Wave/current forces on platform decks, if applicable, for any exposure category, should be calculated using the procedure defined in 9.3.4.

**Table 6—Ultimate Strength Metocean Criteria, U.S. Gulf of Mexico [a e f]**

| Category | Design Edition | | |
|---|---|---|---|
| | API 2A-WSD, 19th Edition and Earlier [c] | API 2A-WSD, 20th or 21st Edition | API 2A-WSD, 22nd and Later |
| L-1 | 300-year [b] | 300-year [b] | 1000-year |
| S-2 [d] | 2500-year sudden hurricane | 2500-year sudden hurricane [g] | 500-year |
| C-2 | 25-year | 300-year | 500-year |
| L-3 | 10-year | 100-year | 100-year |

[a] Metocean criteria to be developed in accordance with the requirements of API 2MET. Site-specific metocean criteria should be used in preference to the indicative criteria provided in API 2MET.

[b] L-1 for the 19th, 20th, or 21st Editions shall use the higher load measured as base shear for L-1 or S-2 conditions.

[c] Platforms designed prior to API 2A-WSD, First Edition should be considered as pre-19th Edition.

[d] The development of metocean criteria for platforms categorized as L-2 with S-2 are dependent on the time required to evacuate personnel from the platform, with relevant definitions provided in API 2MET. Shorter evacuation windows and a relaxation in criteria maybe justifiable if supported with defensible evacuation procedures.

[e] The selection of the metocean criteria for areas of shallower water or where wind loads are perceived to dominate it may be necessary to consider a different combination of metocean parameters, such as the wind and associated conditions.

[f] All metocean return periods are for full population hurricane conditions unless noted otherwise.

#### 9.5.1.2 U.S. West Coast

For platforms located on the U.S. West Coast, the ultimate strength assessment shall be performed using site-specific 2500-year metocean criteria developed in accordance with the requirements of API 2MET.

#### 9.5.1.3 Other U.S. Offshore Areas

For platforms located in other U.S offshore areas, the ultimate strength assessment shall be performed using site-specific 2500-year metocean criteria developed in accordance with the requirements of API 2MET.

### 9.5.2 Performance Criteria

#### 9.5.2.1 U.S. Gulf of Mexico

For an ultimate strength assessment using an equivalent linear method, the assessment shall demonstrate that the platform withstands the imposed loads from the metocean criteria defined in Table 6 without member overstress. This may be achieved by ignoring all of the safety factors as recommended in the 22nd Edition of API 2A-WSD for a new platform design.

For an ultimate strength assessment using nonlinear methods, the assessment shall show that the platform withstands the imposed loads from the metocean criteria defined in Table 7 without collapse.

#### 9.5.2.2 U.S. West Coast

For platforms located on the U.S. West Coast, recommended acceptable ultimate strength is a RSR of 1.6. The RSR is defined as the ratio of a platform's ultimate lateral load carrying capacity to a reference lateral loading defined in 8.4.1.2 that is computed using API 2A-WSD, 22nd Edition loading methodologies. This RSR is specific to the metocean conditions and types of platforms used in offshore regions on the U.S. West Coast.

The performance criteria for platforms located on the U.S. West Coast are based on the life safety consequence. Economic and environmental consequence may require consideration of higher performance criteria.

#### 9.5.2.3 Other U.S. Offshore Areas

For platforms operating in other U.S. offshore areas, recommended acceptable ultimate strength is a RSR of 1.6. The RSR is defined as the ratio of a platform's ultimate lateral load carrying capacity to a reference lateral loading defined in 8.4.1.3 that is computed using API 2A-WSD, 22nd Edition loading methodologies. This RSR is specific to the metocean conditions and types of platforms used in U.S. offshore regions outside of the U.S. Gulf of Mexico or West Coast and is not applicable for any other worldwide offshore areas.

The performance criteria for platforms located in other U.S. offshore areas are based on the life safety consequence. Economic and environmental consequence may require consideration of higher performance criteria.

### 9.6 Risk Reduction

Structures that do not meet the metocean loading fitness-for-purpose assessment requirements using the methods recommended will need consequence mitigation and/or likelihood reduction measures. Consequence mitigation and/or likelihood reduction measures should be considered at all stages of a fitness-for-purpose assessment and may be used in lieu of more complex assessment. Detailed recommendations on developing consequence mitigation and likelihood reduction measures are provided in Section 13.

## 10 Assessment for Fatigue Loading

All offshore structures, regardless of location, are subject to fatigue degradation. In many areas, fatigue is a major design consideration due to relatively high ratios of operational sea states to maximum design metocean events. In the U.S. Gulf of Mexico, however, this ratio is low. Still, fatigue effects should be considered and engineering decisions should include consideration of fatigue analysis results.

In the U.S. Gulf of Mexico, cracking due to fatigue is not generally experienced. If cracks occur, they are most likely found at joints in the first horizontal conductor framing below water, normally resulting from fatigue degradation. Fatigue cracks may also occur at the main brace to leg joints in the vertical framing at the first bay above mudline, normally due to metocean overload (i.e. low cycle fatigue), or at the perimeter members in the vertical framing at the first bay below-water level, normally as a result of boat impact.

As part of the assessment process for future service life, consideration should be given to accumulated fatigue degradation effects. Where Levels III and/or IV inspections are made and any known damage is assessed and/or repaired, no additional analytical demonstration of future fatigue life is required. Alternatively, adequate fatigue life may be demonstrated by means of an analytical procedure compatible with those specified in API 2A-WSD, 22nd Edition.

In some cases, Level IV inspection of the joint can be used to “reset” accumulated fatigue degradation if there is no evidence of surface cracking. Such information can also be used to establish risk-based inspection intervals as discussed in 6.5.2.2. Monitoring fatigue-sensitive joints, and/or reported crack-like indications, is an acceptable alternative to analytical verification.

## 11 Assessment for Seismic Loading

### 11.1 General

The assessment of platforms for seismic loading shall follow the analysis procedures and criteria definition for offshore structures as specified in API 2EQ. The basic flow chart shown in Figure 5 is applicable to determine the fitness-for-purpose for seismic loading.

All platforms located in U.S. areas with seismic activity are considered L-1 exposure category.

## 11.2 Simplified Analysis

A validated simplified analysis may be used for seismic assessment as defined in 8.5.2. However, the simplified analysis should be demonstrated to be more conservative than a detailed seismic strength analysis.

## 11.3 Design Basis Check

The design basis check procedures noted in 8.5.1 are appropriate provided no significant new faults in the local area have been discovered, or any other information regarding site seismic hazard characterization has been developed that significantly increases the level of seismic loading used in the platform's original design.

For all exposure categories defined in 5.3.4, platforms designed or recently assessed in accordance with the requirements of API 2A-WSD, Seventh Edition, which required safety level analysis (referred to as "ductility level analysis" in subsequent editions), are considered to be acceptable for seismic loading, provided the following:

a) no new significant fault has been discovered in the area;

b) no new data indicate that a current estimate of strength level ground motion for the site would be significantly more severe than the strength level ground motion used for the original design;

c) proper measures have been made to limit the life safety risks associated with platform appurtenances as noted in API 2A-WSD, 22nd Edition;

d) the platforms have no significant unrepaired damage;

e) the platforms have been inspected;

f) the present and/or anticipated payload levels are less than or equal to those used in the original design.

## 11.4 Extreme Level Earthquake

For seismic fitness-for-purpose assessments, the extreme level earthquake (ELE) analysis is not applicable. An abnormal level earthquake (ALE) analysis is required if the platform does not pass the design basis check or screening.

## 11.5 Abnormal Level Earthquake

### 11.5.1 Assessment Criteria/Loads

The assessment criteria and procedure for performing an ALE assessment shall be based on the recommendations in API 2EQ.

### 11.5.2 Performance Criteria

Assessments of platforms may be considered adequate for seismic loading provided it can be demonstrated that the platforms meets the performance criteria for an ALE as defined in API 2EQ. For platforms designed to the 19th Edition or earlier, 1000-year return period conditions can be used for the ALE assessment. In addition, the life safety requirements associated with platform appurtenances as provided in API 2A-WSD, 22nd Edition shall be met.

## 11.6 Risk Reduction

Structures that do not meet the seismic loading fitness-for-purpose assessment requirements using the methods recommended will need consequence mitigation and/or likelihood reduction measures. Consequence mitigation and/or likelihood reduction measures should be considered at all stages of a fitness-for-purpose assessment and may be used in lieu of more complex assessment. Detailed recommendations on developing consequence mitigation and likelihood reduction measures are provided in Section 13.

# 12 Assessment for Ice Loading

## 12.1 General

For all platforms which may be subject to ice loading, the assessment shall follow the procedure provided in API 2N. The loads used for the assessment shall be identical to those used for design unless reevaluation of ice loading data results in a justifiable change in criteria. The selection of the appropriate ice criteria and loadings are provided in API 2N. However, it is noted that the ice feature geometries provided in API 2N are not associated with any return period as no encounter statistics are presented.

All references to simple, design level, and ultimate strength analyses in Section 8 assume the use of the values noted in API 2N. Where ranges of loads are recommended, the smaller number can be used for a design level assessment and the larger number can be used for an ultimate strength assessment. Additional details can be found in Reference [17]. Special attention should be given to exposed critical connections where steel was used that were not specifically specified for low temperature service.

## 12.2 Design Basis Check

A design basis check may be used to demonstrate the fitness-for-purpose of a platform for ice loading, provided that it has been maintained and inspected, has had no increase in design level loading, is undamaged, and was designed or previously assessed in accordance with API 2N. The design basis check is applicable for all platform exposure categories defined in 5.3.4.

## 12.3 Simplified Analysis

A validated simplified analysis may be used for the assessment of ice loading. It shall be demonstrated that the simplified analysis will be as or more conservative than the design level analysis.

## 12.4 Design Level Method

L-1 exposure category platforms that do not meet the screening criteria may be considered adequate for ice loading if they meet the provision of API 2N, using a linear analysis with the basic allowable stresses referred to in API 2A-WSD, 22nd Edition, increased by 50 %.

C-2 exposure category and C-3 exposure category platforms that do not meet the screening criteria may be considered adequate for ice loading if they meet the provisions of API 2N using a linear analysis with the basic allowable stresses referred to in API 2A-WSD, 22nd Edition, increased by 70 %.

## 12.5 Ultimate Strength Method

Platforms that do not meet the design level analysis requirements may be considered adequate for ice loading if an ultimate strength analysis is performed using best estimate resistances and the platform is shown to have a RSR equal to or greater than 1.6 in the case of L-1 exposure category platforms and a RSR equal to or greater than 0.8 in the case of C-2 exposure category and C-3 exposure category platforms. RSR is defined as the ratio of platform ultimate lateral capacity to the lateral loading computed with API 2N.

## 12.6 Risk Reduction

Structures that do not meet the ice loading fitness-for-purpose assessment requirements using the methods recommended will need consequence mitigation and/or likelihood reduction measures. Consequence mitigation and/or likelihood reduction measures should be considered at all stages of a fitness-for-purpose assessment and may be used in lieu of more complex assessment. Detailed recommendations on developing consequence mitigation and likelihood reduction measures are provided in Section 13.

# 13 Risk Reduction

## 13.1 General

Risk reduction measures should be considered if a structure does not meet the fitness-for-purpose performance criteria, as defined in Section 9 for metocean loading, Section 9 for fatigue loading, Section 11 for seismic loading, and Section 12 for ice loading. Risk reduction should be considered at all stages of assessment and may be used in lieu of more complex assessment.

Risk reduction may include consequence mitigation through measures that reduce the exposure of the platform or may include likelihood reduction through measures that reduce the likelihood of platform failure.

## 13.2 Exposure Reduction

### 13.2.1 Life Safety

Life safety mitigation measures involve demanning the platform either permanently or temporarily during a forecasted extreme event.

### 13.2.2 Consequence of Failure

Consequence of failure mitigation measures should include one or more of the following:

a) installation of subsurface safety valves that are manufactured and tested in accordance with applicable API standards,

b) removal or reduction of hydrocarbon storage or inventory volume,

c) removal or rerouting of major oil lines,

d) removal or rerouting large volume gas flow lines,

e) permanent abandonment or temporary abandonment of nonproducing wells,

f) isolation of the pipeline to reduce the potential volume of hydrocarbon release.

### 13.2.3 Hurricane Preparedness

Advanced planning can reduce hurricane risks as well as improve post-hurricane response. Written hurricane preparedness plans should be developed covering both general hurricane preparedness activities and structure-specific response activities. Checklists and platform-specific guides can assist during the evacuation process. Platforms with higher life safety, environmental, and/or economic risk may require additional considerations.

Examples of hurricane preparedness are as follows.

a) Evacuation planning for major hurricanes, including priority evacuation of platforms that are at greater risk of failure and those that are furthest from shore. Initial evacuation of nonessential personnel should begin early.

b) Evacuation planning for sudden hurricanes that occur with short notice should be given special consideration, including evacuation from S-2 and C-2 offshore platforms to more robust L-1 platforms.

c) Begin preparing structure operations for safe shut-in as early as possible including system pump down, securing equipment and control panels, reducing liquid inventories, etc.

d) Secure loose objects and equipment that can become airborne projectiles. Store movable equipment in safe and dry areas (e.g. generators).

e) Develop advance plans for accessing the structure post-hurricane should normal access and safety systems such as boat landings, walkways, power, etc. not be available due to damage.

f) Establish evaluation guidelines and procedures for the eventual safe reboarding of a damaged structure in terms of whom, how, and when. Minimum acceptance criteria for platform access should be established.

g) Identify critical members and joints for structural integrity for post-hurricane inspections.

## 13.3 Likelihood Reduction

### 13.3.1 General

Several likelihood reduction methods are available, with details on their implementation provided in:

— 13.3.3 for removal of a known damaged component,

— 13.3.4 for load reduction,

— 13.3.5 for localized strengthening or repair, and

— 13.3.6 for global strengthening or repair.

Strengthening of the jacket structure can be an effective means of reducing the likelihood of failure of the platform. The strengthening scheme should be designed to increase the system capacity of the platform to the level necessary to meet the appropriate performance criteria, for the exposure category of the platform as defined in 5.3.4. Alternatively, it is possible to modify the structure to reduce the loading.

The platform fitness-for-purpose shall be demonstrated for the selected likelihood of failure reduction method.

### 13.3.2 Factors to Consider

There are a large number of SMR techniques available for consideration as shown in Figure 8. The platform fitness-for-purpose assessment, as defined in Section 8, will determine whether platform strengthening or repair is required to meet the assessment performance criteria. If strengthening and repair are to be considered, the assessment model should be used to develop strengthening options. Global and local SMR schemes should be considered in terms of their effects on the structure as a whole.

Once a decision has been made in favor of SMR, an appraisal should be completed of all available SMR techniques. Subsequently, the most appropriate scheme from technical, cost, and safety standpoints should be selected. Considerations for selecting and designing a SMR technique include, but are not limited to, the following:

a) safety of diving, diving support, construction, and operations personnel;

b) potential for use of diverless techniques;

c) difficulty of fabrication, handling, and installation;

d) rigging complexity and layout;

e) list support vessel type, availability, and access;

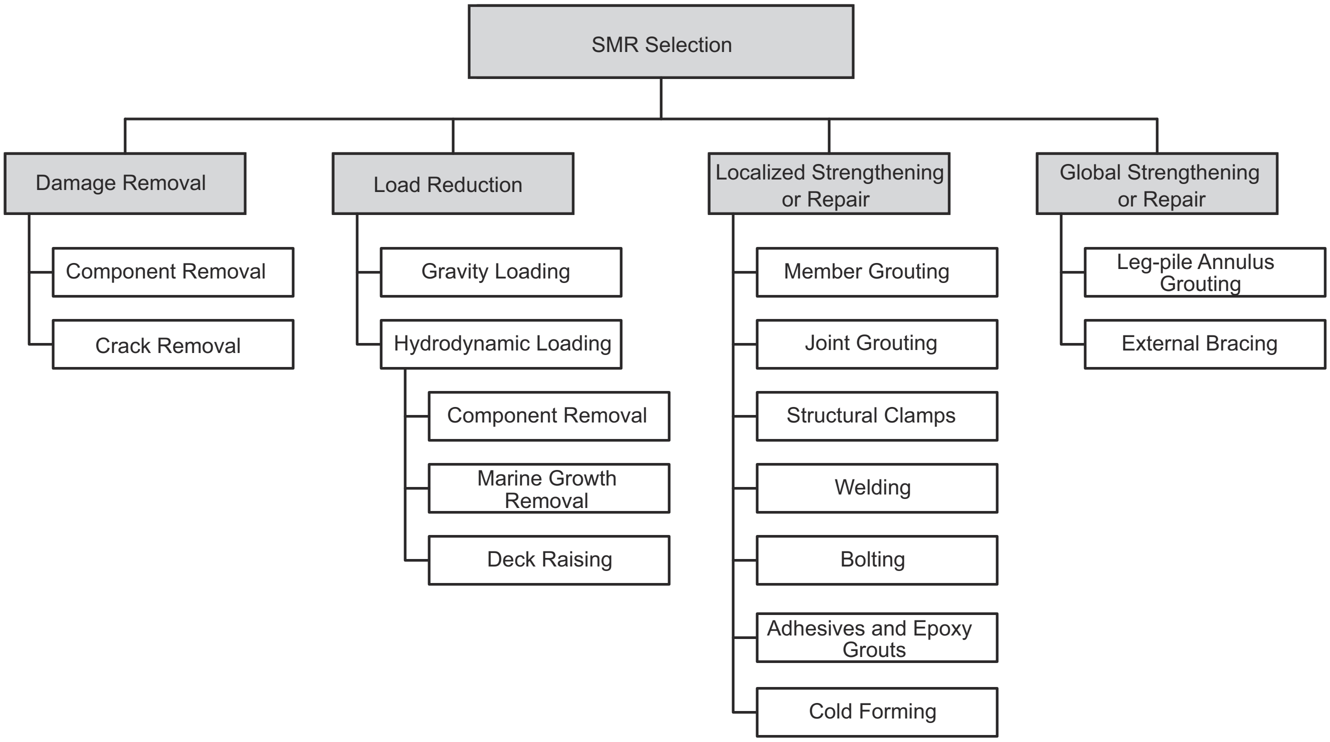


**Figure 8—SMR Techniques**

f) fit-up tolerance (clamps and members);

g) interference with conductors, jacket members, and appurtenances (sumps, caissons, anodes, etc.);

h) potential for collision with existing risers and control bundles;

i) requirements for predesign inspection, field measurements, and materials samples;

j) outfitting with well-designed installation aids;

k) required weather windows.

The design practices for platform SMR are usually outside the scope of recognized codes of practice, standards, and regulations. Competent assessment engineering should determine the need for and appropriate selection of either, or both, load reduction or strengthening options. Strengthening and repair of existing platforms requires specialist engineers to provide reliable and economical solutions that can be efficiently and safely installed.

### 13.3.3 Damage Removal

#### 13.3.3.1 General

An approach to the SMR of damaged structures is to completely remove the damage.

#### 13.3.3.2 Member Removal

The removal of damage by cutting out the affected member should only be considered if it can be demonstrated during the assessment phase that the member is no longer required for the structure's in-place condition.

#### 13.3.3.3 Crack Removal

The removal of cracks may be achieved by remedial grinding. In the case of cracks caused solely by fatigue loads (i.e. not in combination with a fabrication defect), other SMR techniques may be considered in addition to grinding.

### 13.3.4 Load Reduction

#### 13.3.4.1 Gravity Loading

During the operation of the platform the actual topsides loading may be significantly lower than the loads assumed for the design of the platform. Operational procedures can be implemented to reduce and control topsides loads, for example by:

— removal of unnecessary equipment and/or structures,

— effective weight management procedures with defined weight limits,

— use of lightweight drilling rigs or rigless operations, and

— use of cantilever jack-up drilling operations.

The major impact of load reductions will be to reduce leg and pile stresses and pile reactions. Reduced mass generally has a beneficial effect on platform dynamics (although not necessarily for earthquake response) although in most instances, this effect will generally be small. On platforms with pile tips founded in sand layers, tensile pile capacities may need to be checked. One potential benefit of removing equipment is a possible associated reduction of wind area.

#### 13.3.4.2 Hydrodynamic Loading

##### 13.3.4.2.1 General

Several methods are available for reducing hydrodynamic loads on existing platforms.

##### 13.3.4.2.2 Component Removal

Load reduction may be achieved by removing items that attract metocean loading; this will be most beneficial in the upper water column where wave kinematics is highest.

Removal of nonessential or out-of service components such as barge bumpers, boat landings, walkways, stairs, or risers can reduce load. Boat landings, walkways, stairs, and ladders can be removed only after verifying that they are no longer part of the platform escape routes (see 6.3.5.6).

Removal of conductors can reduce load; however, conductors may also contribute to the capacity of the platform foundation. This should be confirmed during the assessment process. If the conductors increase the foundation capacity of the platform, consideration may be given to removal of the upper portion in order to reduce the hydrodynamic loads.

Removal, or relocation, of equipment on lower deck elevations can reduce loads on the platform in the event of wave inundation of the deck.

##### 13.3.4.2.3 Marine Growth Removal

Load reduction may be achieved by the removal of areas of excessive marine growth. However, the amount of load reduction to be achieved should be evaluated prior to implementation. The load reduction to be achieved will need to be sufficient (in combination with any other load reduction measures) to enable the platform to meet assessment criteria. Measures shall be taken to ensure that returning growth does not cause the hydrodynamic loading to exceed the level required to pass assessment. Such measures may include installation of sliding marine growth preventers and/or adding periodic removal to the SIM program for the platform.

#### 13.3.4.2.4 Raise Deck

For platforms where the wave crest is expected to inundate the deck, raising the deck out of the wave crest will significantly reduce global hydrodynamic loading. However, the structural stability of increased deck legs lengths shall be evaluated.

Due to the high cost and operational impact of raising the deck the cost-benefit should be considered on a case-by-case basis. An alternative to raising the deck is to remove or relocate equipment and nonessential structures from the lower deck elevations; this results in lower hydrodynamic forces and will reduce equipment damage from direct wave loads.

Deck grating instead of plating can be beneficial in reducing vertical loads on the underside of the deck by allowing encroaching water and trapped air to dissipate more easily.

In some locations, field subsidence has caused a general settling of the seafloor. Mitigation alternatives for this case often rely on reservoir pressure techniques such as water or gas injection. This approach, however, does not recover lost height but can be used to slow future subsidence.

Some platforms with low decks have been strengthened by direct bracing to a modern structure. This allows for the placement of the process and control equipment on the new, acceptably high, deck. The affected structure may then be reduced to a wellhead platform.

#### 13.3.4.2.5 Hydrodynamic Blockage and Shielding

In special situations, in particular for structures having dense framing, hydrodynamic studies may be able to justify lower hydrodynamic forces than used in the original design. Dense framing has the effect of developing internal shielding of the members and may result in lower overall global loads.

### 13.3.5 Localized Strengthening or Repair

#### 13.3.5.1 General

Localized strengthening or repair can be used to directly strengthen or repair a component without altering load paths within the structure. For damaged structures, the damage will normally be left in place. The designer should recognize that additional load may be attracted to the component, either by virtue of its increased stiffness following SMR or due to increased hydrodynamic loads. Localized strengthening or repair options include the following:

a) grout filling—members and joints;

b) clamps—unstressed grouted, stress grouted, mechanical, and elastomer lined;

c) welding, one atmosphere, wet welding, and hyperbaric techniques;

d) weld improvement, grinding, shot peening, and toe dressing;

e) member removal as a standalone repair technique;

f) mechanical repair system such as bolts and swaging;

g) composite materials.

#### 13.3.5.2 Member Grouting

Member grouting, which involves completely filling the tubular member with grout, can be used as an effective means to enhance their axial compressive capacity. This procedure will not be fully reliable unless complete grouting along the member length can be assured (i.e. avoiding voids at the member end). For bending strength increases near midspan, the presence of small voids at member ends is less critical.

Additionally, tests have shown that significant capacity (up to the original capacity) can be obtained by grouting all or only the dented portion of dented members.

The impact of the increased gravity loads and dynamic mass as well as possible decommissioning implications should be considered before grouting.

#### 13.3.5.3 Joint Grouting

Grout filling of tubular chord elements can be used to improve the static strength of the joint and if needed increase the fatigue life of the connections at the joint. The repair method has the advantage of introducing no additional metocean loads on the platform; however, the increased chord rigidity restricts joint ovalization thereby significantly increasing joint capacity for both compression and tension loads. In some cases, grouting may also increase the moment at the joints and this should be considered.

Grouting may be counterproductive for seismically loaded structures, where the grouting leads to an increase in joint stiffness and a reduction in joint ductility. In addition, the impact of the increased gravity loads and dynamic mass as well as possible decommissioning implications should be considered before grouting.

#### 13.3.5.4 Structural Clamps

Structural clamps can be an effective means to repair brace members or joints of jacket structures. They can also be used to connect external bracing to additional piles in a global strengthening scheme, to add new members into a structure to increase redundancy, to increase the capacity of existing members or joints, and/or to reinstate the capacity of damaged members of joints.

Stressed clamps rely on bolt tension to induce hoop stress around the member or joint to resist axial and bending loads in the structure. In many cases, the clamp is made oversized in order to accommodate lack-of-fit tolerances and the annulus between the clamp and the structure is grout filled prior to bolt tensioning—the grout acts a load transfer medium. Unstressed grouted clamps can be applied to intact or damaged brace members to increase the axial and bending capacity of the member.

Reliable structural clamp design is a specialized activity that requires careful control of bolt strength, bolt length, fatigue design, and detailing to avoid loss of prestress over the life of the repair. Tight fabrication tolerances are required to avoid fit-up problems during fabrication and suitable installation procedures are essential to effective long-term performance.

#### 13.3.5.5 Underwater Welding

Welding is often regarded as the best strengthening or repair technique and would be used even more often if it were not for certain operational difficulties in its execution. There are several underwater welding techniques that can be considered, such as

— dry welding at or below sea surface at one atmosphere using a cofferdam or pressure-resisting chamber,

— hyperbaric welding using habitats, or

— underwater wet welding.

Repairs by both cofferdam and hyperbaric habitat welding techniques have proven track records and can produce high quality welded connections. The disadvantages to both are the high cost and extended schedules associated with cofferdam or habitat design, fabrication and deployment, and the associated hazardous diving operations.

Wet welding is underwater welding, when the arc is operated in direct contact with the water. The principal advantage over conventional welding is the ability to weld below the water surface without the need for a welding habitat or chamber. Provided the weld is suitably designed for low stress, good fit-up can be assured, and the parent material is tested to ensure compatibility, wet welding can be a viable solution.

#### 13.3.5.6 Bolting

Bolts are an integral part of steel repair clamps and are found in riser and other pipe supports throughout a platform. They are used for topsides repair where a bolted joint can be made in a hazardous area without the need to shut down the platform operations.

Maintaining the long-term bolt tension is critical to a safe bolt design. Proof of the applied tension at the time of bolt installation is the normal standard for acceptance and should be indicated by the pressure applied through hydraulic equipment. Good engineering practice demands that the loss of bolt tension through load transfer and elastic relaxation be calculated. Additional long-term bolt tension losses can occur by creep in stressed grouted and elastomer-lined clamps.

There are physical limits placed on bolt sizing, spacing, and group number when tensioning devices are used. Also, corrosion of bolting materials has been a problem and particular attention should be given to material selection of bolts on any part of an offshore installation.

#### 13.3.5.7 Member Removal

Structural member removal may be a staged development in a larger repair scheme or may constitute a repair in its own right. In either event the structural framework will need to be checked to ensure adequacy under the proposed loading and revised framing configuration.

#### 13.3.5.8 Member Flooding

The intentional flooding of structural members that are subjected to a combination of structural and hydrostatic loading can be used as a method for increasing the load carrying capacity of the member. The impact of the increased gravity loads and dynamic mass as well as possible decommissioning implications should be considered before flooding members.

#### 13.3.5.9 Adhesives and Epoxy Grouts

There are three main structural uses of resins offshore: as adhesives, as grout, and as the matrix in composite materials.

#### 13.3.5.10 Cold Forming

Two broad categories of cold forming techniques are available: mechanical connectors and swaging.

A swaged connection between two concentric tubular members is formed when the inner one is expanded (by internal pressure) and is plastically deformed into grooves machined in the other member. The technique has been used to successfully make pile-sleeve connections offshore.