



Antarctic Research Vessel (ARV)

Engineering Report: Habitability Study

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1. Executive Summary

The Antarctic Research Vessel (ARV) Habitability Report evaluates and provides recommendations for the arrangements and outfitting of scientific spaces (as related to habitability), staterooms, and common areas on the ship to offer a high standard of habitability.

The report is in compliance with guidelines listed in the ARV Performance Specification, Reference (1) for the accommodation block arrangement. The primary regulatory requirement identified by Reference (1) is the American Bureau of Shipping (ABS) Guide for Crew Habitability on Workboats, Reference (2).

At this time, the ARV General Arrangement supports both the threshold HAB+(WB) and objective HAB++(WB) requirements as defined in Reference (2) for the general habitability considerations. Parts of the report concerning environment aspects of the living arrangements such as noise and vibration are still pending completion of supporting analysis. Findings from these analyses will provide a basis for future arrangement decisions as well as define ways to mitigate any issues that should be captured in the design going forward such as relocation of equipment, resilient mounting equipment, adding insulation or damping.

This report also identifies areas compliant with Americans with Disabilities Act (ADA) as required in Reference (1) and specifies any additional provisions considered during the design of the vessel, such as improvements to accessibility and other general considerations to extend compliance with ADA.

1.1. Acronyms

ABS	American Bureau of Shipping
ADA	Americans with Disabilities Act
ARV	Antarctic Research Vessel
HAB+(WB)	Workboat Habitability Plus notation
HAB++(WB)	Workboat Habitability Plus Plus notation
IMO	International Maritime Organization
MLC	Maritime Labour Convention
NSF	National Science Foundation

2. Introduction

The intent of this report is to outline the habitability design onboard the Antarctic Research Vessel (ARV). This is accomplished by:

- Identifying the requirements for the accommodation areas and ambient environment exposures.
- Outlining all spaces that comply with the Americans with Disabilities Act (ADA).
- Evaluating the present design against the requirements (Threshold and Objective).
- Performing a comparison to international habitability standards, identified as the Similar Vessel Study in this report.

Stringent compliance to the guidelines listed in the ARV Performance Specifications, Reference (1), for the accommodation block arrangement is critical to achieve the intended high standards of living and functionality onboard. The primary regulatory requirement identified by Reference (1) is the American Bureau of Shipping (ABS) Guide for Crew Habitability on Workboats, Reference (2). ARV is designed to comply, as a minimum, with threshold performance notations for habitability as defined in Reference (2) and HAB+(WB) requirements. As well as specific ADA requirements as defined here in.

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3. Approach

The ARV Performance Specification, Reference (1), provides requirements for the habitable spaces of the vessel. The primary regulatory requirement identified by Reference (1) is the American Bureau of Shipping (ABS) Guide for Crew Habitability on Workboats, Reference (2). This ARV habitability study uses the ABS guide to identify requirements, outlines the plan to incorporate those requirements into the ARV design, and identifies additional tradeoffs to be considered for incorporation of threshold versus objective requirements.

3.1. Habitability Guidelines and Notations

Reference (1) requires the ABS notation HAB+(WB) as a threshold requirement, and HAB++(WB) as an objective notation. The requirements that must be met for these notation levels are contained in Reference (2). The ABS guidelines segment the habitability requirements into two major components:

- Accommodation Areas: Criteria pertaining to the dimensional and outfitting aspects of spaces and open deck areas for activities including crew eating, sleeping, recreation and daily routine.
- Ambient Environment: Criteria pertaining to the environment that crew or passengers are exposed to during periods of work, leisure, and rest.

Reference (1) also contains additional habitability requirements not found in Reference (2); including specific to ADA. This study will note where these additional requirements apply.

3.2. Habitable Areas Considered

Using Reference (1) and (2), this habitability study evaluated the following areas of the vessel:

- General Habitability Considerations
- Access and Egress
- Crew and Scientist Staterooms
- Sanitary Spaces
- Food Service Spaces
- Recreation Areas
- Laundry Spaces
- Medical Spaces
- Scientific Mission Spaces as related to habitability

3.3. Americans with Disabilities Act (ADA)

This report will identify areas compliant with ADA as required in Reference (1) and specify any additional provisions considered during the design of the vessel.

3.4. Similar Vessel Study

The similar vessel study uses the IMO Maritime Labour Convention (MLC), 2006, Reference (3), to compare the habitability requirements of the ARV to a common international standard. Details of this study can be found in Section 4.4 of this report.

4. Results

Incorporation of the ARV habitability requirements outlined above are discussed herein. The initial discussion evaluates the accommodation area size, location, and features. The second provides details on the ambient environment requirements for each, while the third provides discussion on meeting ADA compliance. Lastly, the habitability results are compared against similar vessels as a comparative means to evaluate the standards required for ARV.

4.1. Accommodation Area Requirements

4.1.1. General Considerations

All accommodation areas onboard the ARV, for both threshold and objective goals, are compliant with Appendix 3 of Reference (2) requirements for:

- Clear headroom
- Nonslip decks
- Rounded bulkhead, door, and other similar vertical edges
- Drawers and internal doors designed to prevent opening caused by vessel motion, and operable by one hand
- Light paint colors and surfaces designed for easy cleaning and impervious to moisture
- Kick spaces at the base of all standing workstations
- Heads located near common areas
- Well-marked means of escape
- Flooring material with joints filled to prevent crevices
- Accommodation locations

To comply with these requirements, the ARV will be designed to locate the accommodation spaces as far as practicable from machinery spaces. Clear headroom of at least 81 inches is required in all accommodation areas. On the Main Deck, the headroom is 90 inches and 84 inches in common areas. Flooring materials will be chosen to ensure non-slip characteristics where occasional water or other liquids spills are expected and to ensure no crevices. Selection of interior joiner system will provide an acoustic solution with rounded corners to reduce injury and light colors to allow for easy cleaning. Where required, kick spaces will be 4 inches deep and 4 inches tall with length to match working area. The false ceiling will use acoustic panels to reduce noise.

In accordance with Reference (1), at least one public head will be located on each deck, and it will be easily accessible from the following locations:

- Near the Engineer's Control Room
- Main Deck off the passageway
- In the Bridge (equipped with both white and red low intensity lighting)
- Near the Mess
- Near the Gym
- Main Deck adjacent to aft working deck

Additional opportunities to improve habitability include designing additional public heads near conference rooms, libraries, lounges, and offices.

All escape routes will be well marked, with additional markings provided for any routes that are not readily apparent.

The general considerations for both HAB+(WB) and HAB++(WB) are the same, with no additional requirements to meet the objective requirement.

At this time, the ARV General Arrangement supports both the threshold and objective requirements for the general habitability considerations outlined above.

4.1.2. Access and Egress

All access and egress to accommodation areas considers and ensures compliance with threshold requirements HAB+(WB) outlined in Appendix 3 of Reference (2) for:

- General Access and Egress
- Door Dimension
- Railings
- Stairs
- Ladders
- Ramps
- Passageways

To comply with the threshold requirements, the ARV will be provided with well labeled doors, operable from both sides, in both light and dark conditions. Doors will have minimum width clear opening of 28 inches, with the top of door at least 75 inches from the deck. Deck scuttles and hatches will be quick acting if along an egress route or along an emergency escape route.

All interior passageways wider than 72 inches and exterior walkways in way of deckhouse sides will be designed with storm handrails between 34 and 38 inches in height. At deck edges, or where fall or machinery hazards are present, railings of 39.5 inches with 4-inch toe boards will be provided. Stanchions for these railings will be spaced no more than 60 inches apart and every third stanchion supported by a bracket. Railing course clear openings are not to exceed 9 inches on lower and 15 inches for middle and upper.

Stairs will be designed at a 40-degree angle, at least 36 inches wide, with a landing of the same width at the top and bottom. Stairs will have depth of at least 9 inches and be provided with a handrail on one side. All steps will have a uniform height and surfaces will be non-slip.

Where provided, vertical ladders will have at least 7 inches clearance behind the rungs. Non-slip rungs at least 16 inches wide will be uniformly spaced 11 – 12 inches apart. At the ends of ladders, landings of at least 30 inches will be provided and grab bars will extend at least 42 inches above the top landing.

The access and egress requirements for both HAB+(WB) and HAB++(WB) are almost identical, with only the following additional requirements for HAB++(WB):

- Door height from deck to top of door increasing to 78 inches
- Railing and bulwark heights increasing to 42 inches
- Stairs
 - Intermediate landings to be provided for rise greater than 240 inches
 - Depth increases to 10.75 inches
 - Handrail required on both sides
- Ladder clear landing length increases to 36 inches

At this time, the ARV General Arrangement supports both threshold and objective requirements for the access and egress considerations outlined above.

4.1.3. Crew and Scientist Staterooms

All staterooms onboard the ARV consider and ensure compliance with threshold requirements HAB+(WB) outlined in Appendix 3 of Reference (2) requirements for:

- Stateroom minimum areas
- Occupancy levels
- Locations
- Room design and dimensional clearances
- Berths
- Emergency alarms
- Storage spaces

The ARV will be designed with the ship's seafaring crew receiving a single occupancy stateroom with private water closet. The Principal Scientist and most senior scientists will be in single occupancy staterooms with private water closets. The majority of scientists will be in double occupancy staterooms with shared water closets. All staterooms will be located above waterline and along the side shell to provide portholes to allow for a source of natural light. It shall be noted that even though the 1st Platform is above the waterline with the Main Deck occupied by the laboratories and science mission spaces, the 1st Platform deck is unsuitable for staterooms, as they would be located under working compartments/locations. Crew staterooms are located on the 03 and 04 Levels.

Additionally, staterooms will be located at least 17.25 feet aft of the forward perpendicular, and not below any passageways, further restricting use of interior volume.

To meet threshold requirements, the single staterooms will have a minimum of 80.5 ft² and the double staterooms 91.5 ft². The Chief Engineer, Captain, 1st Mate, and Principal Scientist will also be provided with a dayroom.

Staterooms will be provided with:

- Lockable wardrobe, at least 30 inches wide by 24 inches deep with a height to fit the space
- Watertight, rectangular window with inward opening hinged deadlight cover
- 42-inch desk with single pedestal with office chair
- Book storage with sea rail, a minimum depth of 13 inches, and minimum clear height between shelves of 13 inches over the length of the desk
- Berths a minimum of 39 inches wide, 80 inches long. The berth shall not be obstructed by pipes, ventilating ducts, or other installations. Sea rails on berths shall have a gap in the middle and be removable.

The stateroom requirements for both HAB+(WB) and HAB++(WB) hold similar across all topics, with only the following additional requirements for HAB++(WB):

- Single stateroom size increases to 91.5 ft²
- Double stateroom size increases to 102.5 ft²

The ARV design includes four single staterooms with dayroom for principal scientists, nine single staterooms for senior scientists and twenty-one double staterooms for scientists. At least one

double stateroom is compliant with ADA. Each scientist stateroom is provided with its own sanitary space. Scientist Staterooms are located on the 02 and 03 Levels.

At this time, the ARV General Arrangement supports both threshold and objective requirements for the stateroom considerations outlined above.

4.1.4. Sanitary Spaces

The threshold requirements HAB+(WB) outlined in Appendix 3 of Reference (2) for the sanitary spaces include guidance for:

- General sanitary space design
- Showers
- Toilets
- Washbasins
- Urinals

Sanitary spaces are any compartment allocated for toiletries, washing, or showering. These spaces are composed of a head, sink, and shower module. In accordance with Reference (2), all single staterooms are to contain a private sanitary space, and double staterooms are to have a shared sanitary space for the occupants of the compartment. To ensure work force functionality and efficiency throughout all high traffic working and communal areas of the vessel, public heads are also to be located throughout, as detailed in Section 4.1.1.

To meet threshold requirements, all sanitary spaces will be provided with at least 8 ft² of room with lights, heating, and ventilation. Floors will be designed to be well drained, easily cleaned, and of non-slip construction. Bulkheads are to be steel and watertight to 9 inches above the deck. Venting of disagreeable odors will be to the open air, and the vents independent of other accommodation area vents. Electrical outlets that may be reached while standing on a wet deck will have ground fault interrupt (GFI) protection.

All water provided to sanitary spaces will be protected by anti-scalding devices. Showers will be provided with handholds. Toilets shall be provided with independent controls, flush water, and a handwashing station. Each wash basin will be made of a smooth surface and be provided with a mirror and toiletry shelf.

To meet the additional requirements for sanitary spaces from Reference (1), each public sanitary space will also be provided with a wall-mounted liquid soap dispenser. Further opportunity to improve habitability of public sanitary spaces include providing means to dry hands and stow garbage.

The sanitary space requirements for both HAB+(WB) and HAB++(WB) are the same, with only the following additional requirements for HAB++(WB):

- Minimum space required increases to 12 ft²

The ARV design provides a sanitary space for each stateroom. Public sanitary spaces are sized to accommodate ADA compliance and access by only one person at a time.

At this time, the ARV General Arrangement supports both threshold and objective requirements for the stateroom considerations outlined above.

4.1.5. Food Service Areas

The threshold requirements HAB+(WB) outlined in Appendix 3 of Reference (2) for the food service areas include guidance for:

- General food service space design
- Food service doors
- Food service passageways
- Mess Room
 - General design
 - Outfitting
 - Dimensions
- Galley/Scullery
 - General design
 - Potable Water
 - Maintenance/Cleaning
 - Refrigeration
 - Dishwashing

Food service areas on the ARV include the galley, scullery, and mess. In accordance with Reference (1), the food service areas are required to accommodate at least 60 persons at a time. Additionally, an off-watch self-serve area shall be provided.

To meet the threshold requirements, the food service areas will be designed as dedicated spaces, not intended to be used for sleeping. They will be designed to ensure access to all parts for cleaning and chemical treatments. Considerations will also be made to eliminate crevices and inaccessible locations that could harbor vermin or waste. Floors and finishes will be provided with drains to accommodate flood type cleaning and complete draining.

For the mess, natural lighting will be provided by windows. Overall size of the mess will provide at least 18.4 ft² per person. Seating at rectangular tables will be provided. Each seat will provide 29 inches of table width and 17 inches of table depth. For tables arranged in back-to-back configurations, at least 60 inches will be provided between tables.

The galley and scullery will include preparation areas for baking, vegetable, meat, fish, and poultry. All station countertops will be designed with a backsplash. Dish and pan washing, as well as equipment storage, will also be provided. An icemaker capable of at least 1.25 pounds of ice per day per person will be installed. A dedicated handwashing station will be provided within the galley and placed no more than 25 feet from all galley workstations. All water supplied to the galley will be potable and labeled accordingly. To facilitate maintenance and cleaning, all draws, bins, covers, and sea rails will be easily removable. For safety, all refrigerated spaces will be able to be opened from the inside and equipped with a temperature alarm.

To meet the additional requirements for food service areas from Reference (1), the ARV will have the following:

- Mess
 - Direct access to the serving line
 - Commercial grade equipment, to the greatest extent possible
 - Heavy-duty, high-quality vinyl flooring
 - A large flat screen TV, at least 42-inch screen size

- Galley
 - Direct access to food provision stores
 - Stainless steel bulkhead linings and overheads
 - Heavy duty non-slip tiles, covered at boundaries and sealed
 - Magnetic release fire doors
 - Commercial grade dish sanitizer

The food service requirements for both HAB+(WB) and HAB++(WB) are the same, with only the following additional requirements for HAB++(WB):

- Deck area requirements for planned seating capacity increases to 20.5 ft² per person.

The ARV design provides Galley and Mess areas on the 01 Level. The Mess is a dedicated space and is provided with natural lighting.

At this time, the ARV General Arrangement supports both threshold and objective requirements for the mess and galley considerations outlined above.

4.1.6. Recreation Areas

The threshold requirements HAB+(WB) outlined in Appendix 3 of Reference (2) for the recreation areas include guidance for:

- General recreation space design
- Recreation areas to be considered

In accordance with Reference (1), recreation areas on the ARV include the lounges, libraries, gym, and sauna.

The ARV lounges will be provided with 65-inch color flat screen monitors. They will also be provided with facilities for reading and writing, as well as table games. Each seat in the lounge will be provided with 14 ft² of deck area.

The ARV gym will be designed to accommodate a variety of exercise methods. As selection of fitness equipment is made, the design will need to evaluate the headroom and floor space requirements for the equipment being considered.

A sauna will be furnished with two shower stalls, seating benches, and an electric heater/steam generator.

Additional recreation areas identified by ABS but not required by Reference (1) or included in the design are:

- A smoking room
- Facilities for swimming
- Facilities for recreational handicrafts
- Canteen

The recreational area requirements for both HAB+(WB) and HAB++(WB) are identical, with no additional requirements for HAB++(WB).

The ARV design provides several recreation areas. On the 01 Level, a gym and sauna are provided, as well as a lounge.

At this time, the ARV General Arrangement supports both threshold and objective requirements for the recreation area considerations outlined above.

4.1.7. Laundry

Requirements provided by Appendix 3 of Reference (2) for the laundry areas include guidance for:

- General laundry space design
- Outfitting

In accordance with Reference (1), laundry facilities are provided on the ARV. One laundry is permitted, with a preference for two, with one for scientist use and the other for crew use.

Laundry area will be sized appropriately to provide all personnel with clean and dry underwear once per day and clean and dry outerwear and bedding once per five days. Laundry room will contain:

- Clothes washing machines
- Clothes drying machines
 - Equipped with lint filters
 - Exhausted to weather, not into vessel
- Iron(s) and ironing board(s)
- Sink(s) with potable cold and hot water

All equipment inside laundry spaces should be of equal capacities and located as to provide smooth workflow.

The laundry requirements for both HAB+(WB) and HAB++(WB) are the same, with no additional requirements for HAB++(WB).

At this time, the ARV General Arrangement supports the requirements for the laundry considerations outlined above. This is achieved via one laundry space on the 02 Level.

4.1.8. Medical

Requirements provided by Appendix 3 of Reference (2) for medical areas include guidance for:

- General medical space design
- Outfitting

In accordance with Reference (1), one hospital with direct access to exterior deck area is provided on the ARV. The hospital will contain:

- Berthing with walk-around access
- Its own water closet, lavatory, bathtub, and shower
- Lockable medicine storage cabinets
- Refrigerated medical stores cabinet
- Tele-medicine workstation
- A desk and file cabinet
- Racks for oxygen cylinders

The medical requirements for both HAB+(WB) and HAB++(WB) are the same, with no additional requirements for HAB++(WB).

The ARV design provides a dedicated hospital space on the 02 Level.

At this time, the ARV General Arrangement supports both threshold and objective requirements for the hospital considerations outlined above.

4.1.9. Offices

Requirements provided by Appendix 3 of Reference (2) for offices include guidance for:

- Deck Department Office
- Engine Department Office

The ARV will be designed with spaces equipped for use as an office for both the deck and engine departments.

The office requirements for both HAB+(WB) and HAB++(WB) are the same, with no additional requirements for HAB++(WB).

The ARV General Arrangement provides a deck department office on the 06 Level, near the Bridge. The engineering office will be located in the Engine Control Room on the 1st Platform on the forward side of the engine room.

At this time, the ARV General Arrangement supports both threshold and objective requirements for the office considerations outlined above.

4.1.10. Scientific Mission Spaces

Outlined below are the ARV scientific and working spaces. The discussions are based on application of Reference (2) habitability standards and the impact of threshold and objective requirements.

4.1.10.1. Laboratories

Laboratories require long periods of concentration, including steady and comfortable working conditions. These are the main factors to consider for achieving high quality of life for scientists onboard. Laboratory spaces will be located on Main Deck, unless specified to be in another location, allowing efficient flow of people and equipment. An amidships Main Deck position will be reserved for sensitive laboratories requiring low motions, which may increase the size of the superstructure.

Laboratory spaces will be designed with minimum required areas from Table 20 of Reference (1). Section 4.1.1, 4.1.2, and 3.2 covering general considerations, access and egress, as well as ambient requirements will be applied to laboratory spaces as appropriate. All required areas will be confirmed as the design matures.

The ARV General Arrangement features a science-focused Main Deck, with all lab spaces except the Atmospheric Laboratory and Meteorological Laboratory located on Main Deck.

Currently, the ARV General Arrangement supports the area and location requirements for each of the required laboratory spaces. Arrangement has been informed by continued involvement of the scientific community and space adjacencies have been considered.

4.1.10.2. Science Workshops

Locating scientific workshops onboard must be favored towards meeting internal noise requirements while limiting noise propagation from these spaces to adjacent scientific or accommodation spaces. Workshops are not required to have acoustic insulation; however, if compartment location is detrimental to workplace functionality, insulation will be an available tool to combat noise propagation.

Science Workshops will be designed with minimum required areas from Table 20 of Reference (1).

Section 4.1.1, 4.1.2, and 3.2 covering general considerations, access and egress, as well as ambient requirements will be applied to science workshops as appropriate. All required areas will be confirmed as the design matures.

The ARV General Arrangement provides the required science workshops, all located on Main Deck of the vessel.

Currently, the ARV General Arrangement supports the area and location requirements for each of the required science workshop spaces. Arrangement has been informed by continued involvement of the scientific community and space adjacencies have been considered.

4.1.10.3. Science Hangars

Science hangars are spaces where quality of life is vulnerable from temperature, weather, and noise exposure. This is a major component of the ambient environment guidelines, and it is furnished with adequate HVAC to maintain acceptable air temperature and quality requirements, per Reference (2). Supplementary heat source when the vessel is in port and in zero-emission operation is included in accordance with requirements in Reference (1). Lighting must be adequate in hangar spaces as the criteria within Reference (2) requires high luminance levels to maintain a high safety standard during mission tasks. Low white or red-light applications will be considered for ARV hangars.

Science Hangars will be designed with minimum required areas from Table 20 of Reference (1).

Section 4.1.1, 4.1.2, and 3.2 covering general considerations, access and egress, as well as ambient requirement will be applied to science hangars as appropriate. All required areas will be confirmed as the design matures.

The ARV General Arrangement provides the required science hangars, all located on Main Deck of the vessel, except for the Aviation Hangar located on the 04 Level.

Currently, the ARV General Arrangement supports the area and location requirements for each of the required science hangar spaces. Arrangement has been informed by continued involvement of the scientific community and space adjacencies have been considered.

4.1.10.4. Science Support Spaces

Science support spaces are intended for communication, analysis, and recording, and these spaces will receive care in ambient environment noise, vibration, and acceleration exposures. While not required, acoustic insulation and careful placement of compartments will assist in reducing the impact of the ambient environment on scientific procedures.

Science Support Spaces will be designed with minimum required areas from Table 20 of Reference (1).

Section 4.1.1, 4.1.2, and 3.2 covering general considerations, access and egress, as well as ambient requirement will be applied to science support spaces as appropriate. All required areas will be confirmed as the design matures.

Currently, the ARV General Arrangement supports the area and location requirements for each of the required science support spaces. Arrangement has been informed by continued involvement of the scientific community and space adjacencies have been considered.

4.1.10.5. Science Storage Spaces

Science storage spaces are to be treated similar to normal ship stores and cold or freeze stores where required. Science stores are intended for storage only, so no substantial periods of personnel exposure to the ambient environment is present here. These storage spaces pose a low risk to ambient environment exposure, with indoor climate and lighting as the main ambient environment considerations.

Science Support Spaces will be designed with minimum required areas from Table 20 of Reference (1).

The storage of any hazardous materials onboard the ARV should undergo careful scrutiny of requirements for individual substances and compliant design of stowage spaces. This may possibly drive specific arrangement requirements depending on the substances to be stowed.

At this time the scientific hazardous materials storage space is located in a weather deck accessible area, away from all internal laboratory spaces, staterooms, and other commonly occupied areas.

Section 4.1.1, 4.1.2 and 3.2 covering general considerations, access and egress, as well as ambient requirement will be applied to science storage spaces as appropriate. All required volumes will be confirmed as the design matures.

Currently, the ARV General Arrangement supports the area and location requirements for each of the required science stores spaces. Arrangement has been informed by continued involvement of the scientific community and space adjacencies have been considered.

4.1.10.6. Workshops and Stores

Workshops for ship support tasks are utilized by the crew and do not hold the same delicate work activities as scientific spaces. These ship support workshops are sources of noise and high traffic, so design of acoustic insulation and deck location will be a priority to mitigate noise and vibration propagation from these workshops to sensitive areas.

The ARV will be provided with the appropriately sized shops and stores for the repair and maintenance of the vessel.

Section 4.1.1, 4.1.2, and 3.2 covering general considerations, access and egress, as well as ambient requirement will be applied to workshops as appropriate.

Stores and workshops are located on Main Deck and the 1st Platform of the vessel.

Currently, the ARV General Arrangement supports the area and location requirements workshops and stores.

4.2. Ambient Environment

The ambient environment pertains to the environment that the crew is exposed to during any periods of work, leisure, and rest. Reference (2) provides guidance in four general categories of ambient environment.

- Whole-body Vibration and Acceleration
- Noise
- Indoor Climate
- Lighting

The information within the following sub-sections covers the four ambient environment topic types to be applied consistently across the habitable areas listed in Section 3.2 of this report. For each section, the threshold requirements as well as additional requirements to meet objective performance are discussed.

4.2.1. Whole-Body Vibration and Accelerations

Whole-body vibration and acceleration is the exposure of low frequency mechanical vibrations and single impulse shock loads to the human body. In the interest of the ARV and the Antarctic voyages, it is important to define these vibration limits through analysis so scientist and crew quality of life within the workplace is of the highest standard, allowing the desired quality of research.

Both mechanical vibrations and vessel motions contribute to low frequency vibrations and accelerations. Additionally, the dominant heavy beam sea state in the Antarctic region will need to be analyzed for any effect on acceptance criteria. Table 2, Section 3 of Reference (2) details the maximum weighted root-mean-square (RMS) acceleration level for both transit and dynamic positioning conditions. The RMS values, measured in mm/seconds squared, are more stringently constrained as the standard moves from threshold to objective requirements of Reference (1).

Applying the guidance in Table 2, Section 3 of Reference (2) to a global analysis of vibration and accelerations on the vessel will allow the accommodation areas and working spaces to be kept within reasonable range of exposure.

Reference (2) also provides guidance on testing methods and acceptance criteria for the whole-body vibration and acceleration requirements.

The whole-body vibration and acceleration criteria will adhere to requirements specified in Reference (1) and Section 3 of Reference (2).

At this time, a whole-body vibration and acceleration analysis of the current arrangement has not been completed. Findings from this analysis will provide a basis for future arrangement decisions.

4.2.2. Noise

Noise exposure is a significant component for high quality of life at sea, and the transit of scientists to Polar Regions with long voyages and large periods of work create substantial periods of noise exposure. Employing Reference (2) guidance provides a means to improve crew performance, facilitate communication and improvements to sleep and comfort, while also complying with the Airborne noise criteria listed in Reference (1) Section 073 and presented below.

Space

Airborne noise criteria

- Laboratories 60 dBA
- Boat embarkation areas 75 dBA
- Open deck (aft) 75 dBA
- Open deck (forward) 75 dBA

Reference (2), Section 4, Table 2 provides a maximum acceptable noise level in decibels for transit and dynamic positioning conditions. Each compartment is divided into type, based on rest, leisure, and work, with increasing allowable noise as each compartment designation progresses to noise borne sections of the vessel.

The noise criteria will adhere to the requirements specified in Reference (1) and the Section 4 portion of Reference (2). Designing the vessel to the objective requirement could result in the need for increased interior volume to allow adequate separation of sources of noise or to provide room for the additional required insulation.

Reference (2), Section 4/5.2 also requires acoustic insulation to reduce the propagation of noise from working and machinery spaces, as well as cabin to cabin propagation. The insulation is considered to be airborne sound insulation and will need to be applied to bulkheads, both structural and joiner, and the underside of decks. This insulation is measured by its weighted sound reduction index (R_w).

Reference (2) also provides guidance on testing methods and acceptance criteria for noise requirements.

The acoustic insulation criteria will adhere to the requirements specified in Reference (1) and Section 4 of Reference (2).

At this time, a noise analysis of the current arrangement has not been completed. Findings from this analysis will provide a basis for future arrangement decisions.

4.2.3. Indoor Climate

Reference (2) uses thermal comfort as a measure of indoor climate. It also provides the following definition of thermal comfort, “that condition of mind which expresses satisfaction with the thermal environment.” As such, indoor climate is a complex problem for the ARV as “thermal comfort” will vary significantly from person to person, especially when applied to the Polar Region. Employing Reference (2) guidance provides a means to improve thermal comfort of the crew and scientists, while also complying with the Reference (1) required habitability standards.

Reference (2) provides criteria for the following indoor climate items:

- Adjustability
- Air temperature
- Relative Humidity
- Vertical Gradient
- Air Velocity
- Horizontal Gradient
- Air Supply Quantity

The ARV will be designed to provide an air temperature of 68 to 77 degrees Fahrenheit in the heating season, and 73.5 to 82.5 degrees Fahrenheit in the cooling season. Relative humidity will be required to be between 40% and 70%. The vertical temperature gradient in a space will be between 0 to 6 degrees Fahrenheit. All air velocities will be less than 1.7 feet/second. In crew

staterooms, the horizontal gradient will be less than 18 degrees Fahrenheit. The minimum quantity of fresh/outdoor air supply shall be not less than 0.28ft³/second per person and in addition will need to be at least 40% of the total air supplied to a specific space.

Reference (2) also provides guidance on testing methods and acceptance criteria for indoor climate requirements.

The indoor climate requirements for HAB+(WB) and HAB++(WB) are the same across all topics with the exception of adjustability. The objective HAB++(WB) range of air temperatures must be adjustable and as specified in Reference (1), Section 044 Table 6 Interior HVAC requirements, all normally occupied spaces (AC) will follow ABS HAB++(WB) requirements.

At this time, the ARV General Arrangement supports an HVAC design that is compliant with both threshold and objective requirements for the indoor climate considerations outlined above.

4.2.4. Lighting

Visual task performance is a critical component for scientists and crew, and lighting should facilitate improved performance and comfort. Reference (2) provides illuminance levels, measured in Lux, for the following types of spaces:

- Crew Accommodation Spaces
- Entrances and Passageways
- Navigation and Control Spaces
- Service Spaces
- Operating and Maintenance Spaces
- Red and Low-level White Spaces

It is noted that the threshold and objective requirements for lighting include areas outside the habitability areas discussed in this report, such as the engine room.

Reference (2) also provides guidance on testing methods and acceptance criteria for lighting requirements.

The lighting requirements for HAB+(WB) and HAB++(WB) are the same, with no additional requirements for HAB++(WB).

Currently, the design of the ARV does not detail individual lighting features. As there are no additional objective requirements, threshold compliance will not restrict overall objective habitability compliance.

4.3. ADA Compliance

Reference (1) requires the vessel meet ADA guidelines where feasible. The ARV has been designed to be ADA-compliant in the following locations:

- A minimum of one stateroom
- A minimum of one ADA compliant public head on each ADA accessible deck
- All lounges and libraries
- Sauna and Gym
- Mess
- Laundry
- Lab bench heights and reaches

To assist in accessing each level of the vessel containing common spaces, lifesaving appliances, medical services, or laboratory spaces, the ARV General Arrangement provides two ADA accessible elevators.

At this time, the ARV General Arrangement has incorporated additional improvements to accessibility. The main lift has been extended to service all laboratory spaces and the mammal observation space. The ADA stateroom has been moved to a lower level with better direct access to lifeboats.

4.4. Similar Vessel Study

The ARV threshold and objective requirements of HAB+(WB) and HAB++(WB) notations aim to provide an elevated level of habitability standards for the crew and scientists involved. As Reference (2) is not an international standard, but rather specific to only those vessels classed by ABS, it is difficult to make comparisons to a global research fleet. To provide a clear comparison to a more universal standard, the IMO Maritime Labour Convention (MLC), 2006, Reference (3) and amendments were used.

The MLC provides guidance on vessel operations and treatment of seafarers, as well as requirements for the physical vessel. These physical requirements are found in Title 3 of the MLC and were used for comparison to Reference (2) in this study. The following list outlines the habitability standards included in Reference (3) that were evaluated:

- Headroom
- Wall surface
- Flooring joints
- Accommodation compartment locations
- Cabin area, outfitting, sizing, occupancy, and designations
- Berth sizing and arrangements
- Sanitary and toiletries compartment locations, outfitting, arrangement, and area
- Office spaces
- Mess, galley and scullery location and outfitting
- Recreation and exercise areas
- Laundry outfitting
- Medical facility size and outfitting

Comparing the MLC Title 3 requirements with Reference (2), the HAB+(WB) and HAB++(WB) guidelines are found to meet all MLC requirements for the categories above. Further, it is noted that the ABS Reference (2) guidelines provide additional requirements that result in both HAB+(WB) and HAB++(WB) certified vessels to exceed the quality of life provided by the MLC Title 3 requirements in Reference (3). This comparison provides assurance that the use of Reference (2) will ensure the ARV will exceed the current standards set by IMO.

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5. Conclusion

This habitability report utilized the primary ARV requirements in Reference (1) and the main habitability guidelines in Reference (2) to outline the requirements needed to meet the threshold requirements for the vessel. Most requirements were found to be the same for both threshold HAB+(WB) performance notation and objective HAB++(WB) notation levels. Objective requirements that are presently not being met will be further evaluated for impacts to the overall design in order to receive the objective notation in all areas. In the case where a single objective requirement is unable to be met, all others should be reevaluated for inclusion in the design.

This report will be updated as selection of materials and detailed interior design is finalized. All attention will be given to maximize comfort and overall living conditions.

The overall ADA requirements for the vessel have been met. However, further analysis and details need to be developed to make sure the actual individual compartment arrangements are ADA compliant. In addition, optimization of the access and egress routes, especially for an emergency event, should continue to be considered during any future updates to the General Arrangements.

Finally, the comparison of the ARV habitability requirements to an internationally recognized standard found the vessel requirements will provide a level of habitability that exceeds the IMO guidance.

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6. References

- (1) ASC Research Vessel Replacement Program, ARV Performance Specifications; Glosten; 16 August 2021
- (2) Guide for Crew Habitability on Workboats; American Bureau of Shipping; February 2016
- (3) Maritime Labour Convention, as amended, 2006; International Labour Conference; 2018

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