BUREAU VERITAS RULES FOR THE CLASSIFICATION OF TRADITIONAL NAVAL SUBMARINES

Bureau Veritas will soon launch classification rules for naval submarines. These rules are presently published as tentative rules that will be made available to the navies and the building shipyards for comments and possible application in June 2008.

They will be updated and formally published one year later when the first comments are taken into consideration.

This paper aims at introducing these rules to the naval community.

1. Philosophy of the rules

The rules for classification aim to protect the safety of the crew and of the environment by setting minimum safety standards that will be verified neither by the shipyard nor by the end user Navy but by an independent third party in charge of the submarine safety: the classification society.

Classification rules for surface vessels benefit from more than 150 years of experience. We have adapted this experience to the underwater naval world.

1.1 Principles of classification

Classification is the compliance with safety rules developed and published by the classification society. These rules are public, they belong to the classification society that is the only body empowered to interpret them.

Classification rules include design requirements applicable at new construction stage and maintenance requirements that are checked all along the life of the submarine.

1.2 Classification process

Classification is carried out within two major cycles:

- Initial verification at the newbuilding stage
- Maintenance of classification during the whole life of the submarine through a survey regime based on periodical inspections.

The Navies involved in the classification process have for a long time classed their vessels at the newbuilding stage. It is quite a recent policy to maintain the classification of the unit during its whole life.

1.3 Verification at the newbuilding stage

The classification of submarines at the newbuilding stage results in the verification of their conformity to the appropriate rules of the classification society, in our case the rules for classification of naval traditional submarines.

Classification is carried out within a three-step process:

- Design approval where the conformity of all the parts related to safety is verified versus the applicable rule requirements. This concerns: structure, production and distribution of energy, propulsion, fire safety including structural fire protection and fire-fighting
devices, escape routes and evacuation, atmosphere control, stability at surface and submerged.

- Materials and safety related equipment certification at maker’s works. The main equipment concerned are: auxiliary engines, propulsion set, batteries, insulated bulkheads, fire-fighting equipment, fire detection, electrical cables-switchboards-connecting devices …

- Construction survey at yard including:
  
  - kick-off meeting, where the applicable rules and the working procedures are agreed,
  - approval of internal shipyard fabrication and quality plan; that should provide Bureau Veritas with the opportunity to carry out the verifications requested by the rules,
  - approval of welders and of welding procedures,
  - survey at the yard's premises, where the surveyor will validate the different parts of the submarine and will ask for modifications when deemed necessary,
  - attendance to tests and to quay and sea trials, which are the ultimate validation of the whole building process,
  - issuance of classification certificates.

1.4 In service survey regime

The survey regime is based on a term of classification of five years. During the term the submarine is to be inspected six times by the classification society:

- four annual surveys,
- one intermediate survey,
- one class renewal survey.

Annual surveys consist in deep visual inspections of all the safety related items without dismantling, the submarine being alongside.

The intermediate survey focuses on the inspection of the capacities and on thickness measurements.

The class renewal survey is the inspection of all parts of the vessel with dismantling of major equipment including the propeller shaft and the visit of the hull in a dry-dock.

Example of the five year term survey regime.

<table>
<thead>
<tr>
<th>Start of class period</th>
<th>End of class period</th>
</tr>
</thead>
<tbody>
<tr>
<td>years</td>
<td>0</td>
</tr>
<tr>
<td>Annual survey</td>
<td></td>
</tr>
<tr>
<td>Intermediate survey</td>
<td></td>
</tr>
<tr>
<td>Class renewal survey</td>
<td></td>
</tr>
<tr>
<td>(nominal system)</td>
<td></td>
</tr>
</tbody>
</table>

Five year term survey regime
As an example of the verifications carried out, below is a description of the items inspected during the annual surveys.

**General**
- Examination of the naval submarine, logbooks, operational records.
- A visual inspection of the hull, equipment and machinery of the submarine and some tests thereof, so far as necessary and practicable in order to verify that the submarine is in an acceptable general condition and is properly maintained.
- A depression test to be carried out for pressure hull and means of closure including first and secondary ones.
- A diving test.
- A schnorchel navigation test.
- The demonstration that the alarms and safety devices are functioning correctly.

**Pressure resistant hull, structures and hull equipment**
- Pressure resistant hull and structures.
- Outer hull and exostructures above the waterline, and accessible parts of the rudder(s) including blades and fines.
- Internal examination of accessible parts of exostructures.
- If retractable trimming devices are fitted, a functional test will be carried out.
- Hull openings, doors and hatch covers, their securing arrangements and sealing arrangements are to be checked in satisfactory conditions.
- Hull penetrations with their sleeves, and weld connection to the hull.
- General external examination of mooring equipment.
- A functional test of hoistable or movable parts and of interlocks and safety devices is to be carried out.
- Spaces including compartments and cofferdams with particular attention to bilges.
- Accessible resisting structures including torpedo tubes, capacities and collective rescue platform.
- Strength and watertight bulkheads, batteries compartments, watertight doors, and associated local and remote controls, and their watertight penetrations.
- Confirmation that watertight doors are not precluded from immediate closure.
- Fire divisions and fire doors.
- Hull and bulkhead cable penetrations.
- Confirmation that emergency escape routes are practicable and not blocked.
- Critical structural areas.
- Hull equipment.
- Hull valves and hull plugs.
- Scuppers, valves on discharge lines and their controls.
- Closing systems.

**Machinery and systems**
- General examination of machinery spaces with particular attention to the fire and explosion hazards.
- General examination of the machinery, hydraulic, pneumatic and other systems and their associated fittings, for confirmation of their proper maintenance.
- General examination of the ventilation system, their ducts, valves and fans including spare fan(s) with a functional test of the different modes.
- Visual examination of the condition of flexible hoses and expansion joints in sea water systems.
- External examination of pressure vessels, high pressure piping, their appurtenances, including safety devices, foundations, controls, relieving gear, clamp fittings, insulation and gauges.
- As far as practicable, external examination of heel, trim and regulating tanks, their water level indicators and gauges and their piping systems.
- Control and monitoring of air inlet valve of fresh air cupola.
- Functional test, control and monitoring of hull opening moving equipments including masts, air inlet valves and exhaust gas system.
- External examination of leakage indicators, drains with associated cocks.
- External examination of ballast vent valve as far as practicable.
- External examination of sea water piping withstanding immersion pressure, their accessories, including operation of the pumps and detection.
- Bilge wells.
- Examination and functional test of main and auxiliary steering arrangements, including their associated equipment and control systems, and manoeuvring gear.
- When the submarine is equipped with a refrigerating plant:
  - pressure vessels of the installation,
  - refrigerant piping, as far as practicable,
  - for spaces where refrigerating machinery are fitted:
    - electrical equipment, confirming its proper maintenance,
    - gas detection system.
- Functional test of masts lowering without hoisting energy source available.

**Communication**
- Underwater, surface, emergency and internal communication systems are to be function-tested. It will be checked that the means of communication dedicated to rescue teams are in place; they will be tested if applicable.
- Test of means of communication and order transmission between the control station and the propulsion station.

**Navigation**
- Confirmation that the calibration of navigating and locating equipments including depth is still valid. As a rule, calibration is not to have been performed for more than one year.
- Confirmation that the rudders angle indicators on navigation control room and locally are in working order.
- Confirmation that navigation radar and gyro compass are in satisfactory working condition.
- Functional test of optical surveillance system.
- Confirmation that safety navigation equipments including navigation lights and sound signalling equipments are in satisfactory working conditions.
- Functional test of echo sounding and speed loch systems.

**Electrical machinery and equipment**
- General examination, visually and in operation, as feasible, of the electrical installations for power and lighting, in particular main and emergency sources of electrical power if fitted, electric motors, switchboards, converters, switchgears, cables, cable supports and circuit protective devices, indicators of electrical insulation and automatic starting, where provided, of emergency sources of power
- Functional test of lighting fittings including main and emergency.
- Checking, as far as practicable, of the operation of emergency sources of power, including the automatic mode, if any.
- Checking, as far as practicable, of the proper operation of safety and ultimate functions, that their instrumentation and safety devices are operational and that their alarms are satisfactory

**Batteries**
- Batteries log books are to be made available to the Surveyor for examination of the records since the last survey, and checking of any unusual record, breakdown or defective items.
- The survey of batteries is to cover the following items:
  - General examination of battery compartments, piping and equipments fitted inside including battery cells and trays.
  - Examination of battery cells shoring and connections.
Examination and confirmation of the satisfactory operation of battery auxiliary systems, including:
- ventilation system,
- electrolyte agitation system,
- refrigeration system.

- Checking that the hydrogen detection system is in working order and checking of calibration.
- Function testing, as far as practicable, of detection, remote control and monitoring systems and alarms.

**Fire protection, detection and extinction**
- Checking that relevant instructions are available.
- Examination and testing, as feasible, of the operation of fire doors, where fitted.
- Checking, as far as practicable, that the following are in working order: remote controls for stopping fans and machinery, shutting off of fuel supplies in machinery spaces, remote controls for stopping fans from a control station, means of cutting off power to the galley.
- Examination, as far as practicable, and testing, as feasible and at random, of the fire and/or smoke detection systems and fire dampers.

**Fixed fire-fighting systems**
- Examination of the system including piping.
- Checking that fire hoses, nozzles, spanners and international shore connection, where fitted, are in satisfactory working condition and situated at their respective locations.

**Fixed gas fire-extinguishing system**
- external examination of receivers of CO₂ (or other gases) fixed fire-extinguishing systems and their accessories,
- examination of fixed fire-fighting system controls, piping, instructions and marking; checking for evidence of proper maintenance and servicing, including date of last system tests,
- test of the alarm triggered before the CO₂ is released.

**Sprinkler system when fitted**
- examination of the system, including piping, valves, sprinklers and header tank,
- test of the automatic starting of the pump activated by a pressure drop,
- check of the alarm system while the above test is carried out.

**Water-spraying system or water mist system**
- examination of the system, including piping, nozzles, distribution valves and header tank,
- test of the automatic starting of the pump activated by a pressure drop (applicable only for machinery spaces)

**Fixed foam systems (low or high expansion)**
- examination of the foam system,
- checking of the supplies of foam concentrate and receiving confirmation that it is periodically tested (no later than three years after manufacture and annually thereafter) by the manufacturer.

**Atmosphere control**
- Oxygen containers are to be surveyed.

- The air regeneration systems including soda-lime, oxygen candle or unit, their fittings, valves and safety devices when applicable are to be examined and a functional test is to be carried out as far as applicable. Checking of their proper stowage, expiry date and appropriate quantities.
- The survey is also to include:
- examination and testing as appropriate of gas analysis equipment,
- confirmation of the availability and suitability of the portable gas detection equipment and instruments for measuring gas levels.
- verification of calibration status of the measuring instruments. As a rule calibration is not to have been performed for more than one year.
- checking of proper stowage and expiry date of emergency oxygen candles and chemical product for carbon dioxide elimination and their appropriate quantities for survival period.
- checking that emergency breathing air appliances are in sufficient number, in satisfactory condition and properly stowed onboard.

Flooding fighting
- Detection systems and their alarms. Level detectors shall be tested at default and incident levels. Flow detectors as far as practicable
- Flow detectors inhibition of automatic action as far as practicable
- Safety shut-off valves and their emergency system including hydraulic energy accumulators

Emergency and rescue installations
- Verification of expiry date of the alert and localization items including batteries when applicable.
- Verification of proper stowage and expiry date of the food and fresh water emergency stock and their appropriate quantities.
- Verification of proper stowage and expiry date of the medical supplies in each refuge compartment.

General emergency alarm system
- Functioning to be carried out

Stability
- Confirmation that the following documents are available on board:
  - weighting, trim and stability booklet,
  - damage control documentation in the appropriate language.
- Confirmation that periodical weighing and stability checks have been carried out in due time.
- Confirmation that the scales of draughts are permanently marked at the bow and stern as far as visible.

One can see from this long list the extent of the annual survey. The same list applies to the class renewal survey but all major equipment is dismantled and internally inspected.

2. Area covered by the rules

The rules for classification cover all parts participating in the safety of the submarine. These parts are presented in the rules under seven main chapters covering stability and weight control, resistance of the structure, propulsion and systems, human occupancy and fire safety, additional class notations and trials.

The arm system itself is not covered by the rules except when it has a direct influence on the safety of the submarine, water tightness of the torpedo tubes for example.

2.1 Stability and weight control

Intact stability, with requirement for a minimum module of stability of 0.2 meter in surface condition.
Diving and resurfacing conditions, with stability module to remain positive, otherwise operational precautions to be taken.

Damage stability with requirement that submerged module of stability remains greater than 75% of minimum module in surface

Weight control with rule requirements about the capability of systems involved in weight and trim control to be able to restore weight-buoyancy at any time and to operate trim correction.

2.2 Structure

The main concern about structure is the scantling of the pressure hull; particular attention is paid to the scantling loads, the qualification of hull material and corrosion.

For a better calculation of the pressure hull the rule requirements introduce a correlation between safety coefficients to be taken into account for design appraisal and the admissible shape default acceptable during construction.

Exostructures, non-resisting structures and hull outfitting, in particular diving and direction rudders are also covered by rule requirements.

2.3 Propulsion and energy

Requirements related to propulsion are to some extent similar to those of surface vessels with special emphasis on the water tightness of the line shaft (at least two sealing glands).

Design and testing of diesel engine shall take into account surface and snorkelling operations.

Requirements related to energy concern batteries (two batteries and a recharging device are required). The batteries are to be located in non-contiguous compartments; the system is to be so designed that one battery remains operational in case of damage (including fire or flooding) of one battery compartment.

The rules also include requirements concerning ventilation and monitoring of battery compartment.

2.4 Systems

Diesel engines, pressure vessels, masts, piping systems, refrigerating systems, steering gear are covered by requirements taking into account the operation in depth:

- Requirements exist for automatic actions (engine shut down, air tube and exhaust valves closing).
- Specific requirements, in particular double closing devices, are developed for pipes likely to withstand immersion pressure.
- Requirements for masts deal with water tightness of the mast itself and associated penetrations, and safety of mast in case of over-immersion.

Rules requirements also cover communication and navigations. Navigation radar, radio navigation system, depth indicator, acoustic sensors, UT system are requested. COLREG convention is applied for navigation lights and whistles.

2.5 Fire Safety and Human Occupancy

Fire structural protection and fire fighting systems requirements take into consideration the specificities of potential fire hazards on board a submarine, i.e. little heat released but large smoke production.
A15 insulation is the maximum standard for structural insulation.

Requirements dealing with atmosphere control on normal operation and under survival period are covered:
- Main gas monitoring systems (O₂, CO₂, CO, H₂),
- Oxygen production,
- Dangerous gases elimination,
- Emergency breathing air systems.

2.6 Emergency and rescue

Particular attention is paid to emergency situations:
- Flooding fighting: detection of flooding and means designed in order to recover pressure hull integrity are covered by the following requirements:
  - Compartments where detectors are to be implemented are detailed; location of detectors in compartment is to allow proper detection independently from trim and list,
  - Two “levels” for signals: default level just indicates presence of water in compartment; incident level involves immediate actions against water leakage,
  - Safety shut-off valve closing shall remain possible even in case of loss of hydraulic energy in order to recover pressure hull integrity.
- Emergency blowing: this piping system is not to be used for another purpose than emergency blowing
- Emergency lightening: this system, when present, must remain available even in case of loss of its energy source through a dedicated standby source.

2.7 Additional Class Notations

Additional class notations cover functions or specific equipment that are not strictly related to the safety of the vessel but indicate a greater level of equipment.

The rule requirements related to these additional notations become compulsory only when the notation is selected by the client.

The additional class notations applicable to submarines are:

- **Comf-noise**
  Limit noise levels are defined per type of space, under 2 situations: transit and snorkelling.
  Conditions for the noise level measurements are defined in details: measuring instruments and locations, operating conditions (water depth, meteorological conditions), suggested format for recording the data.

- **Ref-store**
  This notation provides optional requirements for frigorific installations of submarines such as equipment redundancy, arrangement of refrigerated chambers, design of refrigerating units. It also enables review of the frigorific function in itself.

- **HSE**
  Granted when BV has been requested to check Health, Safety and Environmental regulations specified by the Naval Authority.

- **AIP**
  Air Independent Propulsion is considered an additional means of propulsion, including:
  - Electric energy production system
  - Fuel & combustive storage systems
Discharge system of the residual products
Specific safety study is to be performed, addressing potential hazards: Explosion, Fire, Toxicity, Collision, Overpressure, Failure of support systems, Leakages …
Requirements are covering operation, installation, safety, certification and testing.

- **Anchoring**
  This notation provides optional requirements for: design of anchor chain, design of anchor, design of windlass and chain stopper, arrangement of chain locker.

- **Refuge compartment**
  Refuge compartment is to be able to resist at least 20 bar immersion pressure (unless other pressure explicitly required by the Naval Authority) when pressure hull integrity has been jeopardized.
  Refuge compartment is to include:
  - Rescue equipment mentioned in the Rules (oxygen supply,…) and a direct access to an escape trunk,
  - An access door able to withstand design pressure of refuge compartment.
  Piping system entering in refuge compartment is to be designed in order to obtain water tightness of refuge compartment when used

2.8 Quay and sea trials

Trials and in particular sea trials are the ultimate verification showing that all functions and systems of the submarine are working correctly together.

For classification the success of sea trials is the confirmation that all the necessary controls have been carried out satisfactorily. It is the validation of all the work done at the design stage and during construction that enables the classification society to issue the certificates.

Quay and sea trials are carried out, in line with the following sequence:
- Tests at harbour are required to validate essential functions involved in safety, production and storage of energy.
- Tests at sea are provided to validate submarine hull and systems ability to manoeuvre in depth. This capability is tested gradually in an increasing range of immersion.

3. Interests of classification

The great interest of classification lies in the fact that a third independent party, recognised by more than 125 government and flag authorities in the merchant ship community, will certify the safety of the submarine.

This third independent party is bound neither to the building shipyard nor to the Navy that will use the submarine, the classification society is solely dedicated to the safety of the unit.

The other advantage of classification is the classification rules themselves. These rules are self supporting; they contain the exhaustive list of requirements related to safety and therefore are easy to use for building shipyards and design offices.

The rules also benefit from the return of experience gained during classification of all types of vessels, surface and submarine; they are developed, maintained and updated regularly under the aegis of the naval ship committee of Bureau Veritas, the members of which belong to several European navies and naval shipyards.

The maintenance carried out within the scope of submarine in-service survey regime is cost effective and all the items important for the safety of the submarine are verified by the classification society.
Last but not least, the classification of the unit when granted at newbuilding stage and maintained through the submarine in-service survey regime is a guaranty for the Admiralty that the safety of its submarine is effective, the certification by an independent recognised body is likely to protect its legal liability in case of a casualty occurring during peace time operations.