



Hardware-in-the-Loop Testing

January 2016

**Rule Note
NR 632 DT R00 E**

MARINE & OFFSHORE DIVISION

GENERAL CONDITIONS

ARTICLE 1

1.1. - BUREAU VERITAS is a Society the purpose of whose Marine & Offshore Division (the "Society") is the classification ("Classification") of any ship or vessel or offshore unit or structure of any type or part of it or system therein collectively hereinafter referred to as a "Unit" whether linked to shore, river bed or sea bed or not, whether operated or located at sea or in inland waters or partly on land, including submarines, hovercrafts, drilling rigs, offshore installations of any type and of any purpose, their related and ancillary equipment, subsea or not, such as well head and pipelines, mooring legs and mooring points or otherwise as decided by the Society.

The Society:

- "prepares and publishes Rules for classification, Guidance Notes and other documents ("Rules");
- "issues Certificates, Attestations and Reports following its interventions ("Certificates");
- "publishes Registers.

1.2. - The Society also participates in the application of National and International Regulations or Standards, in particular by delegation from different Governments. Those activities are hereafter collectively referred to as "Certification".

1.3. - The Society can also provide services related to Classification and Certification such as ship and company safety management certification; ship and port security certification, training activities; all activities and duties incidental thereto such as documentation on any supporting means, software, instrumentation, measurements, tests and trials on board.

1.4. - The interventions mentioned in 1.1., 1.2. and 1.3. are referred to as "Services". The party and/or its representative requesting the services is hereinafter referred to as the "Client". The Services are prepared and carried out on the assumption that the Clients are aware of the International Maritime and/or Offshore Industry (the "Industry") practices.

1.5. - The Society is neither and may not be considered as an Underwriter, Broker in ship's sale or chartering, Expert in Unit's valuation, Consulting Engineer, Controller, Naval Architect, Manufacturer, Ship-builder, Repair yard, Charterer or Shipowner who are not relieved of any of their expressed or implied obligations by the interventions of the Society.

ARTICLE 2

2.1. - Classification is the appraisalment given by the Society for its Client, at a certain date, following surveys by its Surveyors along the lines specified in Articles 3 and 4 hereafter on the level of compliance of a Unit to its Rules or part of them. This appraisalment is represented by a class entered on the Certificates and periodically transcribed in the Society's Register.

2.2. - Certification is carried out by the Society along the same lines as set out in Articles 3 and 4 hereafter and with reference to the applicable National and International Regulations or Standards.

2.3. - It is incumbent upon the Client to maintain the condition of the Unit after surveys, to present the Unit for surveys and to inform the Society without delay of circumstances which may affect the given appraisalment or cause to modify its scope.

2.4. - The Client is to give to the Society all access and information necessary for the safe and efficient performance of the requested Services. The Client is the sole responsible for the conditions of presentation of the Unit for tests, trials and surveys and the conditions under which tests and trials are carried out.

ARTICLE 3

3.1. - The Rules, procedures and instructions of the Society take into account at the date of their preparation the state of currently available and proven technical knowledge of the Industry. They are a collection of minimum requirements but not a standard or a code of construction neither a guide for maintenance, a safety handbook or a guide of professional practices, all of which are assumed to be known in detail and carefully followed at all times by the Client.

Committees consisting of personalities from the Industry contribute to the development of those documents.

3.2. - The Society only is qualified to apply its Rules and to interpret them. Any reference to them has no effect unless it involves the Society's intervention.

3.3. - The Services of the Society are carried out by professional Surveyors according to the applicable Rules and to the Code of Ethics of the Society. Surveyors have authority to decide locally on matters related to classification and certification of the Units, unless the Rules provide otherwise.

3.4. - The operations of the Society in providing its Services are exclusively conducted by way of random inspections and do not in any circumstances involve monitoring or exhaustive verification.

ARTICLE 4

4.1. - The Society, acting by reference to its Rules:

- "reviews the construction arrangements of the Units as shown on the documents presented by the Client;
- "conducts surveys at the place of their construction;
- "classes Units and enters their class in its Register;
- "surveys periodically the Units in service to note that the requirements for the maintenance of class are met.

The Client is to inform the Society without delay of circumstances which may cause the date or the extent of the surveys to be changed.

ARTICLE 5

5.1. - The Society acts as a provider of services. This cannot be construed as an obligation bearing on the Society to obtain a result or as a warranty.

5.2. - The certificates issued by the Society pursuant to 5.1. here above are a statement on the level of compliance of the Unit to its Rules or to the documents of reference for the Services provided for. In particular, the Society does not engage in any work relating to the design, building, production or repair checks, neither in the operation of the Units or in their trade, neither in any advisory services, and cannot be held liable on those accounts. Its certificates cannot be construed as an implied or express warranty of safety, fitness for the purpose, seaworthiness of the Unit or of its value for sale, insurance or chartering.

5.3. - The Society does not declare the acceptance or commissioning of a Unit, nor of its construction in conformity with its design, that being the exclusive responsibility of its owner or builder.

5.4. - The Services of the Society cannot create any obligation bearing on the Society or constitute any warranty of proper operation, beyond any representation set forth in the Rules, of any Unit, equipment or machinery, computer software of any sort or other comparable concepts that has been subject to any survey by the Society.

ARTICLE 6

6.1. - The Society accepts no responsibility for the use of information related to its Services which was not provided for the purpose by the Society or with its assistance.

6.2. - If the Services of the Society or their omission cause to the Client a damage which is proved to be the direct and reasonably foreseeable consequence of an error or omission of the Society, its liability towards the Client is limited to ten times the amount of fee paid for the Service having caused the damage, provided however that this limit shall be subject to a minimum of eight thousand (8,000) Euro, and to a maximum which is the greater of eight hundred thousand (800,000) Euro and one and a half times the above mentioned fee. These limits apply regardless of fault including breach of contract, breach of warranty, tort, strict liability, breach of statute, etc.

The Society bears no liability for indirect or consequential loss whether arising naturally or not as a consequence of the Services or their omission such as loss of revenue, loss of profit, loss of production, loss relative to other contracts and indemnities for termination of other agreements.

6.3. - All claims are to be presented to the Society in writing within three months of the date when the Services were supplied or (if later) the date when the events which are relied on were first known to the Client, and any claim which is not so presented shall be deemed waived and absolutely barred. Time is to be interrupted thereafter with the same periodicity.

ARTICLE 7

7.1. - Requests for Services are to be in writing.

7.2. - Either the Client or the Society can terminate as of right the requested Services after giving the other party thirty days' written notice, for convenience, and without prejudice to the provisions in Article 8 hereunder.

7.3. - The class granted to the concerned Units and the previously issued certificates remain valid until the date of effect of the notice issued according to 7.2. here above subject to compliance with 2.3. here above and Article 8 hereunder.

7.4. - The contract for classification and/or certification of a Unit cannot be transferred neither assigned.

ARTICLE 8

8.1. - The Services of the Society, whether completed or not, involve, for the part carried out, the payment of fee upon receipt of the invoice and the reimbursement of the expenses incurred.

8.2. - Overdue amounts are increased as of right by interest in accordance with the applicable legislation.

8.3. - The class of a Unit may be suspended in the event of non-payment of fee after a first unfruitful notification to pay.

ARTICLE 9

9.1. - The documents and data provided to or prepared by the Society for its Services, and the information available to the Society, are treated as confidential. However:

- "Clients have access to the data they have provided to the Society and, during the period of classification of the Unit for them, to the classification file consisting of survey reports and certificates which have been prepared at any time by the Society for the classification of the Unit ;
- "copy of the documents made available for the classification of the Unit and of available survey reports can be handed over to another Classification Society, where appropriate, in case of the Unit's transfer of class;
- "the data relative to the evolution of the Register, to the class suspension and to the survey status of the Units, as well as general technical information related to hull and equipment damages, may be passed on to IACS (International Association of Classification Societies) according to the association working rules;
- "the certificates, documents and information relative to the Units classed with the Society may be reviewed during certifying bodies audits and are disclosed upon order of the concerned governmental or inter-governmental authorities or of a Court having jurisdiction.

The documents and data are subject to a file management plan.

ARTICLE 10

10.1. - Any delay or shortcoming in the performance of its Services by the Society arising from an event not reasonably foreseeable by or beyond the control of the Society shall be deemed not to be a breach of contract.

ARTICLE 11

11.1. - In case of diverging opinions during surveys between the Client and the Society's surveyor, the Society may designate another of its surveyors at the request of the Client.

11.2. - Disagreements of a technical nature between the Client and the Society can be submitted by the Society to the advice of its Marine Advisory Committee.

ARTICLE 12

12.1. - Disputes over the Services carried out by delegation of Governments are assessed within the framework of the applicable agreements with the States, international Conventions and national rules.

12.2. - Disputes arising out of the payment of the Society's invoices by the Client are submitted to the Court of Nanterre, France, or to another Court as deemed fit by the Society.

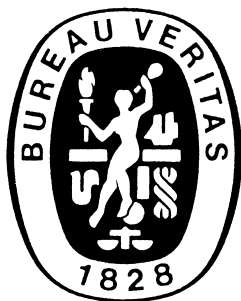
12.3. - Other disputes over the present General Conditions or over the Services of the Society are exclusively submitted to arbitration, by three arbitrators, in London according to the Arbitration Act 1996 or any statutory modification or re-enactment thereof. The contract between the Society and the Client shall be governed by English law.

ARTICLE 13

13.1. - These General Conditions constitute the sole contractual obligations binding together the Society and the Client, to the exclusion of all other representation, statements, terms, conditions whether express or implied. They may be varied in writing by mutual agreement. They are not varied by any purchase order or other document of the Client serving similar purpose.

13.2. - The invalidity of one or more stipulations of the present General Conditions does not affect the validity of the remaining provisions.

13.3. - The definitions herein take precedence over any definitions serving the same purpose which may appear in other documents issued by the Society.



RULE NOTE NR 632

NR 632 Hardware-in-the-Loop Testing

SECTION 1 **HARDWARE-IN-THE-LOOP TESTING**

Section 1 Hardware-in-the-Loop Testing

1	General	3
1.1	Application	
1.2	Definitions	
1.3	Stakeholders	
1.4	Certification	
1.5	HWIL set content	
1.6	Tests and findings	
1.7	HWIL tests documentation	

SECTION 1

HARDWARE-IN-THE-LOOP TESTING

1 General

1.1 Application

1.1.1 Hardware-in-the-loop (HWIL) testing purpose is to check proper working of control systems according to specifications in a simulated environment.

HWIL testing as defined in this Note may be applied for certification of any embedded system in a ship or offshore unit, selected under a voluntary basis.

1.2 Definitions

1.2.1 Control system (CS)

CS is defined as system for control, protection or monitoring based on one or more programmable electronic devices, including:

- Hardware
- Software
- Data highways
- Other communication paths and operator stations.

1.2.2 Failure testing

Failure testing is defined as CS functions testing as foreseen when submitted to relevant failures. Relevant failures shall be defined though specified performance requirement.

1.2.3 Functional testing

Functional testing is defined as CS functions testing when submitted to relevant actions with respect to functional specification and requirements.

1.2.4 Hardware-in-the-loop (HWIL) testing

HWIL testing is defined as complex CS testing by using tools to simulate real environment with which CS interacts.

1.2.5 HWIL simulator

An HWIL simulator is designed to interact with CS in real time.

1.2.6 HWIL set

HWIL set shall include HWIL simulator and documentation which allows testing to be carried out and results documented.

1.3 Stakeholders

1.3.1 HWIL set provider

The HWIL set provider is in charge of delivering the HWIL set.

The HWIL set provider shall have an agreement with Bureau Veritas to deliver such equipment and documentation, as per [1.5.3] and [1.7.1], in the scope of certification of the CS by Bureau Veritas.

HWIL set provider shall have procedures dealing with:

- Software development
- Quality insurance of software
- Creation of testing programs
- Test reporting
- Skill requirements for staff engaged in HWIL set adjustment and HWIL tests
- Preparation of risk assessment of operations taking place during HWIL tests (in workshop and onboard)
- Traceability of simulator hardware and software versions.

HWIL set provider shall be part of sessions organized for findings evaluation.

1.3.2 HWIL Tester

HWIL tester is the entity responsible for testing the CS.

HWIL tester shall have an agreement from Bureau Veritas to perform testing activity the scope of certification of CS by Bureau Veritas Marine and Offshore.

HWIL tester shall provide references regarding qualification of testers about:

- being familiar with simulation devices
- being familiar with field of activities tested.

HWIL tester shall be part of sessions organized for findings evaluation.

1.3.3 CS integrator

CS integrator is in charge of integrating the CS in a wider entity like a ship or an offshore rig.

CS integrator may be a yard.

CS integrator shall be part of sessions organized for findings evaluation.

1.3.4 CS Manufacturer

CS Manufacturer is involved in HWIL process for:

- Providing technical information about hardware and software to HWIL set provider.
- Providing equipment to be tested to HWIL set provider and HWIL tester.

CS Manufacturer shall be part of sessions organized for findings evaluation.

1.3.5 Owner

Owner is the party responsible for operating the CS inside a wider entity as a ship or on offshore rig.

Owner is responsible for declaring modification to installation previously tested and to initiate updating process of certification and may have the role of system integrator.

1.3.6 Bureau Veritas

Bureau Veritas acts as a third party for HWIL testing certification.

1.4 Certification

1.4.1 HWIL test certification

Upon satisfactory completion of HWIL testing, each of the tested CS may be granted a HWIL test certificate, indicating:

- CS configuration
- CS Hardware version
- CS Software version
- HWIL set provider reference
- Simulator hardware and software reference
- HWIL tester reference.

1.4.2 Validity of certification

When a CS is certified according to HWIL, any modification of the CS material environment as simulated inside HWIL simulator makes this certification non valid. It is the duty of the Owner to inform Bureau Veritas of such modifications in order to keep the certification valid.

1.4.3 Maintenance of certification

When the CS or its environment are modified as described in [1.4.2], the HWIL testing process needs to be started again with updated testing procedures.

1.5 HWIL set content

1.5.1 Simulator

Simulator hardware and software shall be separate from the CS hardware.

Configuration of hardware and software for simulator shall be clearly identified for HWIL testing certification.

1.5.2 Procedures

Following items are to be covered by procedures or documents provided by the HWIL set provider:

- The simulator shall be tested without connecting to actual CS to verify functionalities
- Test program for the CS lab test, as per [1.6.2]
- Test program for onboard test as per [1.6.3]
- Reports of findings as per [1.6.4]
- Methodology in order to categorize and treat findings
- Risk assessment analysis during HWIL testing focused on safety of HWIL testers, Surveyors, HWIL manufacturer staff and crew members without risking integrity of the ship or offshore unit systems.

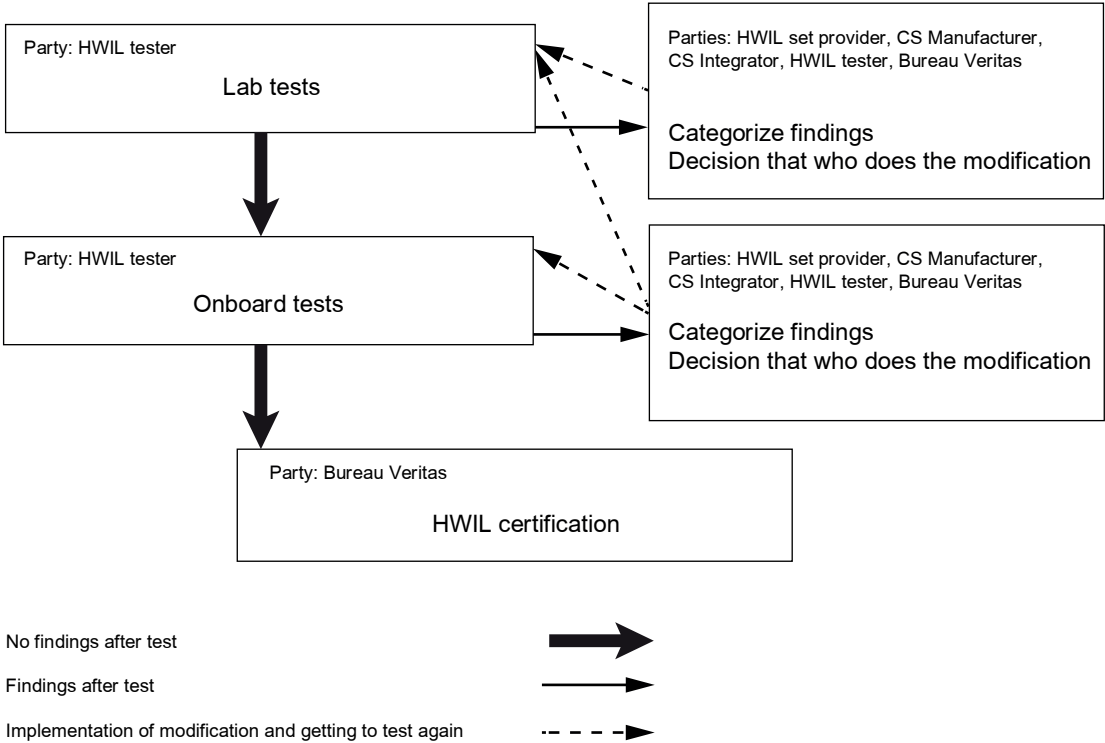
1.5.3 HWIL set documentation

The documentation listed in Tab 1 is to be submitted by HWIL set provider, for information.

Table 1 : HWIL set documentation table

Ship or offshore unit	• General description of vessel • Main purpose of vessel • Phases of operations included inside testing • Main systems installed onboard
CS	• List of functions required from CSTCS • List of tested functions • List of failures tested • Schedule of testing activities • Risk assessment during testing activities • Reference of hardware and software at the beginning of testing • Detailed procedure for testing • Reports sheets for: - Test activities followings - Findings tracking - Software modification tracking - Decisions made during meeting sessions to evaluate findings and decide course of action • Procedure for software modification and implementation; at workshop on onboard
Simulator	• Description of simulator functions • User manual • Reference of hardware and software version used for tests • Simulator testing procedures • Simulator plugging procedures • Simulator un-plugging procedures
Organization	• Organization procedures regarding responsibilities during tests • Quality assurance assessment of HWIL set provider • Quality assurance assessment of HWIL tester

Figure 1 : HWIL tests and findings



1.6 Tests and findings

1.6.1 General scheme

Tests and findings general scheme is described in Fig 1.

1.6.2 Lab test

a) Simulator testing

It shall be checked that simulator is able to reproduce real environment around CS as described by HWIL set provider.

It shall be checked that signals able to be emitted or received between simulator and CS are in line with CS specification.

b) CS testing thanks to simulator:

Lab tests shall be prepared in order to run functional testing and failure testing in any configuration of controlled system (normal and abnormal).

Results of each step shall be registered in a report.

Bureau Veritas Surveyor is to be present during the tests and validates each testing steps. The Surveyor may request repetition of any testing step.

1.6.3 Onboard tests

a) Purpose of onboard tests

On board tests shall be prepared in order to check:

- Correct installation and configuration of controlled system
- Correct interactions with other onboard systems
- Testing steps that could not be achieved during workshop tests.

b) Precautions related to HWIL testers, Surveyors, CS manufacturer staff, crew members and hardware:

It is to be referred to risk assessment analysis mentioned in [1.5.2]. If some testing steps are considered as too high risk for personnel or hardware, alternative solution should be considered.

1.6.4 Findings

Meetings shall be established in advance during tests in order to evaluate findings. These meeting shall include at least:

- HWIL set provider
- CS Manufacturer
- CS integrator
- HWIL tester
- Bureau Veritas.

Criteria in order to evaluate the importance of findings and the type of treatment that should be undertaken are to be decided as early as possible in the project, before any tests are undertaken.

The software modifications, if any, should be detailed enough in order to evaluate what steps of test need to be redone in order to check that no regression has impacted any other functionality of CS.

If findings appear during onboard tests, repeating workshop testing steps needs to be considered after software modifications in order to check non-regression of the software.

1.7 HWIL tests documentation

1.7.1 The documentation listed in Tab 2 is to be submitted by HWIL set provider, for information.

Table 2 : HWIL test documentation table

Test report	• Each major set of steps of tests shall be separately documented (at least workshop tests and on board tests) • Each individual step of tests shall be able to be registered as acknowledged by the HWIL Tester and the Society Surveyor
Findings registration	Findings are to be registered for each individual step in test reports If it appears that some individual step is missing, this should be registered as a finding
Findings treatment	Reports of meeting sessions should about classification ad treatment of findings should be kept In the same time, a document should keep traceability of: • Findings description and reference to test step • Findings categorization • Findings treatment and associated software modification and re-testing if any • Which party is responsible for these actions