



GUIDE FOR

RISK EVALUATIONS FOR THE CLASSIFICATION OF MARINE-RELATED FACILITIES

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**American Bureau of Shipping
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Foreword

The mission of the American Bureau of Shipping (ABS) is to serve the public interest, as well as the needs of its clients, by promoting the security of life, property, and the natural environment primarily through the development and verification of standards for the design, construction and operational maintenance of marine-related facilities.

The Rules on which classification is predicated are established from principles of naval architecture, marine engineering and other engineering principles that have proven satisfactory by service experience and systematic analysis. The perceived benefits of the deterministic and prescriptive regulatory requirements were based mostly on experience, testing programs and expert judgment. The objective of these Rules has always been to ensure that the probabilities of accidents with the potential for adversely affecting life, property and the natural environment are low. However, this assurance was not explicit, as Rules and regulations until recently were developed without the benefit of explicit estimates of risk.

In recent years, there have been significant advances in and experience with risk assessment methodology. ABS is continually seeking the improvement of its Rules and methods of analysis and exploring the directions where the industry is headed. Thus, ABS is exploring certain changes to the development and implementation of its Rules and regulations through the use of risk-based, and ultimately performance-based, approaches. The rewards for this potential process are improved classification services and, ultimately and foremost, improved safety and productivity.

The transition to a risk-based regulatory framework is expected to be incremental. Many of the present requirements are based on deterministic and prescriptive requirements that cannot be quickly replaced. Therefore, the current requirements will have to be maintained, while risk-based and/or performance-based approaches are being developed and implemented.

The information and process outlined in this Guide provides a risk-based perspective to evaluating proposed designs that offer alternative means of compliance to current prescriptive requirements, or novel designs for which classification requirements do not exist. This perspective offers many advantages to ship owners/designers and ABS. Some of these advantages are:

- i) Increased ability to suggest innovative designs that are technically superior and more cost-effective.
- ii) Increased confidence that the proposed designs will provide the same level of safety.
- iii) Better understanding of hazards, mitigation measures, and risk posed by the proposed design.

The process defined in this Guide provides a sound and practical approach for performing risk-evaluations to support the classification of proposed designs, so that the advantages listed above can be realized.

This document provides guidance on how to prepare a risk-based submittal to demonstrate that a proposed design meets the overall safety and strength standards of the Rules. It defines a process that the client can implement to prepare and submit documentation for consideration by ABS. It also outlines the approach that ABS will take in reviewing the submittal to determine if the proposed design is acceptable for classification.

Additional guidance will be published on the application of risk-based approaches to classification activities, such as the *ABS Guidance Notes on Review and Approval of Novel Concepts*, the *ABS Guide for Surveys Using Risk Based Inspection Techniques*, and the *ABS Guide for Surveys Based on Reliability Centered-Maintenance*.

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SECTION 1 General

1 Objective

This document provides guidance to ABS clients on how to prepare a risk evaluation to demonstrate that a design proposed for classification meets the overall criteria for safety and strength standards of the ABS Rules and Guides. It defines a process that the client can implement to prepare and submit documentation for consideration by ABS. It also outlines the approach that ABS will take in reviewing the submittal to determine if the proposed design is acceptable for classification.

2 Application

This document applies to any situation where a design is being proposed on the premise that it provides equivalent protection against the risks addressed by the ABS Class Rules, rather than by strict compliance with existing prescriptive classification Rules. Evaluations of hardware and survey issues are included in the scope of this document.

This Guide is applicable to both ships and offshore facilities. Specifically, this Guide is applicable when ABS clients are proposing:

- i) *Alternative Arrangements.* Marine-related facilities with design characteristics that include alternative means of compliance to applicable prescriptive classification Rules.
- ii) *Novel Features.* Marine-related facilities that contain novel features of design in respect to the hull, machinery, or equipment to which provisions of the Rules are not directly applicable.

A special comment will be entered in the *Record* indicating that classification of the vessel/installation has incorporated the provisions of this Guide.

If proposed designs include alternative arrangements or novel features that conflict with existing applicable statutory requirements or regulations from any other regulatory body outside ABS, the decision for approval lies with those external bodies. While many regulatory bodies are evolving to accept the use of risk evaluations to demonstrate safety equivalency to prescriptive requirements, there may always be a number of regulatory bodies that will not accept such flexibility. The cognizant administration or regulatory body is the final determining body for statutory or regulatory requirements under their jurisdiction.

Note that if a proposed design is categorized as a Novel Concept according to the application scope defined in the *ABS Guidance Notes on Review and Approval of Novel Concepts*, then those Guidance Notes should be followed, unless otherwise instructed by ABS.

3 Definitions

Absolute Risk is the expression of risk in terms of the specific estimates of the frequency and consequence.

Acceptable Risk is the expected risk that is considered tolerable for a given activity.

Analysis Team is a team of the subject matter experts and risk analyst(s) who are responsible for performing the risk assessment.

Change Analysis is a comparative risk assessment technique that logically identifies risk impacts and risk management strategies in situations where change is occurring.

Confidence is the analyst's/team's certainty of the risk evaluation.

Consequence is an unwanted event that can negatively affect subjects of interest. It can be expressed as number of people affected (injured or killed), property damage, amount of a spill, area affected, outage time, mission delay, dollars lost or other measure of negative impact.

Direct Design is a design that results from the direct application of the ABS Rules or Guides.

Evaluation Metrics are qualitative and/or quantitative parameters selected to characterize or evaluate a proposed design in terms of its level of safety, that are used to judge the adequacy of the proposed design for classification. The evaluation metrics could be directly a risk measure (e.g. fatalities per year), but it could also be any one component that affects risk. Examples of evaluation metrics are: the reliability of a system, the frequency of loss of propulsion events, the number of safeguards available to mitigate a fire in a specific location, etc.

Event is an occurrence that has an associated outcome. There are typically a number of potential outcomes from any one initial event that may range in severity from trivial to catastrophic, depending upon other conditions and subsequent events.

Frequency is the expected number of occurrences of an undesirable event expressed as events per unit time.

Hazards are conditions that exist that may potentially lead to an undesirable event.

Major Hazard is a hazard with potentially unacceptable risk if not eliminated, controlled, and/or managed. Chapters 4 and 5 of ABS's *Guidance Notes on Risk Assessment Application for the Marine and Offshore Oil and Gas Industries* provide a list of major hazards.

Qualitative Risk Assessment is a risk assessment that expresses the risk in terms of quality or kind (e.g., low, high, very high).

Quantitative Risk Assessment is a risk assessment that expresses the risk in terms of risk impact per unit time (e.g., \$1,000,000 per year).

Relative Risk is the expression of the change in risk relative to a case of interest or baseline case.

Risk is the product of frequency with which an undesirable event is anticipated to occur and the consequence of the event's outcome.

Risk Analysis is the process of understanding (1) what undesirable things can happen, (2) how likely they are to happen, and (3) how severe the effects may be. More precisely, it is an integrated array of analytical techniques, e.g. reliability, availability and maintainability engineering, statistics, decision theory, systems engineering, human behavior, that can successfully integrate diverse aspects of design and operation in order to assess risk.

Risk Assessment includes a risk analysis, but it also involves the process by which the results from risk analysis are considered against judgment, standards or criteria.

Safety Margin is an adjustment made to compensate for the uncertainties and assumptions used in the risk assessment.

Sensitivity Analysis is the determination of how rapidly (sensitive) the output of a risk analysis changes with respect to variations in the input (it can include variations in input data or assumptions.)

SECTION 2 Concept of Equivalency

1 General

Proposed designs that do not strictly comply with applicable prescriptive classification Rules can be submitted to ABS for consideration for class under the terms of this Guide, if equivalency to the ABS Rules and requirements is demonstrated. For a design to be considered equivalent, it must provide compliance with the overall criteria for safety and suitability for intended service established in the applicable ABS Rules and Guides. This is called an equivalency demonstration.

An equivalency demonstration can be relatively simple in some cases, but it can be very complicated in others. It depends on the degree of innovation of the proposed designs, on the number of prescriptive requirements involved and on the nature of the goals/objectives of those requirements.

The key issue in the demonstration of equivalency is the identification of the criteria for safety and suitability for intended service of the applicable ABS requirements. These criteria are the objectives of the ABS Rules.

The primary objective of the classification Rules and Guides is to promote the security of life, property and the natural environment. Consequently, any equivalency demonstration needs to consider the following areas:

- i) Personnel safety
- ii) Property protection
- iii) Environmental protection

The objectives of the Rules constitute the foundation for demonstrating equivalency. A proposed design can be approved for classification under the terms of this Guide if it is shown that even though some prescriptive requirements are not strictly complied with, all the goals and objectives of those affected requirements are being met by the proposed design. This equivalency can be demonstrated by defining parameters for evaluation, based on the goals and objectives of the Rules under consideration, and then demonstrating that the estimations of those parameters for the proposed design are acceptable or equivalent to the same parameters for the direct design. The following subsection describes the concept of these parameters called evaluation metrics.

2 Evaluation Metrics

Evaluation metrics are qualitative and/or quantitative parameters selected to characterize or evaluate a proposed design in terms of its level of safety. They are used to judge the adequacy of the proposed design for classification. The goals and objectives of the prescriptive classification Rules constitute the foundation for defining the evaluation metrics that can be used to demonstrate acceptability for classification.

In the most generic case, the total risk of a proposed design constitutes a valid evaluation metric that could be used to demonstrate acceptability for classification design. However, in many cases, the estimation of such metrics could be very time consuming, and its accuracy may not be sufficient to confidently arrive at an acceptability conclusion. In general, it is advisable to select evaluation metrics

that are simple to estimate, and still capture the goals and objectives of the Rules for which alternative compliance is being sought. Examples of simpler evaluation metrics could be: the reliability of a system, the frequency of loss of propulsion events, the number of safeguards available to mitigate a specific undesirable event, etc. Being that the objectives of ABS Rules and requirements are to reduce risks, the evaluation metrics are always going to be related to risk, directly or indirectly. For that reason, risk assessment techniques are useful to estimate the evaluation metrics.

The selection of appropriate evaluation metrics is a very important task in determining equivalency, because the evaluation effort and adequacy of the demonstration are directly dependent on this selection. The following subsections give more details on the selection of evaluation metrics for the two distinctive cases of application: alternative arrangements and novel features.

3 Evaluation of Alternative Arrangements

Alternative arrangements refer to proposed designs that include alternative means of compliance to applicable prescriptive classification Rules. In most cases, the affected classification Rules are going to be limited in number, so that the equivalency analysis can be limited in scope to the goals and objectives of only those affected Rules. The selection of evaluation metrics to represent the identified Rule goals and objectives becomes more manageable. If such goals and objectives are not explicitly stated, and cannot be easily inferred, ABS can be contacted for guidance.

Additionally, for alternative arrangements, a comparable direct design is normally easily identified and defined, so that the selection of evaluation metrics and equivalency evaluation can be performed in terms of a comparative assessment. In this case, the change analysis methodology, or any other comparative assessment, should be selected to start the evaluation, as described in Section 5 on Basic Risk Assessment.

Examples of evaluation metrics for alternative arrangements can be:

- i) The reliability of a subsystem (to be compared to the reliability of the comparable subsystem that results from the direct application of the ABS Rules and Guides)
- ii) The effectiveness of a proposed protective control (to be compared with the effectiveness of a specific protective control required by a Rule requirement)

In determining equivalency, there are two major attributes that must be considered:

- i) The safety performance of the proposed design (e.g., the hazards and potential undesirable events addressed by the design) is acceptable, preferably as compared to a direct design, i.e. in comparative terms, or in absolute terms if a comparative assessment is not possible
- ii) An assurance that no new unacceptable hazards are introduced by the proposed design.

Based on these two attributes, equivalency can be established by performing a hazard identification, defining adequate evaluation metrics and applying appropriate risk assessment methodologies to assess the evaluation metrics.

4 Evaluation of Novel Features

Novel features are innovative and unique designs for which provisions of the Rules are not directly applicable, and therefore specific goals and objectives are not available. If a comparable design is identified, then the evaluation can be made in comparative terms to demonstrate equivalency as described in the Evaluation of Alternative Arrangements. However, in some cases, a comparable design cannot be identified, so comparisons are not possible, and “equivalency” cannot be established by comparative means. For such cases, these novel features must be considered for classification based on the concept of acceptability, derived from pre-established (i.e. by the organization, regulatory agency) acceptance criteria.

The selection of evaluation metrics is still possible, based on identified generic objectives, depending on the nature of the novel features. Examples of evaluation metrics for novel features can be:

- i) The number of safeguards provided in the novel design for each potential undesirable event.
- ii) The total risk for the proposed installation.
- iii) The target reliability or frequency of failure of the installation.

For completely new designs, the acceptability demonstration needs to be based on the overall safety of the design, i.e. through an absolute risk assessment.

5 Acceptance Criteria

Once the evaluation metrics are assessed, either qualitatively or quantitatively, they need to be compared with pre-established acceptance criteria. The acceptance criteria can be qualitative (e.g. risk matrix) or quantitative, in accordance with the evaluation metrics selected. The acceptance criteria can be defined in absolute or relative basis, depending on the type of risk assessment (absolute assessment or comparative assessment) and the type of equivalency evaluation being made

In using absolute criteria, each evaluation metric is compared to previously established acceptance criteria. These criteria can be derived from existing designs with an adequate amount of operational history, from internally derived criteria, or from recognized external sources. Appendix 5 provides a survey of risk acceptance criteria used by some organizations.

For relative criteria, equivalency is determined by judging if the level of the defined evaluation metrics increases, decreases, or remains unchanged when compared to the same metrics for a direct design. In general, detrimental or unfavorable changes in the evaluation metrics are not allowed.

In addition, the degree of confidence in the qualitative judgments and quantitative measures needs to be considered when establishing equivalency. The confidence in the estimations of the evaluation metrics is key in determining the safety margin required for the proposed design to be considered equivalent. A high confidence can allow a design to be accepted as equivalent with lower safety margin than the same design with a low confidence in the estimated value of the evaluation metrics.

SECTION 3 Risk Evaluation Process

1 General

Due to the fast pace at which technology develops in the industry, ABS recognizes that ship and offshore facility designers and Owners have the need to propose novel designs, or designs that include alternative means of compliance to existing ABS Class Rules. Typically, alternatives or novel designs are proposed as a means to optimize resources while at the same time providing an equivalent (or better) level of safety. The application of risk evaluations provides a practical and effective means to demonstrate that the proposed designs appropriately manage the risk, and thus provide an equivalent level of safety. The evaluation process described in this section provides ABS clients with a formal method for risk evaluation when proposing designs to ABS for classification approval.

The major activities in the evaluation process are:

Step 1 – Define the objectives of the evaluation.

Step 2 – Conduct a Basic Risk Assessment (comparative or absolute).

Step 3 – Conduct a Detailed Risk Assessment (comparative or absolute, if needed).

Each of these steps is explained in Sections 4 through 6, respectively. Section 3, Figure 1 is a flowchart outlining the risk evaluation process.

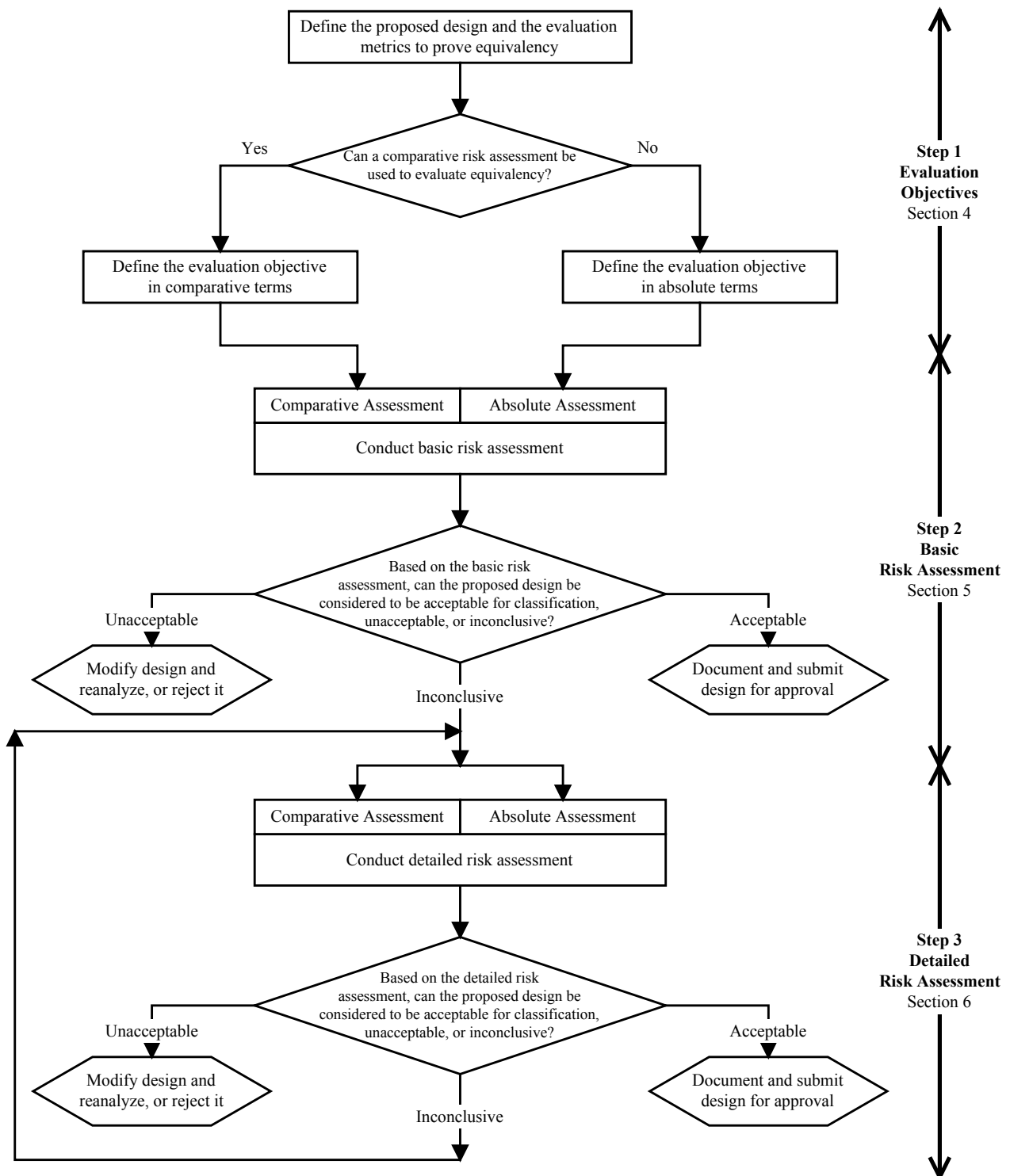
This process provides a flexible evaluation approach that can be applied to a variety of situations. It provides ABS and its clients with opportunity to determine (1) the appropriate level of analysis required and (2) the acceptance criteria to be used to judge the equivalency of the design to be classed. Increased communication between ABS and clients during development and execution of the risk evaluation process will be necessary as the complexity of the evaluation increases.

The risk evaluation process can use any combination of basic, detailed, comparative or absolute assessments and as many iterations as necessary, provided that the analysts believe that such combination of techniques will support a conclusion.

The responsibility for developing the assessment plan and performing any analysis rests with the organization proposing the design to be classed.

Past experience, if available, can be used in the risk assessments to demonstrate equivalency. The ABS client must demonstrate that (1) the past experience is applicable and (2) it has provided an acceptable level of safety.

FIGURE 1
Risk Evaluation Process



SECTION 4 Evaluation Objectives

1 General

The first step in the risk evaluation of the proposed design is to define the objectives of the evaluation. This is a very critical step, because the objectives will dictate the type of risk methodology to use and the necessary level of effort. Well-defined, written objectives for the risk evaluation are necessary to efficiently execute the risk assessment. Doing more than is necessary to satisfy the particular need is counterproductive and can be very expensive.

In this step, the following items have to be defined and documented:

- i) Design specification of the proposed design,
- ii) Reason for proposing the design (e.g. reduction of risk, reduction of construction cost, lower maintenance cost, etc.),
- iii) Description of a comparable direct design (if applicable),
- iv) Identification of any applicable ABS class requirements for which the proposed design will comply by alternative means,
- v) Definition of the goals and objectives of the ABS class requirements identified above and
- vi) Preliminary selection of the evaluation metrics to be used to demonstrate equivalency.

The design specifications will include the process or functional description, engineering drawings, material specifications, etc.

It is very important to carefully determine the classification requirements of interest and their corresponding goals and objectives. Without an understanding of why the Rule requirements exist, successfully analyzing a proposed design on a risk basis may not be possible. Clients are encouraged to contact ABS to initiate early discussions of specific Class Rule requirements for which the client is considering alternative means for compliance.

The information listed above is used to determine the appropriate analysis methodology to employ for equivalency evaluation. In addition, it provides much of the essential technical information needed to perform the evaluation.

2 Selection of Evaluation Metrics

One or more evaluation metrics should be defined at this step, at least for preliminary considerations. This is desirable, because the risk assessment plan and acceptance criteria can be better selected if the evaluation metrics of choice are known.

In a comparative assessment, if the goals/objectives of the Rules (for which alternative compliance is being sought) can be identified, the selection of evaluation metrics based on those goals may be straightforward. Otherwise, more information may be needed in order to define appropriate metrics.

3 Comparative versus Absolute Assessment

As indicated in the risk-based evaluation process of Section 3, Figure 1, Step 1 includes the determination of whether a comparative risk assessment can be used to evaluate equivalency. As mentioned before, a comparative risk assessment is the preferred method, because it can limit the scope to just the differences of two designs, the proposed one and a direct design, therefore reducing the evaluation effort. However, a comparative risk assessment is not always possible. The following paragraphs give some guidance for when to select each approach.

3.1 Comparative Risk Assessment

In order to simplify the risk evaluation of a new proposed design, a good approach is to first identify a comparable design to the one being proposed; for example one which is already in Class and has significant operating experience. If a comparable design can be identified, then the risk evaluation can be limited to the differences between the two designs, and more specifically to those differences that affect risk.

The comparative evaluation is recommended for designs that include alternative means of compliance to a few and specific ABS Class Rule requirements. Typically, for a design to be evaluated using a comparative analysis, the following should be true:

- i) ABS Class Rules include a specific requirement (e.g., hardware, system, program, activity) for which the proposed design complies in an alternative way (deemed by the client to be equivalent) and
- ii) The alternative means of compliance for the proposed design can easily be defined in terms of discrete changes or deviations from ABS Class Rules.

3.2 Absolute Risk Assessment

Designs that are highly innovative when compared to existing conventional designs (e.g. novel designs) can be difficult to evaluate using comparative analysis because:

- i) A direct design may not be readily identifiable;
- ii) The specifics of the direct design are not readily identifiable; and/or
- iii) The differences may be too numerous to efficiently analyze via a comparative risk assessment.

Submittals that are not covered as an alternative to an explicit ABS Class Rule and are not suitable to be evaluated by a comparative analysis include:

- i) Proposed designs that have never been implemented but are subject to general requirements in ABS Class Rules (e.g., safety objectives) or
- ii) Proposed designs that include too many changes or deviations from a direct design to be easily defined (e.g., complete system changes).

For such cases, the risk evaluation should be conducted by an absolute risk assessment.

SECTION 5 Basic Risk Assessment

1 General

The purpose of this step is to evaluate the proposed design using a simple risk assessment method, usually qualitative, including Change Analysis, Hazard Identification (HAZID), Hazard and Operability (HAZOP), What-If and Failure Mode and Effects Analysis (FMEA). In many cases, the proposed design would be an alternative to a direct design, for which case a comparison assessment using qualitative techniques may be the most effective option. If an applicable risk model is available, it can also be used in this basic risk assessment step. The rationale is to first apply a simple method and/or existing models to determine if equivalency can be demonstrated with a minor level of effort, without initiating more in-depth and complex studies.

It is recommended that this type of analysis be the first type of risk assessment done for any proposed design. There would be instances where the basic assessment provides adequate knowledge and confidence on the risks associated with the proposed design to demonstrate equivalency. In these instances, no additional risk assessments would be necessary for classification purposes.

The basic risk assessment can be done in the very early stages of the design, such as concept design, or later, such as in the Front-End Engineering and Design (FEED) or the detailed engineering phases. A risk assessment for the concept design phase is likely to give insight on the type, number and magnitude of risk scenarios associated with the concept design. This information would allow investigation of lower risk design alternatives before considerable effort has been dedicated to refining the design. In some cases a proposed design that has gone through a risk assessment in the concept stage will need to go through another risk assessment as the design becomes more complete and detailed.

The main steps for conducting a basic risk assessment are as follows:

- i) Development of basic risk assessment plan, including acceptance criteria
- ii) Performance of the basic risk assessment
- iii) Evaluation of results of the basic risk assessment
- iv) Documentation of basic risk assessment

Both comparative and absolute assessments would follow the same steps. The main differences between the two approaches are in:

- i) The scope of the assessment (limited to the differences vs. whole)
- ii) The definition of evaluation metrics (comparative vs. absolute)
- iii) The definition of acceptance criteria (comparative vs. absolute)

The following sections will describe each step in more detail, as well as the differences for conducting a comparative assessment as opposed to an absolute assessment.

2 Development of Basic Risk Assessment Plan

A written plan should be prepared for every risk evaluation for classification. Such a plan will provide direction and ensure that those aspects of the proposed design which are alternative features, can, through the risk evaluation, be demonstrated as being acceptable for classification. ABS will accept and review any risk evaluation plan submitted by the clients in relation to classification. However, submittal of such plans is not mandatory at the basic risk assessment stage, unless specifically requested by ABS. It is the responsibility of the organization proposing the design to select and implement an appropriate plan for the analyses to be submitted.

At a minimum, the following three aspects must be addressed in the basic risk assessment plan:

- i) Selection of a risk assessment technique
- ii) Establishment of acceptance criteria
- iii) Scope of the risk assessment

The following paragraphs provide more guidance on these aspects of a risk assessment plan. This section assumes the use of qualitative risk assessment techniques. Quantitative methods are usually more time consuming and require more detailed information of the proposed design, so they are not normally employed at this stage. However, there are exceptions to this rule, for example when a quantitative risk model has already been developed for some other application.

2.1 Selection of Risk Assessment Technique

In selecting an analysis technique, the following should be considered:

- i) *Type of results needed to determine the acceptability of the alternative.* Typically, this can be determined by considering the following:
 - Possible unwanted events.
 - Ways in which these unwanted events occur (i.e., failure modes, causes, sequences).
 - Ways to reduce the frequency of these unwanted events.
 - Areas needing (or potentially needing) further analysis or input for a quantitative risk assessment.
- ii) *Type of resources available.* The key factors to consider are (a) the current phase of life for the proposed design (e.g., conceptual design, detailed design) and (b) the quality and timeliness of the documentation.
- iii) *Complexity and size of the risk assessment.* Some techniques are not suited to analyze very complicated unwanted events. The complexity and size of the unwanted events are based on the number of activities or systems, the number of pieces of equipment, and the number and types of events and effects being analyzed.
- iv) *Type of activity or system.* While many techniques can be used to analyze almost any marine system, some techniques are better suited for some systems than for others. Appendix 4, Table 2 provides some guidance on this issue.
- v) *Type of accidents targeted.* For proposed designs believed to (a) have a significant risk or (b) potentially result in failures that are expected to result in severe consequences, more thorough analysis techniques are typically used.

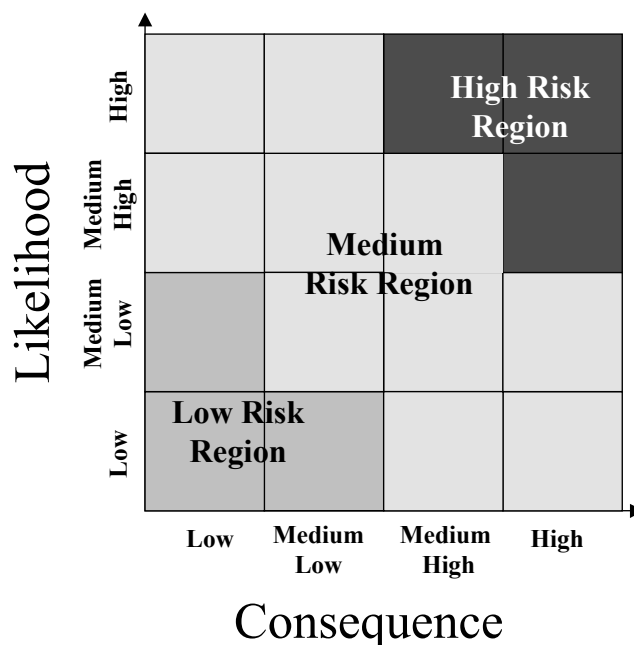
Appendix 4 provides a basic description of most commonly used risk assessment techniques, and a greater level of detail is given in the book *Marine Safety Tools for Risk-Based Decision Making* by Government Institutes/ABS Consulting.

When a comparable direct design can be defined, a comparative risk assessment, such as the change analysis method is recommended as a first approach. Paragraph 5/3.5 gives a description of this methodology.

2.2 Establishment of Acceptance Criteria

Acceptance criteria for judging the equivalency of the proposed design must be established. As described before, the acceptance criteria should be applicable to the evaluation metrics chosen. The criteria can be based on absolute or relative terms, in accordance with the type of assessment being made. If a risk measure is used for evaluation metrics, at this stage, a risk matrix with acceptance criteria will typically be used (Section 5, Figure 1 depicts an example risk matrix). Alternatively, for comparative assessments, the acceptance criteria could be based on consequences or frequencies only, if it is deemed that respective frequencies or consequences remain the same when compared with a direct design. Examples of this and other risk acceptance criteria are provided in Appendix 5.

FIGURE 1
Risk Matrix Concept



2.3 Scope of the Risk Assessment

Scoping the risk assessment involves defining (1) the objectives of the risk assessment, (2) the scenarios of concern, (3) the physical limits of the risk assessment, including the depth of analysis (e.g., system-level, part-level) and the confidence required to meet the risk evaluation's objectives, (4) the analysis assumptions and (5) the operational modes of the vessel/installation that need to be considered during the risk assessment.

In general, the basic risk evaluation will have the following two objectives:

- i) To conduct a hazard identification in order to evaluate if any new hazards have been introduced by the proposed design, and if so, to assure that adequate protection is provided.
- ii) To assess the evaluation metrics previously defined, in order to demonstrate equivalency or acceptability for classification submittal.

3 Performance of the Basic Risk Assessment

3.1 Identifying the Risk Analysis Team

Once it is determined that the proposed design can be evaluated via a qualitative risk assessment technique involving a brainstorming session, an analysis team responsible for performing the risk evaluation is assembled. This is important because many of the risk assessment techniques rely heavily on the team's knowledge and experience. Additionally, it is important to have any brainstorming session facilitated by a person experienced in the assessment technique. Appendix 2 provides information on risk analysis team composition.

3.1.1 ABS Participation in the Risk Analysis Team

ABS does not mandate that ABS personnel be part of the risk analysis team. However, benefits can be derived by the participation of an ABS representative that will be directly involved in reviewing the risk assessment to support the approval decision. Some of those benefits include:

- i) As a participant the ABS representative will be able to point out the issues that ABS considers to be relevant for the classification of the proposed design, and thus should be discussed
- ii) Participation will minimize the amount of questions and clarifications at the time of the ABS review of the risk evaluation because he/she will be familiar with the study and design.

3.2 Preparing for the Risk Assessment

Preparing for the risk assessment involves:

- i) collecting background information (e.g., design drawings, process flow diagrams, piping and instrumentation diagrams, electrical diagrams, layout, process operation and maintenance procedures, design information, reliability data, policies, ABS Class Rules)
- ii) defining a schedule, and
- iii) organizing the information, including preparing worksheets or software

The facilitator must ensure that (1) any meetings run smoothly, (2) the risk assessment is performed in a systematic and thorough manner, (3) the methodology is appropriately applied (i.e., accepted analysis procedures are followed) and (4) the evaluation objectives are met (depth, targets, and completeness).

3.3 Hazard Analysis

The initial step of the basic risk assessment should be to identify the potential hazards posed by the proposed design. To help ensure that all pertinent hazards are considered, a qualitative method is suggested to screen and identify hazards of concern. Hazards can be identified via a variety of analysis methods, such as What-if, checklist and HAZOP.

In order to identify the ultimate consequences, it is necessary to assess the potential hazards posed by the proposed design assuming that the controls or safeguards in place do not work. The credit for the safeguards will be given during the risk impact evaluation phase of the analysis, usually reducing the likelihood of the hazard.

To identify the undesirable events, it is usually helpful to consider the hazards associated with the operation and then postulate deviations that can result in the consequences associated with the hazards. All operational modes of the vessel/installation need to be considered during the risk assessment. The *ABS Guidance Notes on Risk Assessment Application for the Marine and Offshore Oil and Gas Industries* provides lists of typical hazards to be considered when identifying undesirable events for the shipping industry (Chapter 4, Section 2) and for the offshore industry (Chapter 5, Section 2).

For comparative assessments, the hazard analysis can be limited to the differences between the two designs.

3.4 Estimation of the Evaluation Metrics

Once the hazard analysis has been completed, the preliminary evaluation metrics defined in Step 1 should be reconsidered, in case some new safety issues are identified in the hazard analysis which may require a change of the preliminary metrics selected. The preliminary evaluation metrics can be validated for continued use in this step, they can be redefined or additional metrics added to the preliminary ones. The objective is to have a set of metrics that together are sufficient to demonstrate equivalency to applicable Rules objectives or to existing previously classed designs.

Once the evaluation metrics are revalidated or redefined, they have to be assessed using the most appropriate risk assessment technique. The basic risk assessment plan should have defined the technique to use based on the preliminary evaluation metrics. However, if the evaluation metrics have changed, the plan may need to be revised accordingly.

3.5 Comparative Assessments and the Change Analysis Method

The purposes of a comparative basic risk assessment are to:

- i) Identify and define the differences between the proposed design and the specific ABS Class Rule requirements for which the design is complying in some alternative way;
- ii) Perform an assessment of the risk impact of the differences, via the assessment of the evaluation metrics;
- iii) Analyze the results of the comparison and decide if the evaluation can clearly arrive to a conclusion
- iv) If unable to arrive to a conclusion, provide information needed for further risk evaluation, for example (a) to determine an acceptable assessment plan and (b) for any additional analyses.

The change analysis methodology, or another comparative risk assessment method, is an excellent tool for assessing relative risk between two comparable designs (in this case, the proposed design against a direct design). It is a very efficient methodology because it can immediately identify those differences in the designs that affect risk, so that the assessment resources are spent on those important issues.

In conducting the change analysis, the analysis team must:

- i) Establish the key differences between the proposed design and a comparable design that complies with the ABS Class Rule requirements in a conventional way.
- ii) Identify the undesirable events that can potentially be impacted by the differences.
- iii) Assess the impact of the differences on the risk factors of interest for all the identified scenarios.
- iv) Evaluate the results to determine if, based on the analysis, the proposed design can be deemed clearly acceptable or clearly unacceptable for classification. If the analysis is inconclusive, consider developing a risk assessment plan to further evaluate the proposed design.
- v) Document the analysis.

In establishing the key differences, the team should consider technological or equipment changes, layout changes, functional changes, environmental changes, schedule changes and material changes.