



TASK 3: The Vertical Game: *MATE Floats! 2027*

MATE Floats! 2027 is inspired by the National Science Foundation (NSF)-funded [GO-BGC Project](#). The goal of GO-BGC is to build a global network of profiling floats with chemical and biological sensors to monitor circulation, chemistry, biology, and overall ocean health. Scientists, engineers, and technicians are using NSF grant funds to build and deploy 500 robotic ocean-monitoring floats around the globe. GO-BGC is over the 400 mark, with 457 out of the targeted 500 GO-BGC floats deployed and another 29 floats scheduled to be deployed from research vessels.

Once again *MATE Floats!* is challenging NAVIGATOR class competitors to build an autonomous float that can collect temperature data during a vertical profile. And like last year, *MATE Floats!* is also challenging NAVIGATOR companies to incorporate decision-making into their floats by developing a program or code that controls the movement of the float. This means that the float is programmed to autonomously descend to the bottom and return to the surface (i.e., complete a vertical profile). Once on the surface companies are required to graph the temperature data collected by their floats during the profile.

This task involves the following steps:

Design and construct an operational vertical profiling float

- **Game Plan: Prior to the competition, design and construct a vertical profiling float – 5 points**
- **Execute: Float completes two vertical profiles**
 - **Completes first vertical profile as an independent float – 15 points**
 - **Completes second vertical profile as an independent float – 15 points**
 - or**
 - **Completes first vertical profile as an autonomous float – 10 points**
 - **Completes second vertical profile as an autonomous float – 10 points**
 - or**
 - **Completes first vertical profile as a manual float – 5 points**
 - **Completes second vertical profile as a manual float – 5 points**
- **Check the Playing Conditions: Float collects temperature data**
 - **Float records all nine required temperature measurements – 10 points**
 - **Float records two to eight required temperature measurements – 5 points**
- **Review the Play: Data is graphed as temperature versus depth – 5 points**

OR

Company does not design and construct a vertical profiling float, or the float does not contain a temperature sensor

- **MATE-provided data is used to graph temperature versus depth – 5 points**

Total Points = 50 points

Product Demonstration Notes:

Prior to the competition, companies must build a float capable of completing two vertical profiles (i.e., descending from the surface to the bottom of the pool, then ascending back to the surface).

How a company chooses to move their float through the water column does not influence points. The float can use a buoyancy engine or a different mechanism (something other than a buoyancy engine) to complete vertical profiles. A [buoyancy engine](#) moves fluid from inside the float to outside the float, displacing seawater and changing the volume and thus the density of the float. This moves the float vertically (up and down) in the water. Alternatively, companies can use motors and propellers to move the vertical profiling float through the water.

Also, companies can choose to design a float that operates independent of surface control (hereafter called an independent float), is tethered to the surface but operates autonomously (hereafter called an autonomous float) OR is tethered to the surface and is operated manually (hereafter called a manual float).

An independent float:

- Must be independent of surface control and may not be connected to the station by a tether, rope or line. Once deployed, it is on its own. The ROV may not interact with the float after successful deployment until it has completed all its vertical profiles.
- Must be 50 cm or less in overall height
- Must be 18 cm or less in overall diameter/length/width
- Any air used on an independent float must be stored on the float. Independent floats may not have an airline to the surface.
- All electrical power to the float **MUST** go through a single fuse. The float must use onboard batteries for its electrical operations and will operate as a non-ROV device (see Non-ROV Device Power Specifications for additional rules on powering a non-ROV device). All other onboard batteries must adhere to the non-ROV device battery rules.
- An independent float must be 50 cm or less in length for the entire mission, it cannot have multiple compartments that separate, nor may it raise or lower any objects beyond the 50 cm limit.
- Propellers, if used, must be shrouded to IP-20 standards

An autonomous float:

- Must be tethered to and powered from the surface but use a computer program to move the float vertically through the water. An autonomous float may be manually started (i.e., a button pressed or program activated to start the autonomous process), but once started, the computer program must issue commands so that the float descends to the bottom. Companies may not manually reverse the process to bring the float to the surface; a computer program must do this autonomously.
- Must be 50 cm or less in overall height
- Must be 18 cm or less in overall diameter/length/width
- Must move independently from the ROV. After deployment, the ROV may not interact with the float to move it up and down.
- Any source of power for the float must be on the surface. Electronics/computer boards (Arduino/Raspberry Pi, etc.) may be on the surface or on the vehicle. Floats using electrical power must be connected to the MATE power supply. Onboard batteries or onboard power is not allowed for floats tethered to the surface. Floats not using electrical power must still be tethered to the surface by an airline tube, rope or other line.
- May not use an air compressor to send compressed air to the float but may use a manually powered pump (operated autonomously) to push air into an open bottom container. Likewise a syringe (operated autonomously) on the surface could open and close a syringe on the float.
- MUST operate as a non-ROV device. See below for additional information on powering non-ROV devices.
- Propellers, if used, must be shrouded to IP-20 standards

A manual float:

- Is controlled by a company member on the surface, side of the pool. This would include a company member operating:
 - a switch controlling the direction of a thruster motor
 - a manual pump pushing air into an open bottomed section of the float
 - a syringe (operated manually) on the surface opening and closing a syringe on the float.
- Must be 50 cm or less in overall height
- Must be 18 cm or less in overall diameter/length/width
- Must move independently from the ROV. After deployment, the ROV may not interact with the float to move it up and down.
- Any source of power for the float must be on the surface. Floats using electrical power must be connected to the MATE power supply. Onboard batteries or onboard power is not allowed for floats tethered to the surface. Floats not using electrical power must still be tethered to the surface by an airline tube, rope or other line.
- May not use an air compressor to send compressed air to the float but may use a manually powered pump to push air into an open bottom container. Likewise a manually powered syringe could open and close a syringe on the float.
- MUST operate as a non-ROV device. See below for additional information on powering non-ROV devices.

- Propellers, if used, must be shrouded to IP-20 standards

Companies will receive 5 points for designing and building a float. Successfully designing and building a float is defined as submitting a non-ROV device document and SID that meets the requirements of DOC-004 and transporting the float to the product demonstration station. The document must outline the company's float design, detailing its operation, and demonstrating that it does not violate any safety rules. This document must also detail whether the float uses a buoyancy engine or uses a different mechanism (i.e., uses something other than a buoyancy engine) and which building option, independent float, autonomous float, manual float, the company uses. The float design document should include a photo or CAD diagram of the float. If the design is an independent float design, companies must also specify what type of batteries are used and the fuse size for safe discharge of the current. A SID of the float MUST be included with the non-ROV device design document. See DOC-004 for more information.

Your regional may not require float documentation to be submitted prior to the event. [Contact your regional coordinator or visit your regional contest's website](#) to determine if you must submit your float design document prior to the competition. IF REQUIRED BY THE REGIONAL COMPETITION, COMPANIES MUST SUBMIT THEIR FLOAT DOCUMENTATION OR THEY WILL NOT BE RECEIVE POINTS FOR BUILDING THE FLOAT. If not required by the regional, companies must bring their float documentation, including a SID, and their float to the mission station to receive points for successfully designing and building a profiling float.

Your regional may not allow independent floats using onboard power. [Contact your regional coordinator or visit your regional contest's website](#) to determine what options are available for building your float.

Companies may choose to either hand-launch the float from the side of the pool or the pilot of the ROV may maneuver the float to a position on the surface of the pool. The float should attempt to complete two vertical profiles. A vertical profile is defined as the float on the surface of the water, descending to the bottom of the pool, then ascending to and breaking the surface of the water. Depending on the float design, companies will receive variable points for completing two vertical profiles.

If the float operates independently, companies will receive 15 points for completing their first vertical profile and 15 points for completing their second vertical profile. If the float operates autonomously, companies will receive 10 points for completing the first vertical profile and 10 points for completing their second vertical profile. If the float operates manually, companies will receive 5 points for completing their first vertical profile and 5 points for completing their second vertical profile.

Companies must incorporate a temperature sensor on their float to record nine temperature measurements. The temperature measurements should be taken at the:

1. **Surface** prior to the first vertical profile
2. **Midwater** on the descent of the first vertical profile

3. **Bottom** on the first vertical profile
4. **Midwater** on the ascent of the first vertical profile
5. **Surface** after the first vertical profile but before the second vertical profile
6. **Midwater** on the descent of the second vertical profile
7. **Bottom** of the second vertical profile
8. **Midwater** on the ascent of the second vertical profile
9. **Surface** after the second vertical profile

Companies will receive 10 points for successfully recording all nine temperature measurements. Companies will receive 5 points if they successfully record two to eight temperature measurements. Successfully recording a temperature measurement is defined as showing the station judge your temperature reading and recording that temperature at the mission station. Companies may record the temperature by hand on paper or enter them into a computer or other device. MATE will not provide paper or a device for recording.

Temperature collection on the surface is defined as the float in the water, but any part of the float protruding above the surface.

Temperature collection midwater is defined as no part of the float above the surface and the float not touching the bottom.

Temperature collection on the bottom is defined as the float on the bottom or within 5 cm of the bottom of the pool.

The accuracy of the temperature measurement must be within 4° Celsius of the true temperature. Station judges will have a temperature sensor that will measure the temperature of the pool. Companies can compare their temperature sensor against the station sensor to determine if there is any offset (i.e. to determine if your sensor differs from the station sensor). Temperature measurements outside of the 4°C range will not be counted as successful temperature measurements. For example, if a company collects nine temperatures, but one of those temperature measurements is outside of the 4°C range, that company would only be successful in recording eight temperatures, and would receive 5 points for this portion of the task.

Companies deploying independent floats may retrieve temperature data from their float by having the float transmit that data when on the surface, or companies may recover the float and download the temperature data to a device. Companies may use their ROV to recover the float after it has completed both vertical profiles. Whatever method is used, companies building an independent float must show the temperature data to the station judge.

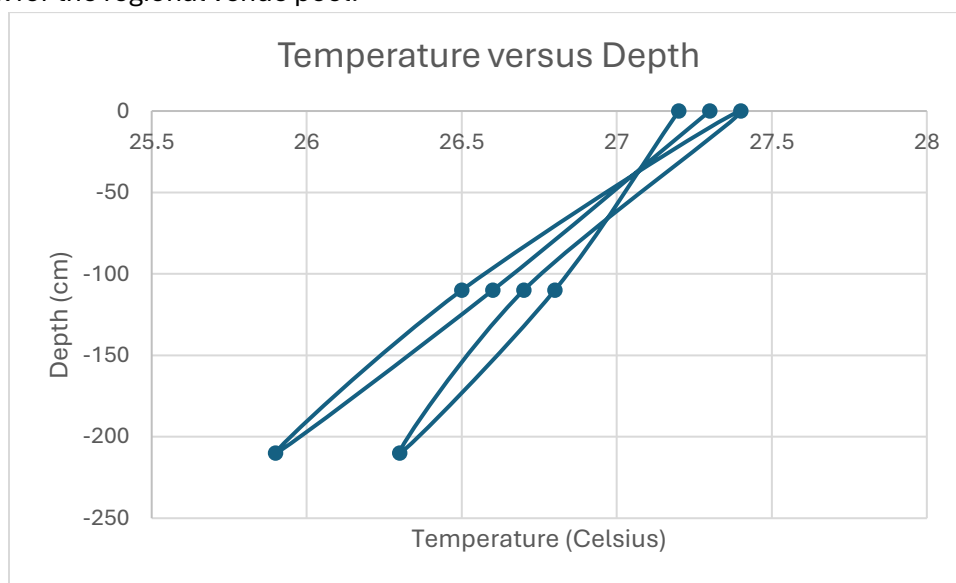
Companies must graph the temperature data collected by their float. Companies will receive 5 points when they successfully graph temperature versus depth. Successfully graphing data is defined as plotting the depth on the Y-axis and temperature on the X-axis and showing the resulting graph to the station judge. All dots should be linked by a line. Companies may use Excel or another computer program to plot their data points or may graph the data points on paper. MATE will not provide computers or graph paper at the mission station; companies must provide their

own method for graphing the data. All graphs must have their axes labeled. An example of a graph plotting temperature versus depth is represented below:

Data measured:

Location	Depth (cm)	Temperature (°C)
Surface 1	0	27.2
Midwater Descent 1	-110	26.8
Bottom 1	-210	26.3
Midwater Ascent 1	-110	26.7
Surface 2	0	27.4
Midwater Descent 2	-110	26.5
Bottom 2	-210	25.9
Midwater Ascent 2	-110	26.6
Surface 3	0	27.3

Note: Depths reflect a 2.1-meter (7 feet) deep pool. Depending on the depth of your regional pool, other midwater and bottom depths can be used. Companies do not need to determine the exact depth the temperature measurement was taken, any mid-water measurement can use the halfway depth mark for the regional venue pool.

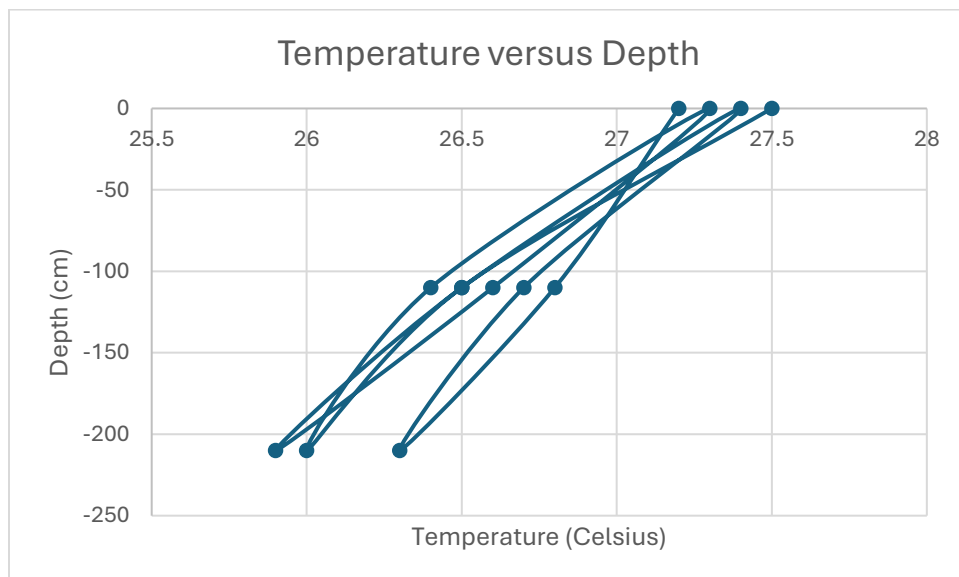


If a company does not build a float, or if the float that they built does not have a temperature sensor, or if the temperature sensor fails to send temperature data back to the mission station, companies should inform the station judge that they are choosing to instead graph data provided by MATE. The judge will then provide a set of 13 depth versus temperature data points. Once a company requests the MATE data, they can no longer receive points for graphing their own data. Instead, companies will receive 5 points for successfully graphing the data provided by MATE.

Successfully graphing the data provided by MATE is defined as showing the station judge a graph with temperature on the X-axis and depth on the Y-axis. All thirteen data points must be included on the graph. MATE will not provide computers or graph paper at the mission station; companies must provide their own method for graphing the data. All graphs must have their axes labeled.

An example of MATE supplied data and graph resulting from the data:

Location	Depth (cm)	Temperature (°C)
Surface 1	0	27.2
Midwater Descent 1	-110	26.8
Bottom 1	-210	26.3
Midwater Ascent 1	-110	26.7
Surface 2	0	27.4
Midwater Descent 2	-110	26.5
Bottom 2	-210	25.9
Midwater Ascent 2	-110	26.6
Surface 3	0	27.3
Midwater Descent 3	-110	26.4
Bottom 3	-210	25.9
Midwater Ascent 3	-110	26.5
Surface 4	0	27.5



Like ROVs, floats do not need to be overly complicated to work.

- One motor is sufficient to move your ROV up and down in the water and your float only needs to move in those two directions. For manual piloting, a DPDT switch is capable of controlling a bilge pump motor on your float.
- For a buoyancy engine, moving air into the float can make it positively buoyant (ascend). Pushing a syringe on the surface can open and close a syringe on the float.
- For autonomous control of the vertical profiling float, consider using a board such as Arduino, Raspberry Pi, or other to control the motor. The board can send signals through the tether to the motor to turn in one direction to have the profiler descend to the bottom, then send signals to reverse the motor direction to ascend. Consider how that motor could open and close a syringe on the float, changing its density and moving it up and down in the water. For all of these devices, companies can adjust the timing of their program depending on the depth of the pool. [Contact your regional coordinator or visit your regional contest's website](#) to determine the depth of the pool.

The SeaMATE Store offers a Profiler kit: [MATE Floats! Vertical Profiler Kit – SeaMATE](#). This kit is designed to run **manually** but can be modified to operate autonomously.

Images of competition floats can be seen in the [MATE ROV Competition Flickr](#) albums. For examples of independent floats, see the Technical Reports, Spec Sheets section of the 2022-2026 [competition archives](#). The 2022 float mission for RANGER, PIONEER and EXPLORER is quite similar to the 2027 NAVIGATOR mission. Good examples of independent profiling floats:

- [St-Francis-High-School_Geneseas_Non-ROV-Device-Documentation_2022.pdf](#)
- [Homeschooling_Hydro-Kinetics_NON-ROV-DESIGN_2022.pdf](#)
- [EMCC_Desert Star Robotics_Vertical Profiler Design Document_2024.pdf](#)

DOC-004: Non-ROV device design document: Companies will be required to submit a written and photographic description of their non-ROV device. This document is limited to 2 pages in length. This non-ROV device design document must contain:

- Information on the type of float designed (independent, autonomous, or manual) and whether the device uses a buoyancy engine or does not use a buoyancy engine.
- If the float uses a buoyancy engine, companies must describe how their buoyancy engine operates
- A photo or diagram of the non-ROV device.
- A photo of the fuse(s) used on the ROV (if electrical power is used).

A SID of the non-ROV device document must be included with the non-ROV device design document. This SID must be one page in length and is in addition to the 2 pages required for the non-ROV device design document (i.e. DOC-004 can be a total of 3 pages, 2 pages for a description, one page for a SID). The SID must include:

- A fuse using a standard fuse symbol (if electrical power is used)
- Full load amps fuse measurements (if electrical power is used)

Companies that design an independent float that uses onboard batteries must also include information on:

- The type of batteries used.
- A photo of all battery packs.
- Fuse determination showing the full load amps measurements for both waiting mode (motors off) and buoyancy change mode (motors on).
- A description of how the battery pack was designed to safely fulfill the full load amps needs and the voltage requirements of the float device.

3.3.1 Non-ROV Devices

The vertical profiling float qualifies as a non-ROV device in 2027. This is a device separate from the ROV that a company can deploy and control to fulfill its mission. The following are rules for the float.

ELEC-NRD-001: The vertical profiling float can be powered from the surface or from onboard batteries. Voltage is limited to **12 VDC maximum**; amperage is limited to **5 amps maximum**. All power for the non-ROV device must go through a single fuse (see ELEC-NRD-005).

Companies powering their float device from the surface are required to plug into a MATE power supply. The connection requires red/black Anderson powerpole connectors. If plugging into the surface power supply, the onboard battery rules presented in ELEC-NRD-003 do not apply.

Companies using onboard batteries **MUST** follow the battery pack specifications outlined in ELEC-NRD-003.

ELEC-NRD-002: The vertical profiling float non-ROV device may not include any cameras.

NOTE for 2027!!! New battery limitations are in place. Read the following information carefully!

ELEC-NRD-003: Onboard power is allowed for non-ROV devices. If onboard batteries are being used, the following specifications must be met.

- NiMH (Nickel Metal Hydride) and AGM (Absorbed Glass-Mat) batteries only. **Alkaline batteries are not allowed.**
- NiMH battery packs consisting of 9-volt, AA, C or D cell batteries are allowed. **See table below for maximum amperage allowed for each battery type.** This includes battery packs with multiple small batteries wrapped in plastic.
- Larger NiMH and AGM (Absorbed Glass-Mat) 12 volt batteries are also allowed. This includes large (brick sized) batteries.

- No other size or chemical composition is allowed. 12-volt outdoor, re-chargeable batteries are not allowed. **Hi discharge LiPo batteries are not allowed.**
- Batteries are mounted in a manner that they are not loose inside the container.

All batteries are limited to the maximum allowed current shown in this table. Above this current, batteries will overheat.

Battery Type	Maximum Fuse Size
NiMH AA	2.0 A
NiMH C or D	5.0 A
NiMH 9-volt	200mA
NiMH* / AGM 12V	5.0 A

*The 5.0 amp maximum fuse size for NiMH 12 volt batteries refers only to the larger, brick sized batteries. 12-volt battery packs, consisting of multiple AA or 9-volt batteries, require the smaller fuse size for those batteries.

To determine a NiMH battery's maximum fuse size, see the individual battery's mAH (milliamp hours) rating. Divide that number by 1000. For example, if a NiMH AA battery has a rating of 2300 mAH, its maximum current would be 2.3 amps, requiring a 2-amp fuse. If a NiMH battery has a rating of only 1900 mAH, its maximum current would be 1.9 amps, requiring a 1-amp fuse. The above table was derived from the general mAH from the types of batteries in question.

ELEC-NRD-004: Battery fusing for non-ROV devices is an important consideration and the following rules must be adhered to.

For floats using surface power:

- A single fuse must be utilized that will shut down all power sources in the non-ROV device if the fuse blows.
- A fuse (5 amps max) must be installed within 30 cm of the battery positive terminal.

For floats using onboard batteries:

- A single fuse must be utilized that will shut down all power sources in the non-ROV device if the fuse blows.
- A fuse (5 amps max) must be installed within 5 cm of the battery positive terminal.
- All fuses, when installed, must be able to be visibly inspected for amperage through a clear housing or immediately after an opaque NRD device housing is removed without the need to uncover the fuse.
- **Note for 2027!!!** Cartridge, ATO type blade fuses or MINI blade fuses CAN be used for fusing NiMH and AGM batteries. The fuses to select from are 1A, 2A, 3A, 4A and 5A fuses.

These fuses provide easy visual inspection for amperage using industry standard color codes.

Fuse Reference: [ATO fuse](#) [MINI fuse](#)

These fuses are all rated for 32VDC and are color coded for amperage.

- All blade fuses MUST correspond to the standardized color codes listed on the fuse links above. All cartridge fuses must be readily accessible and have the current stamped on the end of the fuse. Minimum DC voltage for the fuse must be 32 volts.
- The maximum distance from a battery pack to any fuse is 5 cm.
- Batteries in Series: No voltage over a nominal 12V is allowed. This means no more than eight 1.5V alkaline batteries in series.
- Batteries in Parallel: Batteries may be placed in parallel to increase the current available to the system within the following limits:
 - In no case shall the current from the pack exceed 5A.
 - The number of series strings in parallel is used as a multiplier to determine the fuse size. For example, using AA batteries, the maximum fuse size is 2.0 amps. If two battery strings are placed in parallel, the maximum fuse size is 2 amps ($2 * 2.0A = 4.0$ Amps).
- **Note for 2027!!!** NAVIGATOR devices are limited to one battery pack. All onboard devices must be powered from a single battery pack.

ELEC-NRD-005: Full Load Amps Value. Companies MUST measure the full load amps (FLA) of their device in water during waiting mode (motors off) AND during buoyancy change mode (motors on). For floats using onboard batteries, the type of battery pack allowed for their system can be determined using the full load amps measurement (See ELEC-004N) in the competition manual for more information).

Using the non-ROV device full load amps values, companies should select the standard fuse closest to their FLA.

Note for 2027!!!

ELEC-NRD-006: **If using onboard batteries**, the enclosure housing must be designed so that it will open if the pressure inside the housing is greater than the outside pressure.

There are two allowable methods for pressure relief:

1. The enclosure is built in a manner that an end cap will pop off if under pressure. This can be an internal or external cap with O-rings to provide sealing. The sealing diameter of the end cap must be 2.5 cm in diameter or greater (this limits the smallest ID of an enclosure to 2.5 cm).
2. **New for 2027!!!** An approved commercial, off-the-shelf pressure relief valve may be used provided it is set to a maximum of 15 PSI. Companies planning to use a pressure relief valve must forward the specifications for the valve to the [Competition Technical Manager](#) by May 1st, 2027, or at least 2 weeks prior to their regional competition. The specifications must show the pressure release rating of the valve. Companies are REQUIRED to bring the

pressure release valve specification to their safety inspection. This may be as a digital copy or a printed copy made available to the safety inspectors.

Additional notes:

- Under no condition should the housing be built with fasteners to hold the housing together. There must be at least one 2.5 cm or larger opening that serves as a pressure release.
- Pop-off end caps that utilize a tightening mechanism (hose clamp, Twist-Tite) are not allowed.
- Companies may use other pressure relief devices as a secondary type of pressure relief, but must institute one of the primary methods to pass the safety inspection.
- **New for 2027!!!** A hole filled with a rubber stopper is no longer acceptable as a primary pressure relief mechanism. Companies may use a rubber stopper as a secondary pressure relief system but must have one of the two acceptable primary pressure relief mechanisms in place.

ELEC-NRD-007: A SID must be submitted for any non-ROV device that uses electrical power