system and plant level /1/. The activities do also include development and utilization of existing and
new condition monitoring techniques. These activities is seen as very important to be able to change the regime from fixed turnarounds to an on-condition and opportunity based philosophy.

**Turnarounds in Statoil**

In Statoil, 20 offshore platforms and 5 on-shore plants (crude oil and gas treatment plants and refineries) are subjected to turnarounds on a regular basis. The facilities are all linked together in a complex production infrastructure consisting of production pipes and shuttle tankers. This infrastructure ensures that oil and gas from the wells finally reaches the marked.

There are differences in the offshore and onshore turnarounds practice. Onshore, the turnaround frequency is typical 5 yrs., the duration is typical 4 weeks and the amount of work approx. 150 000 hours. Offshore, the frequency is typical 1-2 yrs., the duration is typical 2 weeks and the amount of work between 14 000 - 90 000 hours. The turnaround-planning organisation varies from being a fixed organisation to an “ad hoc” organisation for each turnaround. The work is performed by contractors, offshore with one single contractor and onshore with a selection of minor contractors for separate work packages. The logistics support challenge is quite different between offshore and onshore turnarounds. Offshore, the weather dependency (restricted to late spring, summer or early autumn) and limitations related to transport of spares (high costs due to use of supply ship, helicopter), personnel and materials requires much more planning effort and limits the freedom of work execution. The transportation time is long, and it is extremely costly to require a helicopter for transport outside the scheduled routes. Also, limited amount of beds, limited space for storage and limited workspace makes the offshore turnaround planning more complicated compared to onshore. There are also differences in the rules and regulations for execution of maintenance, which requires for differences in the turnaround practices. Onshore, the use of incentive contracts has been used as a mean to increase the quality of work, that is, to keep the budget and time and the HSE objectives. This has not been the practice offshore, so far. In general, the onshore facilities have been challenging the turnaround strategy to a larger extent compared to offshore because the onshore plant normally works within lower margins. As several of the oil fields are maturing (tail end production), the pressure to prolong economic life is forcing an increased focus on cost reduction and minimum lost production. In this new regime, the offshore installations are facing the same “competitive” environment as many of
the onshore plants have been used to since start up. Several external companies are offering “tail end production” as a special service, and are challenging the way Statoil are performing tail-end production. In the British sector, outsourcing of tail end production is common, whereas Statoil has a strategy to do this with internal resources.

**Limitations in today’s turnaround strategy: A hypothesis**

The background for the RAPID project is the hypothesis that the turnaround practice today can be improved, especially for the offshore installations. This is based on the following observations:

- A turnaround is seen upon as a regular event, in which other and not critical jobs usually have been added. The turnaround frequency and duration is typically defined during the project period, and is not necessarily challenged later.

- A turnaround is seen upon as a cost-effective and focused activity, with highly motivated personnel in all phases. This might be based on characteristics of the human being, enjoying focused improvements with common objectives; teamwork and “lots of action” more than continuous improvement as part of daily work. However, recent studies have revealed that the average costs often increases for jobs performed during a turnaround compared to jobs executed as a “normal” maintenance job.

- There is a tendency that modification projects use the regular turnaround as a “free ride”, that is, since the plant already is shut down, the project don’t have to account for the lost production.

- The job candidates for a turnaround are not challenged hard enough, compared to the consequence these jobs have on lost production. The focus is normally higher for the planning and execution phase compared to the job selection and scope of work. A typical offshore plant production value is 3 - 7 mil. $/day, which is a good reason to invest in knowledge, methods and technology in order to reduced the amount of shutdown work.

- The successful turnaround is related to good HSE performance (no injuries, environmental spills, job satisfaction etc.) and to keeping the time and budget. Hence, the evaluation of a turnaround is project execution focused, and does not sufficiently evaluate whether the turnaround frequency and scope of work was optimal.

- There is limited overall optimisation for all installations as seen as a “super production structure”. That is, each plant defines its own turnaround frequency, requested time for
execution and scope of work. There is limited coordination between the shutdowns, only ensuring that the production commitments to the market are fulfilled and that sufficient work craft is available.

- To prolong the turnaround frequency there is a need for improved knowledge of the technical condition to minimize the probability of unforeseen shutdown between two turnarounds by utilizing opportunities caused by unforeseen shutdowns.

**Optimisation of turnarounds**

Optimisation of turnarounds is a challenge in view of the large number of tasks to perform, dependencies on the facility itself as well as dependency between other facilities. The methods, tools and procedures that found basis for the latest turnarounds have mainly been developed and optimised based on feedback from previous turnarounds. Different practices have developed for each facility both due to the age (and generation) of the facilities but also due to minor exchange of experience between the different organisations responsible for each facility. Pre-studies have revealed a great potential for improvements only by performing a more structured exchange of experience, methods, procedures and tools. Examples of such a case is the need of revising procedures used in the shutdown phase before hot work is permitted. Some facilities do already have a nearby optimal procedure while other struggle with procedures that only have been through minor changes since the production start-up. However, it does exist an overall optimisation challenge related to execution of turnarounds in Statoil that will require a considerable effort to accomplish. In this context we have limited the presentation of the topic, and do only include a list of the main observations regarding input to an overall optimisation model. The “big picture” includes:

- 20 offshore installations and 5 land based plants
- Gas and oil pipeline dependency
- Sale obligations (most sale during winter, highest price)
- Available workforce and skill (restricted amount of qualified workers)
- Logistics support (economic dependency, limited resources)
- Weather conditions (turnarounds not feasible during winter time)
- Type of jobs:
  - “Normal” maintenance (planned preventive, planned corrective, unforeseen corrective) that do not influence the production
o Maintenance that requires partly or full production stops (planned preventive, unforeseen corrective)
- Vulnerability for extensive production losses because of a low degree of redundancy, especially on the newest facilities.

The overall optimisation problem can be solved by use of mathematics. If doing so the problem formulation should address aspects as:
- Global optimisation vs. local optimisation
- Objective function: Maximum profitable production of oil, production of gas according to obligations
- Penalty: failures and breakdowns that results in increased costs and lost production
- Constraints:
  o Production [gas: obligation, oil: maximum]
  o Personnel [limited]
  o Weather
  o Logistics support [economic dependency, limited resources]

At present we do only control the local variables and have therefore not elaborated more on the global picture. This will however be an area of interest in the future.

TURNAROUND IMPROVEMENT PROJECT

Statoil is working with several initiatives related to turnaround strategies and execution of maintenance that requires shutdown. One campaign is called RAPID, which stands for “Remove Activities, Prolong Intervals and Decrease durations”. The objective is to reduce lost production due to turnarounds by increased use of condition monitoring, new procedures for hot work, safety integrity verification, opportunity maintenance and improved planning. The work for 2003 is focused on two main products: a new maintenance strategy for a pilot offshore installation (Heidrun) and a best practice guideline for turnarounds.

The Heidrun TLP (Tension Leg Platform) is situated 80 km North-West of Trondheim in mid Norway. It produces crude oil to shuttle tankers, gas and condensate to pipeline. Gas to the methanol plant at Tjeldbergodden and condensate to the Åsgard field. The turnaround interval for Heidrun has been two years, where the latest turnaround was in 2002 (14 days, 24 000
hours). The improvement projects has defined a short term objective and a long term objective:

1. Next turnaround in 2004 with 7 days duration (reducing from 14 to 7)
2. Remove the need for large turnarounds in the future. For production critical jobs this means: reducing the need for these jobs, increase the interval between execution of these jobs and decrease the shutdown duration when executing these jobs.

In this context, the shut down duration is defined as the time from start of production shut down until the first well starts to deliver hydrocarbons to the infrastructure.

A secondary objective is to improve the planning and execution of production critical jobs in general, which has been the “normal” focus of turnaround improvements.

In order to obtain these objectives, the following elements have been identified as important:

- Utilisation of opportunities (unscheduled production shutdowns)
- Improved use of condition monitoring
  o Use of existing methods
  o New methods
- New methods and procedures for welding during operation
- New method for work challenge
- Improved planning

**Pilot project: RAPID**

As previously explained, RAPID is an acronym for “Remove Activities, Prolong Intervals and Decreases duration”. In the following, the RAPID project is described in more detail. Though the RAPID project focuses the effort on only one facility, the observations and methods for improvements are expected to be useful to other Statoil facilities. The future work does also include an approach to generalize the results from Heidrun and to produce content to a “best practice document” within Statoil.

**Remove Activities:**

As seen in previous chapter there is magnitude of decade between the amounts of man-hours carried out during a turnover onshore compared to offshore. The main reason for this is limitations in berthing capacity offshore. Since we have this upper limit of daily man-hours
capacity, there is a danger of prolonging the shutdown and consequently increase the production losses. This, combined with the fact that turnaround work costs 30% more is a driving force to remove activities from the turnaround scope of work. Our approach is first to challenge each job candidate before entered into the turnaround work list in SAP by investigating all means to perform the job during full production. Secondly, the work lists are challenged, both regarding interval and duration. Since the organisation is “used to” having a turnaround on a regular basis, it is quite a challenge to get the organisation to change its behaviour. A key word in the change process is “opportunity maintenance”. As most of our production units have low degree of redundancy or no redundancy at all, one has to use any production trip or stop to perform maintenance. There must therefore exist pre-planned jobs for any length of stop in production. It may also be situations where one will negotiate for longer stops as an extension to a process trip to perform vital maintenance work. This requires a close integration of the Operation and the Maintenance departments and a constant cost/benefit optimisation. Since typical turnaround work includes welding and other types of “Hot work” (Hot work during operation has up to now been banned in Statoil). To be able to perform hot work in a safe manner, special precautions have to be made. This includes welding habitats with overpressure in combination with automatic power cut on welding device.

By excellent planning work and implementation of most recent welding safety precautions it is expected that many typical turnaround activities can be performed during normal operation.

**Prolong intervals**

The second focus area in the RAPID model is to prolong the intervals between major activities. In turnaround terms this is mainly inspection of pressure vessels and drums for corrosion, and overhaul of large rotating equipments as turbines, pumps and compressors. From experience we have learned that these inspections not seldom turn out with no findings, as they hopefully should. If we had known this in advance, the whole activity could be postponed to a time where we expect to find damage. This means that many labour and time intensive activities could be saved. By applying existing and develop new condition monitoring methods, vital process equipment is only opened and inspected when needed and this will affect the time between turnarounds considerably.

For rotating machinery as pumps, turbines and compressors a variety of methods, techniques and equipment is available and in use on our production units.
The largest challenges are related to the areas of corrosion inspection and performance verification of separators, pressure vessels and scrubbers. Since these equipments often are insulated, they are hard to inspect from the outside during operation. Development of new technology may be required.

**Decrease duration**

The third element in our concept is to decrease the duration of the turnaround. Since the main objectives of the two first phases is to avoid work to enter the turnaround work scope the main objective of this phase is to reduce the work further, in addition to plan and structure the work in a manner that minimise downtime and production losses. Key elements here are a strong turnaround planning organisation with authority to prioritise work to be performed, and to exclude work that not have to be done within the time frame of the turnaround. Further the turnaround organisation should have excellent planning skills and capabilities.

Example:

In the Heidrun pilot project, separator maintenance has been identified as the most critical activity, both regarding duration and costs. Based on this fact, a considerable amount of work has been performed, trying to challenge the separator work. In this case, a supplier is responsible for performing the work, and several meetings have been performed together with the supplier in order to identify improvement activities. The separator maintenance work was divided into sub-tasks, where each sub tasks was challenged regarding time and costs. The results for this work have been a long list of improvement activities, reducing the original execution time estimate with 23 hours, from 117 hours to 94 hours.

The experience from the RAPID project so far is that considerable savings can be obtained just by having a sufficient focus and a structured way of working.

**ACADEMIC WORK**

In general, turnaround activities are part of asset management and maintenance optimisation in general. The fundamental system and process characteristics are defined in the design phase of a facility, but there is always room for design improvement also in the operational phase, if proven economical beneficial. Each turnaround activity is identified based on its influence on production or other risk aspect, and is modelled as an activity with a duration
and an associated cost. Each activity has an influence on production with three specific phases: shut down period, execution period and start-up period. Obviously, the main reason for grouping jobs in turnarounds is to minimize losses related to shutdown and start-ups. The interval between turnaround activities is a risk optimisation problem (or a pure cost optimisation problem if all risk elements can be measured in dollars). A long interval has high risk for critical events whereas a short interval is costly due to lost production and the activity costs. Activities governed by rules and regulations are not candidates for interval optimisation. Based on the risk aspect, downtime costs and other relevant constraints, it is possible to establish simulation models that calculates the costs of different turnaround strategies, for example, the cost difference between having a large turnaround each year compared to several small stops based on opportunities. There has been performed some academic studies in the RAPID project. The result of this work will be published later.

In the future, more work will be performed related to mathematical optimisation of turnaround strategies in addition to the more continuous improvement work. Students from NTNU (Norwegian University of Science and Technology) play a vital role in this work together with researchers from SINTEF/ MARINTEK. Also, it is planned to look further into “global” optimisation of turnarounds in Statoil, taking all offshore and onshore facilities into account, with their production infrastructure and various types of local and global constraints. The main objective is to maximise the production, minimize the costs and to be a reliable supplier of hydrocarbons to the market.

CONCLUSION

Our initial studies have shown that there are signification potentials of savings in optimising turnarounds for our production units. The potentials are in magnitude of several million dollars. The Heidrun pilot project has so far demonstrated that by ensuring high focus on turnarounds and work systematic together with experienced personnel, significant improvements can be obtain. In addition, more “academic” tools and methods can be developed and implemented to further obtain savings. These methods will be investigated further in future work, and a “best practice” related to turnaround planning and management will be established for Statoil in general. To materialise these savings more effort must be put into condition monitoring. New monitoring technologies have to be developed and the planning capability has to strengthen significantly. It is important that turnarounds are not seen upon as a special area, divided from other maintenance activities, but as a subset of asset
management, with high criticality, that is, impact on production, safety, environment and costs. In theory, a good design is to minimize maintenance that influence the production, but it will always be a trade off between investment costs and operational costs related to this.

References