

ASME VVUQ 60.1-2025

Considerations and Questionnaire for Selecting Computational Physics Simulation Software: An ASME Guideline

AN AMERICAN NATIONAL STANDARD



**The American Society of
Mechanical Engineers**

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FOREWORD

Results from computational analyses and simulations of physical systems are major factors in engineering decision making. These results are determined by

- (a) the skills of the end user in setting up the computational models
- (b) the approach the end user takes
- (c) the assumptions and decisions the end user makes
- (d) the capabilities of the computational analysis and physics simulation software used

It is critical to consider the capabilities of the selected software tools from the outset to ensure the reliability of engineering decisions based on simulations and verification and validation (V&V) procedures. This Guideline has been created to provide guidance to end users for evaluating and selecting computational physics simulation software appropriate for the intended application of interest. While this Guideline does not provide explicit guidance for V&V, it does offer guidance for assessing the accuracy and credibility of computational models and simulations. The end user's objective in using simulation software is to obtain accurate and reliable simulation results. Commercial software providers are interested in supplying the simulation software used for that purpose. However, the end user and the potential provider need a transparent exchange of information to ensure that the end user selects simulation software that is indeed appropriate for their intended use.

Before selecting a particular simulation software, the end user should understand the software's theoretical basis, dependability, and limitations relevant to one or more of the end user's specific applications of interest. This Guideline provides a list of pertinent questions to help the end user select appropriate simulation software. These questions have been selected based on the experience of the members of the ASME VVUQ 60 Subcommittee on Verification, Validation, and Uncertainty Quantification of Modeling and Simulation in Energy Systems. Answers to these questions can be found in software user manuals and theory guides or obtained directly from the software provider.

This Guideline has been specifically created for the benefit of the computational simulation community. It has been kept short and concise toward this end, and it can be expanded and extended in future versions.

ASME VVUQ 60.1 was approved by the American National Standards Institute on February 12, 2025.

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Revisions and Errata. The committee processes revisions to this Guideline on a periodic basis to incorporate changes that appear necessary or desirable as demonstrated by the experience gained from the application of the Guideline. Approved revisions will be published in the next edition of the Guideline.

In addition, the committee may post errata on the committee web page. Errata become effective on the date posted. Users can register on the committee web page to receive email notifications of posted errata.

This Guideline is always open for comment, and the committee welcomes proposals for revisions. Such proposals should be as specific as possible, citing the paragraph number, the proposed wording, and a detailed description of the reasons for the proposal, including any pertinent background information and supporting documentation.

Cases

(a) The most common applications for cases are

(1) to permit early implementation of a revision based on an urgent need

(2) to provide alternative requirements

(3) to allow users to gain experience with alternative or potential additional requirements prior to incorporation directly into the Guideline

(4) to permit the use of a new material or process

(b) Users are cautioned that not all jurisdictions or owners automatically accept cases. Cases are not to be considered as approving, recommending, certifying, or endorsing any proprietary or specific design, or as limiting in any way the freedom of manufacturers, constructors, or owners to choose any method of design or any form of construction that conforms to the Guideline.

(c) A proposed case shall be written as a question and reply in the same format as existing cases. The proposal shall also include the following information:

(1) a statement of need and background information

(2) the urgency of the case (e.g., the case concerns a project that is underway or imminent)

(3) the Guideline and the paragraph, figure, or table number

(4) the editions of the Guideline to which the proposed case applies

(d) A case is effective for use when the public review process has been completed and it is approved by the cognizant supervisory board. Approved cases are posted on the committee web page.

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CONSIDERATIONS AND QUESTIONNAIRE FOR SELECTING COMPUTATIONAL PHYSICS SIMULATION SOFTWARE: AN ASME GUIDELINE

1 SCOPE

ASME VVUQ 60.1 provides guidance to computational physics simulation software end users for evaluating and selecting simulation software appropriate for their intended application of interest. The selection should be guided by the level of risk associated with the application of interest. The software can be based on theoretical formulations or empirical data.

Before selecting a particular simulation software (either commercial, open-source, or developed in-house), the end user must know its theoretical basis, dependability, and limitations relevant to the end user's application of interest. This Guideline outlines some matters that the end user can take into consideration during the software selection process. A series of questions are also included to help the end user assess the suitability of the simulation software by weighing responses based on the risk associated with their application of interest.

The scope of this Guideline is limited to computational physics simulation software. It does not offer guidance on other software. ASME VVUQ 60.1 has been developed to provide guidance to end users to evaluate simulation software based on its functionality. Other aspects such as cost are not considered. This Guideline is not limited to any physics or any specific engineering application. It assumes the end user is technically skilled to understand the physics underlying the phenomena being simulated, is capable of setting up appropriate computational models, and is appropriately qualified or certified.

2 REFERENCES

The following is a list of publications referenced in this Guideline.

- ASME VVUQ 1-2022. Verification, Validation, and Uncertainty Quantification in Computational Modeling and Simulation Terminology. The American Society of Mechanical Engineers.
- ASME V&V 10-2019. Standard for Verification and Validation in Computational Solid Mechanics. The American Society of Mechanical Engineers.
- ASME V&V 20-2009. Standard for Verification and Validation in Computational Fluid Dynamics and Heat Transfer. The American Society of Mechanical Engineers.
- ASME V&V 40-2018. Assessing Credibility of Computational Modeling Through Verification and Validation: Application to Medical Devices. The American Society of Mechanical Engineers.
- Azadeh, A., Nazari Shirkouhi, S., and Rezaie, K. (2010). "A Robust Decision-Making Methodology for Evaluation and Selection of Simulation Software Package." *The International Journal of Advanced Manufacturing Technology*, 47 (1), 381–393.
- Baguley, D., and Hose, D. (1994). NAFEMS HT02: How to Choose a Finite Element Analysis System. National Agency for Finite Element Methods and Standards.
- IEEE Std 1062-2015. IEEE Recommended Practice for Software Acquisition. Institute of Electrical and Electronics Engineers.
- Oberkampf, W. L., and Roy, C. J. (2010). *Verification and Validation in Scientific Computing*. Cambridge University Press.
- PSIG 003/2000. Recommended Practice for Software Acquisition. Pipeline Simulation Interest Group.

3 CONSIDERATIONS FOR SOFTWARE SELECTION

The end user is responsible for

- (a) defining the problem statement with an understanding of the physical phenomena and the risk inherent in the application of interest

(b) selecting the appropriate software, i.e., one that can represent the physical phenomena in accord with the level of importance of the physical phenomena to the application of interest

(c) performing the simulation and generating results

This Guideline is focused on (b). However, some elements of (a) and (c) are discussed briefly as these can have implications for (b).

The terms used herein are defined in [Nonmandatory Appendix A](#).

3.1 Current Industry Guidance

ASME V&V 10, ASME V&V 20, ASME V&V 40, and ASME VVUQ 1 contain background information and guidance for performing verification and validation (V&V) of computational physics simulations. Many of the terms used in this Guideline are derived from these references.

There is information on simulation software selection in Azadeh, Nazari Shirikouhi, and Rezaie (2010); Baguley and Hose (1994); IEEE Std 1062; and PSIG 003. However, some of these references are incomplete because they neglect physical behavior such as fluid dynamics or multiphysics simulations (Baguley and Hose, PSIG 003) or outdated because they neglect new capabilities (Baguley and Hose). Other references are more focused on business processes such as purchase contracts rather than on the computational aspects (Azadeh, Nazari Shirikouhi, and Rezaie; IEEE Std 1062). This Guideline addresses the need for a comprehensive, updated computational simulation software selection guidance tool.

3.2 Types of Software and Required End User Skill Set

In this Guideline, simulation software refers to computational physics simulation software. It can be special purpose or general-purpose.

(a) Special-purpose software is designed for a narrow context of use and is likely to give inaccurate answers outside that context of use.

(b) General-purpose software is based on broad physical laws.

To make use of the predictive capability of simulation software, the end user should have appropriate engineering expertise, knowledge of and access to reliable input data and modeling parameters, and the required skill set to comprehend and interpret the simulation results. The end user's expertise requirement should be driven by the context of use and the level of risk associated with their application of interest (Oberkampf and Roy, 2010).

3.3 Simulation of Real-World Physical Problems

Real-world applications often involve a multitude of physical phenomena (e.g., structural, fluid, thermal, mass transfer, electrical, corrosion, and chemical changes) and the interactions among them. Any one of these phenomena may not significantly affect the application of interest in the real world that is being modeled. However, for specific applications, one or more of these phenomena can be pivotal in determining the system behavior. If these phenomena are not suitably accounted for in the simulation, any results generated might be suspect and require rework. There may also be other, more unacceptable consequences. End users must identify and consider all significant physical aspects that govern the system behavior and ensure that the simulation software can represent such aspects in the code.

3.4 Steps in Setting up a Simulation

Before beginning a modeling, simulation, or analysis initiative using a particular software product, end users should

(a) identify the context of use of the application of interest and assess the associated level of risk

(b) identify the physical phenomena that is to be simulated

(c) identify the governing physics affecting the system behavior

(d) identify what material characteristics should be represented by the material models

(e) identify the interactions between the components of the system, coupling effects, as well as interference effects, if any, between the components

(f) identify the system and environmental conditions, including the initial, boundary, and loading conditions

(g) decide on how the geometry of the system will be represented

Such due diligence early in the selection process will assist the end user in picking an appropriate software product. The selected software should meet the requirements discerned through this process. To make a proper software selection and to meet the intent of the VVUQ process, end users should align these requirements as closely to the real conditions as possible. Otherwise, the results that end users obtain from their computational simulations can be unrealistic or even a contributory factor to unfavorable and potentially catastrophic consequences in critical applications.

Examples illustrating the undesirable consequences of missing important physics influencing system behavior are included in [Nonmandatory Appendix B](#). If the software is incapable of addressing key aspects in the application, then its use should be evaluated for potential impacts. This evaluation should be made based on the risk associated with the context of use.

4 QUESTIONS FOR SOFTWARE PROVIDERS

The following paragraphs contain a series of questions for the end user to consider or ask the software provider. These questions will help ascertain the appropriateness of the simulation software for a specific context of use. These questions are presented in the form of a checklist and are grouped according to their purpose.

The first group of questions (see [Form 4.1-1](#)) can be used to check whether the software's underlying algorithms have sound theoretical bases and include the physics or multiphysics requirements associated with the context of use. This group also includes questions about the availability of detailed documentation and about assessing the ease of data transfer to and from other software. The second group of questions (see [Form 4.2-1](#)) is for assessing the availability of adequate training and ease of use of the software, including its installation. The third group of questions (see [Form 4.3-1](#)) is to inquire about software verification, and the fourth group of questions (see [Form 4.4-1](#)) is to understand the extent of quality control used during the development and maintenance of the software product. The relevance and relative ranking of specific questions are up to the end user, based on the intended application.

Ideally, such information is included in a user manual, theoretical guide, or similar documentation provided along with the software. During the software selection process, the end user should examine such documentation to obtain answers to the questions in each of the paragraphs below. If appropriate answers cannot be found in the documentation, then the end user should ask the software provider to make the desired information available.

4.1 Suitability Assessment

The end user should identify the specific set of problems at hand and be aware of the physics involved, including governing equations or, in the case of specialized software, the foundations of the empirical formulations. The end user must also identify the physical processes involved in the context of use (e.g., mechanical deformations, fluid flow, heat transfer, mass transfer, electromagnetics, or chemical changes) acting either individually or in conjunction with other physical processes. No matter what physical processes are involved, there are some aspects that the end user should consider to ensure the usability of the software. These include ease of integration with other software, choices for import and export of data, availability of detailed documentation, and execution performance.

The end user should consider the questions in [Form 4.1-1](#) when undertaking the suitability assessment. If answers to the software-specific questions are not in the software documentation, then the end user should ask the software provider to provide the answers.

4.2 Instructions on Usage and Training

The questions in [Form 4.2-1](#) can be used to help the end user determine if adequate training is available and ascertain the ease of use of the software.

4.3 Verification

Software should be verified, and verification includes code verification and solution verification. Code verification, or the process of determining that the mathematical models are correctly used in the computer code, is the responsibility of both the software provider and the end user. Proof of such code verification should be made available by the software provider. The end user should repeat some of the code verification tests to evaluate whether the accuracy claimed by the software provider is observed on the end user's installation. After making sure that the code verification is adequate, the end user should then perform solution verification for problems similar to the intended application. Solution verification includes assessing the effects of algorithmic and discretization features such as spatial and temporal convergence.

Code verification and solution verification are essential prior to performing validation. An extensive discussion on code verification and solution verification can be found in ASME V&V 10, ASME V&V 20, and Oberkampf and Roy (2010). In this Guideline, therefore, only the aspects that are relevant for software evaluation and selection are included.

The most important question in verification is: Are the test cases relevant to the context of use? If yes, then the end user should consider the questions in [Form 4.3-1](#) for assessing the adequacy of the software's code verification. Additional questions for solution verification are also included.

If answers to these questions are not available in the software documentation, then the end user should ask the software provider to provide the answers.

4.4 Quality Assurance

To ensure that quality control measures have been followed, the end user should check if the software provider follows recommended quality assurance procedures by considering the questions in [Form 4.4-1](#). If answers to these questions are not in the software documentation, then the end user should ask the software provider to provide the answers.

Form 4.1-1

Suitability Assessment: Scope, Definition, and Theoretical Basis

Questions		Yes	No	Not Applicable	Not Considered
Have you identified the context of use and the question of interest?					
Have you identified the physical phenomena and multiphysics, if any, relevant to the context of use?					
Are you aware of the governing equations for the physics involved in the context of use?					
Does the software allow users to introduce modified source code if required models are not present in the existing code?					
Capability of Software to Represent the Phenomena of Interest in the Context of Use	Are the governing equations representing the physical phenomena that are relevant to the context of use implemented in the software?				
	If the software is based on empirical formulations, are the empirical bases used in the software relevant to the context of use?				
	Will the solution algorithm (e.g., finite element method, finite difference method, finite volume method, empirical formulations) used in the software provide the kinds of answers needed?				
	Can the software account for the specific environmental conditions (e.g., initial conditions, loading conditions, and boundary conditions, including time dependency) relevant to the context of use?				
	Is the software able to model in the number of dimensions (i.e., 1-D, 2-D, or 3-D) required by the context of use?				
	Is the software able to perform different kinds of temporal analyses (e.g., steady-state, transient, quasi-static, frequency-domain dynamic, or time-domain dynamic) relevant to the context of use?				
	Is the software able to include the material behavior (e.g., creep, plasticity, viscoelasticity, viscosity, damage, conductivity, specific heat, latent heat, thermal expansion) observed in the physical phenomena to be modeled?				
	Is the software able to include material behavior coupling (e.g., creep-plasticity or plasticity with damage)?				
	Is the software able to include coupling between multiphysical processes and multiple phases (e.g., thermal-fluid flow, structural-pore fluid flow, multi-phase flow, phase transitions) in the simulation model solution domain?				

Form 4.1-1

Suitability Assessment: Scope, Definition, and Theoretical Basis (Cont'd)

Questions		Yes	No	Not Applicable	Not Considered
Capability of Software to Represent the Phenomena of Interest in the Context of Use (cont'd)	Is the software able to capture interaction behavior across domain boundaries (e.g., contact, friction, fluid drag, fluid-structure interaction, thermal radiation)?				
	If the software is based on or includes governing equations in physics, is it able to include effects associated with wide-ranging variables? (This is to preclude any inherent limitations in the algorithmic and numerical implementation due to simplifying assumptions regarding the range of such variables, e.g., large deformations, high strain rates, extreme flow velocities, and cavitating flow.)				
	If the software is based on or includes empirical formulations, are you aware of the range of applicability of the software in terms of nondimensional quantities, or in terms of any empirical relationships or data used in the software (e.g., Reynolds number, relative roughness, Prandtl number, Eckert number, or Grashof number in flow assurance software)?				
Documentation for the Software	Is detailed documentation (e.g., a theory manual or guide or a user manual or guide or both) that provides information on the implemented theory and numerical formulations along with their associated references available for the software?				
	Is the detailed documentation available to prospective users?				
	Does the documentation contain detailed information on the algorithmic implementation, including governing equations if applicable, that describes the physics of the phenomena relevant to the context of use?				
	Do you have access to the data sources for any input databases associated with the software, such as material definition tables, in-built loading data as per specific codes, or similar such data?				
	Does the documentation provide a list of references for the representations of the physical phenomena implemented in the software (e.g., material models, friction, contact)?				
	Does the documentation provide sufficient information to independently ascertain the suitability of one or more empirical formulations in the software to the context of use?				
	Does the documentation contain sufficient information to enable users to independently confirm the appropriateness of the empirical formulations used in the software?				

Form 4.1-1

Suitability Assessment: Scope, Definition, and Theoretical Basis (Cont'd)

Questions		Yes	No	Not Applicable	Not Considered
Documentation for the Software (cont'd)	Does the documentation provide examples of the software being used for similar applications?				
	Does the documentation provide guidance on default values used in the software?				
	If these default values have been selected for ensuring robustness rather than for ensuring higher numerical accuracy, are the modifications in these values acceptable in how they affect the robustness or numerical accuracy or both?				
	Are limitations of the software concerning its suitability described in detail in the theory or user manuals?				
	For special-purpose software, is the suitability of the software for off-design applications described in detail in the software documentation?				
Capability of Software to Integrate and Interface With Other Software Tools	Does the software work with other software codes with respect to data sharing of models, input data, and output data?				
	Is the software able to run along with other software tools to simulate coupled multiphysics problems? This type of simulation can entail running multiple software tools simultaneously and allowing them to share data during their executions.				
	Does the software recognize and implement vendor-independent neutral file formats such as IGES, SAT, STEP, and STL for sharing geometry, HDF5 for sharing data and results, and RESQML for sharing reservoir data?				
Parallel Processing and Performance	Does the software work on the available computer systems, including hardware as well as operating systems, to address the known problems?				
	Do you have information on the scaling performance of the software when it is run using multiple processors, and is the scaling acceptable?				
	Can graphics processing units (GPUs) be used?				
	Is partitioning for GPUs or CPUs or both carried out automatically?				
	Are there any limitations on invoking parallel processing options?				

Form 4.2-1
Instructions on Usage and Training

Questions	Yes	No	Not Applicable	Not Considered
Is user training available?				
If the software is commercial, is the level of user training included with the purchase of a license adequate for the end user's needs?				
Does the user training cover the specific multiphysics aspects that are important in the application of interest? This includes specification of material properties, loading and boundary conditions, and interactions between different bodies or domains in the model.				
Does the user training include sample problems and a discussion of software documentation?				
Can a user obtain detailed instructions on installing and executing the software?				
Are the options for having ongoing software maintenance and technical support adequate for the end user's needs?				

Form 4.3-1
Code Verification

Questions		Yes	No	Not Applicable	Not Considered
Code Verification	Are sufficient benchmark problems available that can be run independently to verify the software?				
	Are relevant variables available for input and output by the software?				
	Is the extent of time and spatial discretization allowed in the software acceptable for performing code verification?				
	Is the verification evidence for solving problems similar to the context of use and source references used for comparison (e.g., analytical solutions, manufactured solutions, known benchmark problems) acceptable? (The recommended methods are symmetry tests, conservation tests, comparison of solutions, and observed order of accuracy.)				
	Are the references used for solution comparison in the preceding question relevant to the context of use?				
	Are the acceptance criteria or accuracy criteria being used for code verification by the software provider (e.g., pass/fail criteria, % criteria, or observed order of accuracy) acceptable for this context of use?				
	Do you have full details of the numerical scheme employed in the code to enable you to perform truncation error analysis?				
Solution Verification	Do the available options in the code for mesh refinement (including uniform mesh refinement, graded mesh refinement, and adaptive mesh refinement) fit the needs of the context of use?				
	Are the known solution verification examples provided by the software provider similar to the context of use?				
	Are there any a posteriori gradient recovery methods and local or global error estimation options built into the code?				
	Does the code provide warning or error messages if improper input data (e.g., superfluous boundary conditions, inconsistent loads, or inappropriate material properties) are specified?				
	Does the software include any other tools or features to facilitate the completion of solution verification?				

**Form 4.4-1
Quality Assurance**

Questions	Yes	No	Not Applicable	Not Considered
Does the software provider inform users of corrections or updates to the source code?				
If the software is commercial, are future code corrections available without additional cost?				
Is information on document and software revision controls and reporting of nonconformances, etc., available for the software?				
Are new versions of the software regression tested?				
If so, are any problems similar to the application of interest included in the regression tests?				
If the software is provided by a vendor, are the vendor's software quality assurance (QA) program and the processes in the organization falling under the QA program acceptable?				
Has the vendor's QA software program been successfully audited by an accredited third party?				
Does the software documentation identify processes that are part of the software QA program?				
If simulation results are provided to an external client, e.g., a regulatory authority, does the software provider's QA program meet the requirements of the external client?				
Has the software tool been deemed acceptable by relevant regulatory authorities?				

NONMANDATORY APPENDIX A

GLOSSARY

The following definitions used for the terms in this document are derived from ASME VVUQ 1. Some additional terms that are not found in ASME VVUQ 1, but are used in this document, are also included in the list below.

accuracy: the closeness of the computed value to the referent.

code verification: the process of determining that the mathematical models are correctly implemented in the computer code.

computational analysis software: see *simulation software*.

computational model: a representation of the mathematical model that can be executed on a computer.

conceptual model: a collection of assumptions and descriptions of processes representing one or more specific system behaviors.

context of use: the specification of the role and scope of the computational model used to address the question of interest.

credibility: the trust, established through the collection of evidence, in the predictive capability of a computational model for a context of use.

empirical data: the measured behavior of a physical system with associated uncertainties.

empirical model: a relationship based on data derived primarily through observation and experiment.

end user: the person or persons performing the analysis and simulation who has or have an interest in using the computational model for a specific context of use.

mathematical model: a model that contains all the mathematical concepts and language needed to describe the conceptual model.

model: a representation of a system.

physics-based model: a mathematical model whose functional framework is based on the concepts and theories underlying the physical phenomena of interest.

predictive capability: the anticipated accuracy of the computational model for a domain in which it has not been compared against empirical data.

quantity of interest: a physical variable or simulation result that provides important information about the system behavior.

question of interest: the specific question, decision, or concern that is being addressed.

referent: a reference value or a set of values against which simulation results or empirical data is compared.

simulation: the act of exercising the model.

simulation results: the system behavior output calculated by exercising the computational model.

simulation software: a collection of instructions to a computer for performing simulations based on the computational model. It may be available open source or commercially or it may be developed in-house. For this document, simulation software refers to computational physics simulation software.

software: in this context, a synonym for *simulation software*.

software provider: the entity that provides the simulation software.

solution verification: the process of determining the accuracy of a particular numerical solution relative to the exact solution of the mathematical model.

system: an entity, object, phenomenon, process, or combination thereof.

system behavior: the action, work, or response of a system.

validation: the process of determining the degree to which a model accurately represents the empirical (experimental) data from the perspective of model use.

NONMANDATORY APPENDIX B EXAMPLES OF ADDITIONAL CONSIDERATIONS FOR SPECIFIC SIMULATION APPLICATIONS

B-1 INTRODUCTION

Specific simulation applications require certain dynamic characteristics while other characteristics may be optional. Examples of the undesirable consequences of excluding some of the important physics in typical applications when the end user is selecting and using software are shown in [Table B-1-1](#) on the following page.

Table B-1-1
Additional Considerations for Specific Simulation Applications

Example No.	Application	Important Characteristics	Characteristics Potentially Missed by Software	Implications of Missed Characteristics
1	Simulation of fluid pressure in long flow lines during hydrotesting	Material properties, dimensions, fluid flow or pressure, displacement or force boundary conditions, liquid hydraulics, pipe materials, marine flow, and marine fluid structure interaction	Software used for simulating water-hammer can sometimes ignore fluctuations in end tension associated with movement of endpoints arising from wave action.	Hydrotest simulations that are used to guide physical hydrotesting may not produce dependable results. This can have financial implications due to increased physical testing and possible failure in certain cases. The dynamic pressure of the fluid can be underestimated due to negligence of pipeline deflection and oscillation caused by external marine flow and pipeline structure interaction.
2	Hardware-in-loop (HIL) and software-in-loop (SIL) (e.g., in brake assembly simulations in machinery in the energy industry)	Material properties, dimensions, fluid flow or pressure, and displacement or force boundary conditions	Detailed material behavior of specific components; the material behavior may not have been represented appropriately by the HIL or SIL setup used in simulations.	Inappropriate material behavior can lead to incorrect predictions. These can have serious consequences, including failure, loss of life, and financial implications.
3	Stress analysis of offshore oil and gas risers subjected to wave and current loading	Material properties, dimensions, fluid flow or pressure, and displacement or force boundary conditions	Fluid-structure interaction and vortex-induced vibrations (VIV)	Vortex-induced vibrations can lead to failure of risers, leading to financial costs and environmental damage.
4	Analysis of offshore platforms and structures due to wave and current loading	Wave motion, material properties, dimensions, and displacement or force boundary conditions	Wave shadowing effects and wave diffraction effects due to the presence of structures upstream of the structure of interest	Inaccurate computations of wave loading on structures can have financial implications.
5	Seismic analysis of critical structures	Material properties, including those of soil and rock; dimensions; displacement or force boundary conditions	Structures on soft soils need to account for soil properties. The waves emanating from the structure due to its motion need to pass through the external boundaries of the soil with minimal reflection into the interior.	Omission of appropriate soil-structure interaction can lead to incorrect results, which can have serious consequences including failure, loss of life, and financial and environmental impacts.

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