For operation in hurricane or cyclone regions, some operators may request that the environmental criteria should cover the 25-year return period for the specified region for year-round or specific seasonal operation (at reduced safety factor).

4.2.4 Dynamic Positioning Redundancy

For a DP unit, the level of redundancy should cover the guidelines of a recognized class society. As an example, the equipment configured for an ABS-classed unit should meet the DPS-2 standard at a minimum.

4.2.6 Input Data for Evaluation

For the evaluation of the station keeping and riser analysis the following items should be made available:

4.2.6.1 Metocean Data

- Wind - 1, 5, 10, 25 year return period (1 min mean)
- Wave - 1, 5, 10, 25 year return period (significant) with period (sec)
- Current Profile

4.2.6.2 MODU

- Motion RAOs

- Environmental Force Coefficients
- Air gap and draft
- Winch/windlass capability
- Thruster/DP capability
- Fairlead design

4.2.6 Pre-Set Mooring Layout and Operations

A main purpose of the SBOP operation is to extend the water depth of an existing vessel toward deeper water. It is therefore very likely that the vessel mooring system will also have to be upgraded.

If the upgrade can be performed as part of the vessel general upgrade and the mooring can be self-contained, then the mooring operation is similar to a standard sub-sea drilling operation. If the mooring cannot be self contained for load, space or cost reasons, then the mooring operation will have to be performed either with line inserts to increase the length of the mooring lines or with connection to an external pre-set mooring system.

The wire insert methodology has been used, but it is rather cumbersome and can only be justified on a very small number of wells. The design is straightforward but the installation is a marine operation that needs to be carefully planned with detailed marine procedures involving the

existing and new equipment, the rig, the anchor handling vessel (AHV), the rig crew and the marine crew.

The pre-set option lends itself quite well to the SBOP concept. The anchor and the pre-set portion of the mooring are installed on site prior to the rig arrival. When the rig arrives on site, the AHV recovers the pre-set line and connects it to the corresponding rig end. The pre-set method provides flexibility and allows the option of catenary, semi-taut or taut leg system with wire or synthetic mooring line. The SBOP operations mooring system, whether it is of the conventional, insert wire, or the pre-set design, should satisfy all recommendations contained in these guidelines.

Particular attention must be given to:

- Bollard pull capacity of the AHV to be sufficient for the intended operations
- AHV winch capacity
- Anchor test, if it is necessary, and to which level depending on anchor selection
- Pre-set equipment QA/QC and responsibilities to be clearly established between owner, contractor and possible mooring contractor.
- Pre-set equipment safety when the rig is not around
- Pre-set operation procedure and preparation
- Removal of pre-set system

Rig end mooring line length must be sufficient to reach the pre-set line end with a low tension enabling the AHV to remain maneuverable. In case of a rig equipped with chain, an insert may be used to temporarily reach the pre-set line. In case the rig is equipped with a wire winch, then attention is to be given to the line length remaining on the winch drum when the system is in operation because the winch pulling and holding capabilities decrease with the amount of wire on the drum (unlike with a traction winch).

4.3 Riser and Mooring Management

4.3.1 Offset Criteria

Offset is a critical component in an SBOP operation, thus more stringent limits should be maintained (than with a conventional drilling riser). Riser and riser tensioner limitations will probably determine these limits. The following are samples of the general guidelines which should be developed to assist in operations:

- Green Zone
  - anything <=1.5%
  - Continue normal drilling operations
- Yellow Zone
  - anything >1.5% but <3%
  - Stop drilling and evaluate situation
- Orange Zone

- anything =>3% but <=7%
- Stop operations and secure well in safest and most efficient manner
- Prepare to utilize emergency disconnect device, or abandon well if no device is available

- Red Zone
  - >7% Stop operations
  - Secure or abandon well in safest and quickest manner.

These allowable offset limits are only guidance and should be charted/color coded based on the site-specific mooring and riser analysis. For example, these zones will depend on water depth (i.e., 4,000-ft - 7,000-ft), mud weights (i.e., 12 ppg – 15 ppg), riser size and grade (i.e., high strength 13-3/8”), and station keeping system (i.e., moored vs. DP).

The above-mentioned mooring and riser analyses should be readily available and have been reviewed by both shore based operations support as well as the applicable rig personnel. In particular, key personnel onboard the rig should be familiar with the offset chart and know what procedures to follow for each condition (i.e., Green Zone, Yellow Zone, etc).

It is recommended that the Drilling Contractor or Operator shore base staff have access to a version of mooring software for performing real time analysis and suitably

skilled and experienced engineering staff to perform the analysis.

4.3.2 Mooring Winch Management

Winch operation can be critical in certain cases. Being capable of maintaining the watch circle as described in the mooring analysis is crucial in an SBOP application.

The recommendations below should be followed:
Rig personnel should be familiar and competent with all aspects of winch operation. They should be trained in the use of the winches – whether it be a chain/wire system, chain system, or pre-set system. Quick response times are crucial in cases where a storm hits without any warning, or when a mooring line is broken or lost, or an anchor slips. A rig positioning system must be in place at all times to monitor the vessel excursion.

The rig should have systems in place that indicate clear and concise instructions and procedures for the operation of the mooring winches. These procedures should follow the allowable offset criteria set forth above to indicate when to prepare for winch operations.

In addition to the winch system onboard the rig, an alternate or emergency means to help position the rig should be considered. A fixed pulling point or padeye on the rig designed to withstand the maximum pulling capacity of the AHV should be considered. Appropriate jewelry and

tow-lines should always be available and connected to the rigs padeye and/or towing device, ready to be passed with the rig's crane to the AHV in an emergency.

4.3.3 Rig Positioning Systems

There are numerous on line navigation and positioning DGPS systems used for rig positioning operations. Some larger survey contractors have their own software systems and networks for use of GPS data. Some of the more common types of packages are:

Global Position System (GPS) onboard rig only: This system comprises a GPS antenna feeding a passive GPS signal into a GPS receiver, (which may be typically a 2-channel receiver) that would provide an antenna surface positioning solution from the visible satellites (typically 8 at any one time). The GPS signal could also be received by the reference station(s), which would transmit their corrections to the rig to enable the GPS solution to become a Differential Global Positioning System (DGPS) solution. With this basic package, the survey contractor may only use Single Injection (i.e., use one reference station for the Differential Corrections). If more than one reference station is used for the Differential Corrections, then this is referred to as a multi-reference solution and usually requires a separate computer and monitor to display the positioning solution, based on the differential stations in use.

Global Position System (GPS) onboard rig as well as anchor handling vessels: In addition to the equipment described above, GPS antennae and receivers are installed on the anchor handling vessels (AHVs) in the field. Using this system, the DGPS position of each vessel is transmitted via radio link to the rig for display of the AHV positions on the rig's on-line navigation and data-logging computer. At the same time, the rig transmits its DGPS position to the AHVs and transmits the Differential Corrections from the rig to the vessel(s). Therefore, the vessels can see the rig outline on their screens. The Anchor Foreman for example can send a target position to a vessel so that it has a range and bearing from its present position to the position where the Anchor Foreman wants the tug to drop the anchor.

Acoustic Positioning: Ultra Short Baseline (USBL), Long Baseline (LBL) or a combination of both i.e. LUSBL. USBL is used to track a beacon in the water, which can be installed on a Side Scan Sonar tow wire (for fish tracking) or on an ROV for vehicle tracking. A transducer transmits an acoustic signal to the beacon, which will send back a response that is picked up by the transducer. The two-way time and phase of the signal provides a range and bearing to the beacon which can be displayed as a XY position on the acoustic control and display system, which can be fed into the navigation and positioning system.

The use of LBL, involves laying an array of transponders on the seabed and calibrating the array with DGPS to

navigate and/or accurately position something on the seabed within the array such as a wellhead, subsea equipment, pipeline flange (start-up and laydown), etc. LBL comes in various frequencies such as LF (for long range, MF (for accuracy to say 3-5 meters) to EHF (for short range, sub-meter accuracy, often used for metrology from which spool pieces can be measured for example).

Care should be taken to ensure that there is no interference between the positioning system and the current profiling system in use (if applicable).

A few companies have their own independent on-line QC Position-Monitoring System for real-time QC of the survey contractor's computed drill stem position.

The GPS/DGPS systems are used quite frequently and are accurate to within 2-3 meters typically. These systems can be fairly simple and cost effective for monitoring hole position. Alternatively, acoustic positioning, which requires more hardware to be used, is not as cost effective and is more difficult to install.

This system should be permanent onboard the rig during the SBOP operation. Whichever positioning system is used, properly trained personnel are essential in the correct operation, calibration/setup, and maintenance. It is imperative that a qualified-technician setup the rig's positioning system, as it is an integral part of keeping the well safe.

For a DP vessel, redundancy is also critical for reliable position reference systems. Redundancy is achieved by the use of DGPS and acoustic systems or multiple systems. This level of redundancy is not normally required on a moored rig.

4.3.4 Riser Monitoring and Management

Riser analysis: The drilling riser is a critical component of the system during a SBOP operation, and analysis must be completed and all key personnel should know what mud ranges and required tensions are necessary for the specific location. The maximum allowable ball joint /flex joint angle at the surface and the riser angles at the SID/subsea wellhead at the mudline and in the riser string above the stress joint are also a critical parameters that must be posted on the rig, and procedures must be in place to maintain the allowable angles.

As the riser for SBOP operations is typically threaded coupled pipe (typically wellbore casing), the riser components will experience additional stresses not normally seen when used in the wellbore. As discussed in Section 2.5, a fatigue analysis should be conducted for site-specific parameters such as: casing grade, size, coupling type, met-ocean data, etc.

The rig position indicating system, as described in Section 4.3.3 above, will provide the rig's location with respect to hole position.

The riser may have one or two manual "bullseyes" installed at or near the mudline and one installed mid way up the riser. They should be accurate to within a ½ deg and should range from at least –3 to 3 degrees. These should be positioned in order for an ROV to observe the angle of inclination. It should be noted however that these will not be accurate enough to make determinations as to the rig's position and riser integrity; the rig positioning system should be used instead. ROV retrievable inclinometers and other instrumentation may be considered to measure angles and motions of the high pressure riser, if the additional data is deemed to be of value, depending on the rig and well specific situation.

4.3.5 DP Operations with Casing Risers

When using ship-shaped DP vessels with a casing riser with threaded connections, consideration should be given to potential problems associated with "weather vaning" in response to environmental conditions. A record should be maintained of the amount of rotation of the vessel relative to the initial position at all times, and the status of the riser connections monitored during routine ROV riser inspections.