

# Wellhead Maintenance & Integrity Management

*Safeguarding against the unknown*

N. Dale, D. Heskins, M. Bolton

Claxton Engineering Services Ltd.

Published via: [www.claxtonengineering.com](http://www.claxtonengineering.com)

## **Abstract**

Technological and procedural advances in flow assurance and reservoir management have resulted in an increase in the estimated field lifetime and subsequently field hardware utilisation. In order to safeguard asset structural integrity, it is becoming increasingly important to adequately service and maintain wellhead and tree assemblies to confirm the well integrity is fit for purpose and ensure the surface barrier against hydrocarbon leakage can be relied upon in the event of an emergency situation.

Continuous high-quality and efficient production can lead to complacency about the integrity of the wellhead and a lack of focus on routine maintenance – but what if a catastrophic failure occurs which requires an emergency shutdown?

Lack of critical component maintenance and exposure to the elements can take its toll on mechanical assemblies, increasing the likelihood of production downtime caused by equipment failure.

These very real possibilities can be greatly reduced through a programme of planned and efficiently managed well maintenance including valve servicing, pressure testing, function testing and monitoring of general wellhead condition and operational trends. This can lead to

more efficient production and will increase the asset life whilst reducing the costs associated with work-over programmes.

This paper details the most critical failure mechanisms of the wellhead-tree assembly and describes the benefits of a typical externally-managed long-term well maintenance programme delivering full traceability and integrity assurance to the operator.

### **Introduction**

Oil exploration and production has played a significant part in the financial success of the Middle East since the mid 1900s. The immense size of these oil discoveries has often meant that fields are continuing to produce commercially viable quantities of oil well past their expected field lifetime. Whilst this is highly beneficial from a financial standpoint, it is important that operators are aware of the consequences in terms of the ongoing integrity of the well hardware and the safe operation of the field. The harsh environmental elements of the Middle East region, accompanied with the corrosive and erosive properties of flowing hydrocarbons result in accelerated wear to the wellhead and tree assemblies as well as deterioration of the casing strings, as illustrated in Figure 1 (overleaf).



**Figure 1:** Replacement of a wellhead due to deterioration & environmental degradation

Coupled with general wear and tear of mechanical assemblies and additional unforeseen damage it is critical that field operators have suitable plans in place for routine well maintenance operations so that problem areas can be identified and remedied quickly and effectively. This greatly reduces the risk of catastrophic failure events and having to shut-in the well at a later date to replace worn or seized mechanical parts – an operation with significant financial implications. Regular maintenance is a much more cost effective approach than waiting for problems to occur and reacting to them.

### **Common Failure Mechanisms & Remedies**

The structural integrity of a wellhead and tree assembly is dependent on a number of external influences and scenarios and the causes of deterioration or failure are often not immediately

obvious. Investigations into a small crack or seepage can quickly escalate into a more serious problem with the well construction requiring immediate attention. Regular inspection and maintenance will ensure that a wellhead continues to operate in a safe and efficient manner well past its original field life.

The most common failure mechanisms found during inspections and their associated remedies are detailed below:

Mechanical Assemblies – Master valves and offtake valves are typically the main point of flow control on the Christmas tree and wellhead assembly. Valves and actuators are a common component affected by seizure and breakage caused by a lack of suitable lubrication and long periods of non-operation. Whilst seizures can often be remedied through the use of flushing lubricants, this approach is not 100% effective. Stuck or seized valves will generally need replacing which requires costly well shut-in operations.

This can be complicated further if the valve is stuck in the closed or partially closed position. When this occurs the valve will need to be hot tapped in order to re-open the well bore whilst maintaining pressure control prior to setting plugs using a polished rod lubricator and replacing the valve assembly. Preventative maintenance is key to ensuring the valves remain in an operable condition - monitoring and recording the number of turns to open and close the valve, looking for signs of damage to the valve body and leakage through the seals and also reacting to early indications of seizure ensure that they can be relied upon in the event of an emergency.

Corrosion & Erosion – Wellhead and tree components are continually subjected to corrosion and erosion - whether it is via the external environment with onshore wellheads being sand blasted by wind and offshore surface wellheads sitting in a corrosive salt-water atmosphere, or via the internal environment with hydrocarbons eroding the internal casing/tubing strings over a period of time. The gradual thinning of the metalwork caused by these corrosive environments will eventually lead to cracks or holes, through which hydrocarbons or gas will leak, causing contamination and further speeding up the deterioration of the wellhead materials.

Whilst it is difficult to determine the structural integrity of the casing strings at any given time, regular pressure monitoring of the well bore and casing annuli makes it possible to identify trends in flow characteristics. Changes in pressure over time could mean a transfer of fluids between annuli and therefore a possible breach. In extreme cases it is possible for the hydrocarbons to breach the outermost casing, in which case immediate action is required to locate the point of breach and patch/repair as necessary prior to locating the leak path from the inner tubing and securing the wellhead structural integrity (Figure 2). This has further complications for onshore wells where for near-surface breaches excavation is required to locate the leak origin. However, if the breach is deep inside the well the only option to the operator is to conduct a full workover.



**Figure 2:** Casing cutting and repositioning of a wellhead after a leak path was identified

Corrosion from the environment and weather can be dealt with cheaply and effectively by stripping and re-applying coatings and paint to protect the bare metal. This is a basic requirement of wellhead maintenance and an activity that is recommended whenever the well site is visited for either preventative or routine maintenance work.

Seals & Gaskets – In a similar manner to the erosion and corrosion detection above, pressure monitoring and regular visual inspection are key to ensuring the integrity of the wellhead seals is maintained. This is critically important for elastomer seals which are prone to long-term deterioration and must be replaced once the stated design life has been exceeded. Regular thermal cycling of the wellhead materials also leads to deformation of metal-to-metal seals and the subsequent opening of leak paths. This can be remedied through the injection of sealants. In more severe circumstances, where sealants are ineffective, deconstruction of the wellhead assembly and replacement of the necessary seals becomes necessary.

Missing Components – Not all wellhead maintenance activities are a result of damage or deterioration of the surface equipment. The Middle East is home to many onshore and offshore well sites which not been adequately maintained for decades, either because they have been abandoned or due to neglect.

Often these fields are later purchased by new operators and plans are made for re-entering the wells only to subsequently find that the wellhead assemblies are incomplete due to parts being borrowed to repair nearby wells or even in some instances taken without consent. Through regular asset inspections and preventative maintenance visits, the likelihood of this occurring is reduced and steps can be taken to ensure the well bore integrity is maintained should a critical component go missing. It is generally prudent practise for new owners to have their fields assessed and surveyed by well maintenance specialists prior to planning any form of re-entry to ensure the well condition is as expected.

Formation Changes – As the field life increases, the quality of the hydrocarbons being produced tends to deteriorate, with an increase in the amount of BS&W (basic sediment and water) observed at the surface. Whilst these impurities can be dealt with from a production standpoint, operators need to be aware of the detrimental effect these can have on the well hardware and casing strings. Sand and water can increase the speed of corrosion and erosion of the internal casing walls and can affect the integrity of the wellhead and tree valves and

seals. A change in hydrocarbon quality has a knock-on effect on how regularly the wellheads should be inspected and maintained.

The results of production fluid analysis should be provided to wellhead management personnel so that the structural integrity risks associated with each well can be prioritised and the well maintenance programme adjusted accordingly.

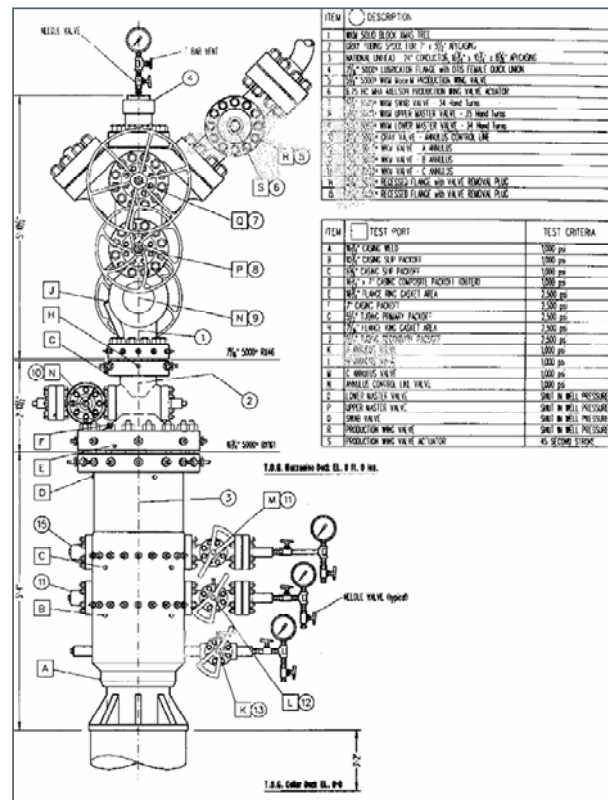
Changes to Company Policies or Technology – Wellhead integrity management is an area where new practises or procedures are constantly being introduced - whether it is through developments in technology by wellhead manufacturers or drilling contractors or improvements in safety management which result in a change in company operating policy. Should these changes result in an operator's decision to make any structural modifications to any of their assets, it is recommended that these changes should be implemented as part of the ongoing well maintenance programme. This ensures that the improvements are adequately recorded and logged and subsequent visits are planned to ensure the modifications are behaving as expected.

### **Well Maintenance Planning & Execution**

In order to ensure that well maintenance campaigns follow a structured approach, it is important that sufficient planning takes place prior to executing the maintenance programme so that each essential activity is given priority and non-essential activities are timed to coincide with planned shut-downs, work-overs or other scenarios which reduce disruption to continuing production. Whilst this is not always possible, every effort should be made to minimise the time spent on the well.

Prior to forming the well maintenance plan, the first and most crucial stage is to conduct a field survey. This provides an opportunity to accurately catalogue the manufacturer, specification and operating characteristics of every well. It is recommended that this information is collated into a central database, along with drawings, GPS location, photos and other pertinent data which can be accessed from the operators office or remotely from the field at all times. This will then form the basis of the well maintenance campaign, giving full traceability to the operator so that all changes can be accurately logged and reviewed.

The field survey is typically the most time consuming part of setting up the well maintenance campaign. This is partly due to the complexity of a typical onshore/offshore wellhead and the number of components that need to be identified and logged, and partly because of the age of many fields in the Middle East and the subsequent lack of accurate historical data. Construction drawings are typically not available or cannot be traced and additional work is likely to have been carried out on certain wells post-installation which mean that the individual components identified during the survey are not necessarily the original items installed.



The field survey is also the first opportunity to identify the critical maintenance items for the subsequent campaign. Visual inspections and initial well bore and annulus pressure/temperature readings will immediately show if the wellhead is affected by leaks, damage, component deterioration or breakage or even missing parts.

Following the field survey and completion of the associated database, the most critical action items are identified and reported on for review by the operator along with a recommendation on how to proceed. These recommendations are typically accompanied by a work pack containing a full step-by-step work procedure for each activity proposed and also a risk assessment for each individual task, along with a list of the tools required and expected timescale.

On-site maintenance work which can be carried out without removing any of the components from the wellhead are generally the least problematic from a maintenance planning standpoint. Bleeding off pressure from an annulus or flushing a stuck gate valve or ball valve can be done relatively quickly by a skilled maintenance technician and can give immediate results.

This is not always as straightforward for instances where components require replacement. Original manufacturer components and assemblies are not always available for fields which have operated for decades. Many changes have happened to original wellhead equipment manufacturers over the last century, with many no longer trading and others being merged together to form new companies. Many parts are now obsolete and not all manufacturers maintain a spares provision for older product lines or will offer the service of fabricating past designs from old drawings. When it is not possible to save or refurbish the worn part in a timely manner there are two options – locate a pattern part manufacturer or reverse engineer the part from scratch. Both of these options, although feasible, come with their own risks as extra care needs to be taken to ensure the new part conforms to the high quality assurance standards of the original and to the correct specification. It is important that industry standard approved fabricators and suppliers are used for all wellhead components, both for new build and refurbishment work. The ability of the supplier or fabricator to provide cost-effective retrofit parts quickly if required is also a significant advantage.

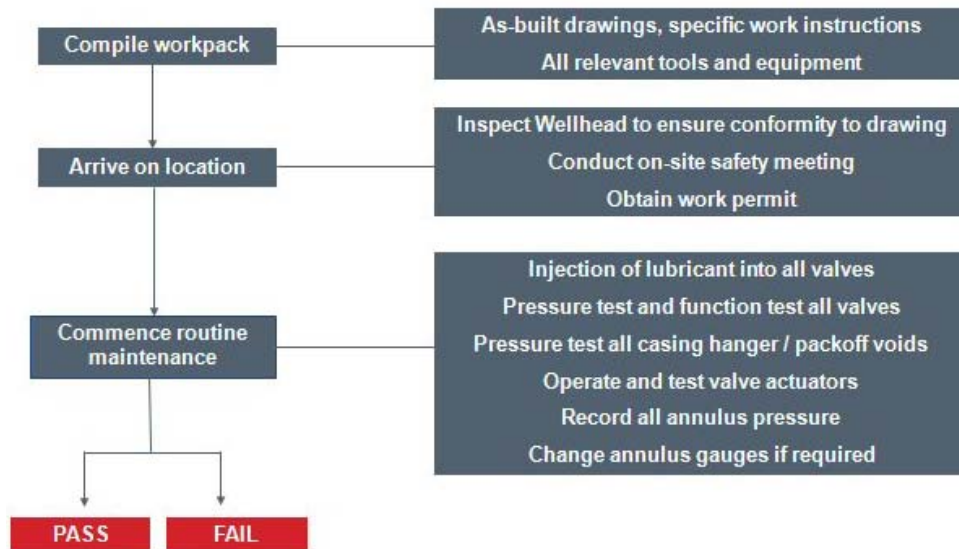
In order to reduce the financial implications of a wellhead maintenance campaign, it is common practise to keep the replaced assemblies in a refurbished stock pool. By stripping the assemblies down and fully refurbishing each worn component, the item can be re-stocked and used at a later date when that particular item is required for another well. Over a period of time, the refurbished stock will increase to a point where the operator has access to a large set of spares which will reduce the need to reverse engineer or buy new parts from an external supplier. By analysing the common failure mechanisms of each component, trends can be identified which can be used to build up a check-list of common faults with particular wellhead designs which will then form part of the preventative maintenance inspections.

Once the critical maintenance activities have been completed, plans must be made for carrying out regular maintenance inspections and ensuring the integrity of the wellhead is maintained. This is carried out on a rotational basis with scheduled visits to each well in turn. Before this can proceed, the wellhead maintenance company and operator must agree to acceptable operating limits for each wellhead variable. Examples of the typical variables that are recorded and monitored during each site visit are as follows:

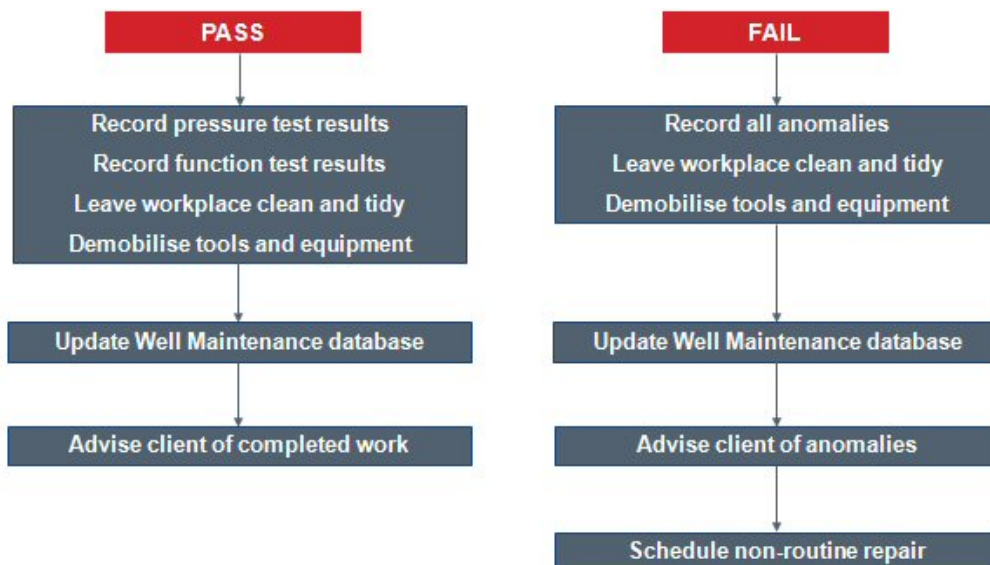
- Functional testing of wellhead and tree gate valves (number of turns to open/close the valve)
- Pressure testing of tubing hanger and all casing hanger voids
- Pressure testing of the tree valves
- Actuator closure times and function testing (reaction time)

In addition to collating this information into a report for the operator, it is beneficial to maintain a record of these readings over a period of time to monitor the gradual deterioration of a particular component or the increase in pressure at a particular location so that steps can be taken to alleviate the problem before the agreed limits are exceeded and it becomes a serious issue. The activities associated with a typical routine maintenance visit are outlined in Figure 4 (overleaf).

### ROUTINE MAINTENANCE INSPECTION



### REMEDIAL ACTION



**Figure 4:** Typical procedure for a routine maintenance inspection

Cost escalation can often play a key part in deciding how to manage the future of a particular well site. For large long-term well maintenance campaigns, the ongoing maintenance cost of each well site is regularly assessed and reported so that the operator is aware of the escalating costs of maintaining each well. If numerous parts are coming to the end of their design life

and large quantities of money are being spent on reverse engineering in order to keep a particular specification of wellhead flowing efficiently, it could be more commercially viable to replace the entire wellhead and tree assembly with one from a modern manufacturer who is able to provide a full spares backup and support. The replacement wellhead can then be installed by the wellhead maintenance personnel and the old wellhead can be returned to the spares stock after being re-worked and brought back up to an acceptable operating condition. This activity also provides an opportunity to check the status of the internal casings and re-cut/re-dress the casing strings prior to installing the new wellhead.

Through careful planning and structured execution, the wellhead maintenance campaign can become an effective asset management tool for every operator, ensuring accurate records are kept of all field sites in a single, central database and maintaining detailed safety records of every operation executed during the field life.

### **Benefits to the Operator**

The benefits of setting up a long-term well maintenance campaign are far greater than purely providing integrity assurance for an operator's assets. There are several other crucial advantages of making sure assets are effectively managed.

Safety is the most important aspect of any onshore or offshore operation. Strict guidelines are imposed on every activity undertaken and risk assessments and stringent procedures form part of everyday work practises long before any personnel are allowed onto the work site. This is particularly true for wellhead maintenance, where every operation is analysed to a high level of detail; weighing up the implications of repairing a single component compared with replacing the entire assembly and prioritising high-risk activities, to ensure safety is maintained at all times.

Wellhead maintenance is a powerful risk management tool. By greatly reducing the number of unknowns for each well site, operators receive operational assurance and there is further reassurance for personnel working around the field on a daily basis - the implications of which must not be underestimated. Health and safety in the workplace is of paramount importance where oil fields are concerned. Hydrocarbons are both poisonous and highly volatile, and must be handled with respect and care. Showing that there are detailed

procedures in place which are enforced to maintain equipment and reduce the risk of leakages indicates that an operator values their employees and the environment, two important factors that will increase a company's reputation and bolster its position and longevity in the marketplace.

This assurance extends further to governing bodies who regularly monitor operator performance and are keen to see that steps are being taken to work safely and competently. By employing a third party wellhead maintenance team, not only are the requirements of the governing body met, but there is a sense of impartiality imposed on the programme, reassuring auditors that every step is being taken to ensure the field is operating safely and efficiently.

In addition, should there ever be an instance where a leak or other emergency situation is investigated; the wellhead maintenance database provides full traceability for every operation undertaken on the field and every component replaced over the duration of the campaign. By giving the investigating company the opportunity to review and analyse the database, operators are able to show them that sufficient precautions were taken to reduce the risk of leaks/damage prior to the event.

By employing a competent, comprehensive and commercially aware wellhead maintenance campaign, there is no reason why even the most mature field cannot continue with high quality and problem-free production for many years after its designated field life.

---

**This paper was First Published at Offshore Middle East 2010, SESSION 5: Asset Management & Facility Integrity, October 12 - 14, 2010 at the Qatar International Exhibition Centre, Doha, Qatar.**

For more information about wellhead maintenance from Claxton, contact us at:

Email: [info@claxtonengineering.com](mailto:info@claxtonengineering.com)  
UK tel: +44 (0) 1493 744500  
Dubai tel: +971 4 8863540