VITROVEX®

Glass enclosures

HANDLING PROCEDURES

Instructions for successful use of VITROVEX glass enclosures in deep ocean exploration

Handling procedures for VITROVEX® glass housings

Content

1. Version history

Fifth edition, November 2020

- Major revision of all chapters
- Installation of bulkhead connector adaptors and vacuum ports added
- References (information drawings) included

Fourth edition, September - October 2013

- Closing procedure modified

Third edition, January 2013

- Changed mind. connector thread length from 30 to 35mm

Second edition, April 2011

- Introduction page added
- Risk of leakage note for Terostat 7 sealing tape

First edition, December 2009

2. Introduction

With your VITROVEX glass enclosure you have purchased a concept in deep sea instrument housings which is different to the common metal or synthetic materials. Though, after a period of familiarisation, you will highly appreciate the host of advantages that glass enclosures offer for many applications.

All stationary and autonomous instrumentation for observational activities in deep ocean exploration have two things in common, they need pressure resistant housings and buoyancy to bring instruments safely back to surface. The use of glass housings thereby seemed to be attractive in many ways. Glass qualities such as the immense strength-weight ratio, corrosion resistance and low cost make glass housings for both flotation and instruments superior to other methods.

On the other hand, glass is brittle and hence subject to damage from impact. Therefore, the production of VITROVEX glass housings requires high quality raw material, advanced manufacturing technology and expertise in processing by Nautilus Marine Service GmbH to meet the strong demands of oceanographers.

Handling and processing of glass housings is somewhat different compared with enclosures made of other materials. The guidelines and recommendations set out herein address significant topics in this regard and supposed to help customers in a period of familiarization.

We encourage in particular new users of VITROVEX glass housings to work through this manual to reduce possible sources of mistakes and to get inspired by the many opportunities VITROVEX glass can offer for deep ocean exploration.

Thank you!

Nautilus Marine Service GmbH

3. General notes

VITROVEX floatation and instrument housings are made of glass that is not a dangerous substance (on the basis of data available to us) in the sense of chemical legislation or hazardous substances ordinance in its currently applicable version. If handled correctly and used for the intended purpose, the material has no health-threatening effects. The material is physiologically harmless.

Glass is sensitive to impact. Always handle with best possible care and use protective work wear. VITROVEX protective shells should be installed during transport.

Do not drop the enclosure or parts of it neither hit the glass against other objects. Even if no obvious damage is noticed after such accident, the enclosure could be exposed to chipping caused by invisible micro cracks.
Use soft stands (e.g. car/bicycle tubes) without sharp edges to place the glass enclosure while you are working on it. A protective cover may be pulled over in idle mode to safeguard the glass surfaces against unintentional mechanical impact.

While glass housings are tremendously strong against pressure, they are particularly sensitive to tension, shear, and torsion. Do not install at instrument platforms where they are subjected to such forces.

Evacuation of the glass housings is recommended for three reasons:

- to settle the parts firmly,
- to avoid inside condensation,
- to avoid excess inside pressure when the instrument is heated up, for instance when it is exposed to sunlight. Air would try to seep out and then cause a leak in the seal.

Sealing is usually done glass-to-glass with an outside sealant tape. Never use grease or oil as a sealing aid between the two mating glass parts. Sealing surfaces must be meticulously clean. Wipe with residual free solvent (e.g. Isopropanol 99,9% or bioethanol) and do not touch again before closing.

Sealant (and protective) tape must be applied AFTER evacuation.
Glass enclosures shrink when they are under pressure. Even if the reduction in diameter is very small, the outer diameter of all built-in items must be at least smaller than the maximum inner diameter of the sphere less the shrinking value for this particular housing. Nautilus Marine Service can supply mounting rings in various diameters to support installation.

All items inside the glass enclosure should be securely mounted with mechanical compliance towards the glass to avoid damages during transportation, deployment, or recovery. It has been shown that rigid PVC has been proven for manufacturing mounting brackets or plates although there are no limitations in view of useable materials.

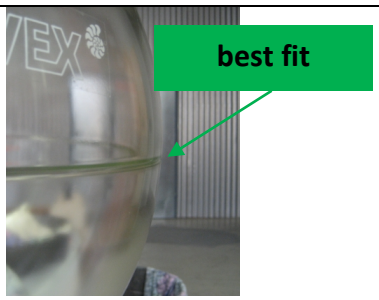
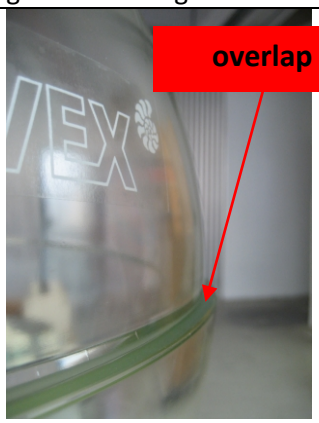
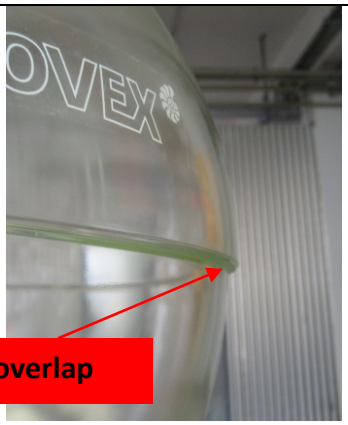
Flexible adhesives should be used to minimize the risk of damages to the inner surface of the glass when pressurized. Resulting micro flaws could propagate over time and eventually lead to larger spalling.

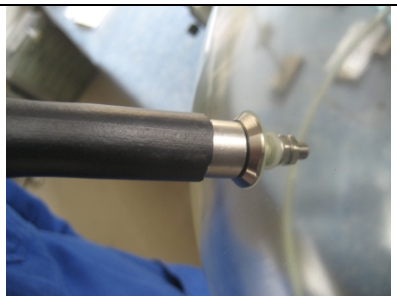
For the installation of penetrators and other wall-thru-items, the application of adaptor plates is strongly recommended. For this reason, it might be necessary to order wall-thru-items with longer and non-default shaft/post length.
Alternatively, VITROVEX bulkhead connector adaptors could be used.

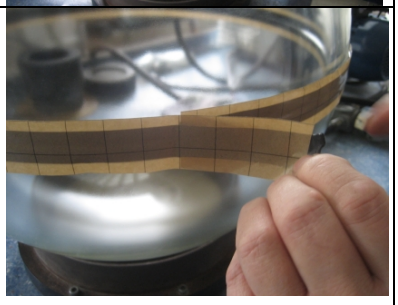
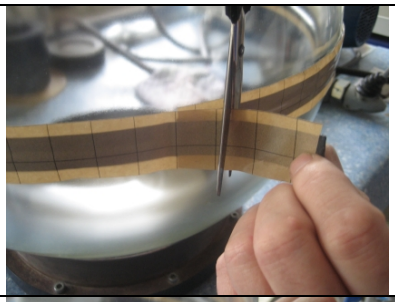
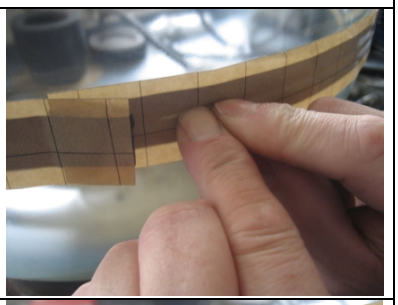
Penetrators and any other wall-thru-items should not be used as attachment points of additional components inside the enclosure as otherwise the resulting bending stress could cause damages to the glass along the edges of the through holes.

Batteries or similar components which emit any kind of gas must not be used as the vacuum inside the sphere could be lost.

4. Closing procedure of a VITROVEX glass sphere

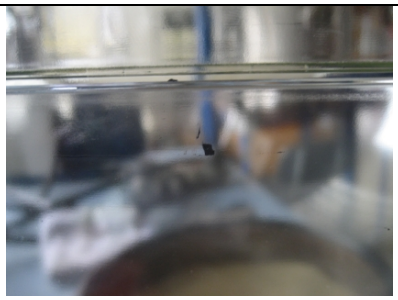
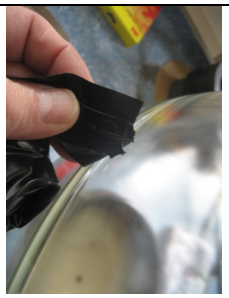
1.	Clean surface of cutting area on both hemispheres by means of a chemical volatile cleaner (Acetone, Isopropanol 99,9%, bioethanol) or just common glass cleaner in combination with a cleaning rag.		 TIP: Spray onto rag rather than onto glass.
2.	Put top and bottom hemisphere exactly on top of each other.	 TIP: Don't look for any corresponding markers on top and bottom hemispheres. VITROVEX hemispheres can be placed on top of each other at any position due to high quality grinded cutting areas.	 TIP: There is no need to rotate the hemispheres just align along the edges by gently pressing against the top hemisphere.
3.	Check for best fit of top and bottom hemispheres (no overlap).		

4.	Open vacuum port by screwing out set screw.		 TIP: Watch out for o-ring of set screw. It might get stuck in the vacuum port.
5.	Put a matching hose from a vacuum pump over the open vacuum port.		
6.	Evacuate the sphere to 0.75 to 0.85 bar below atmospheric pressure (0,15 to 0.25 bar absolute), take off air hose and close vacuum port immediately.		 TIP: A slightly higher depression than 0.8 bar gives you a little bit more time to screw in the set screw of the vacuum port.
7.	Cut off an appropriate length of TEROSTAT 81 sealing tape (approx. 1400mm for 17” glass sphere).		

8.	Align glass sphere horizontally and clean the area along the equator similar to step #1.		
9.	Centre TEROSTAT between the two semi spheres and attach it to the glass sphere all around.		
10.	Cut off surplus TEROSTAT but maintain approx. 30 mm overlap and press TEROSTAT firmly into the bevel along the two hemispheres.		
11.	Apply TEROSTAT entirely onto the glass sphere, remove the protection sheet and push the overlapping tail on top of the beginning.		
12.	Centre SCOTCHRAP between the two semi spheres on top of the TEROSTAT.		 TIP: Start point of SCOTCHRAP should be somewhat away from the junction of the TEROSTAT.

13.	Attach SCOTCHRAP 3 times all around the glass sphere or TEROSTAT respectively and finally clean and push it to the sphere at the same time.		
14.	The glass sphere is sealed, protected and can now be moved into its protective shell.		

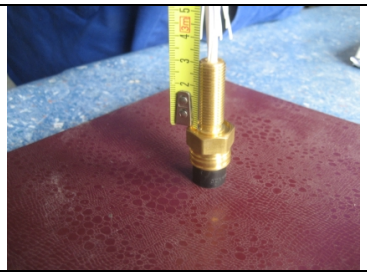
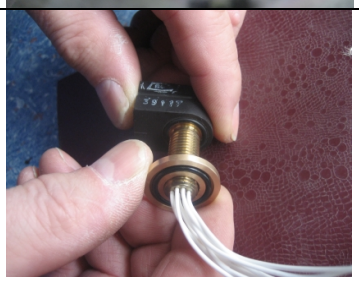
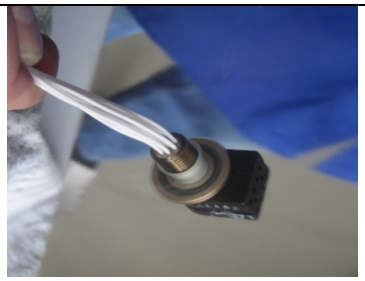
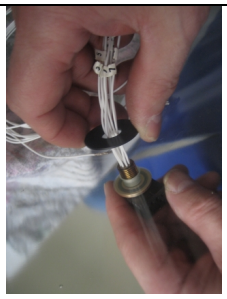
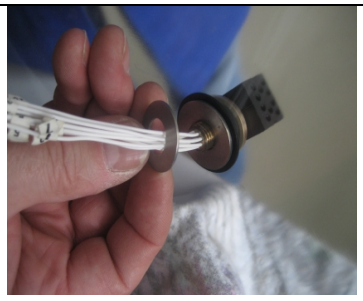
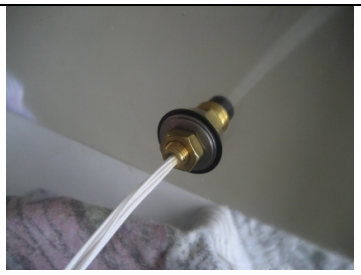
5. Opening procedure of a VITROVEX glass sphere

1.	Open plastic protective cover and put glass sphere to a suitable stand.		
2.	Remove SCOTCHRAP and underlying TEROSTAT sealant tape.		
3.	Remove any small leftovers outside the glass sphere.		 TIP: put the removed TEROSTAT tape onte the small particles to simply remove any remaining leftovers as they stick quite easily to it.
4.	Open vacuum port by screwing out set screw.	 TIP: tighten set screw after vacuum is released in case you are not going to close sphere again soon.	 TIP: Watch out for o-ring of set screw. It might get stuck in the vacuum port.

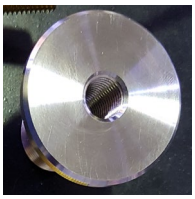
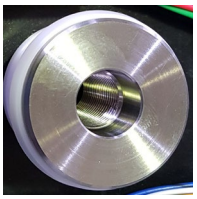
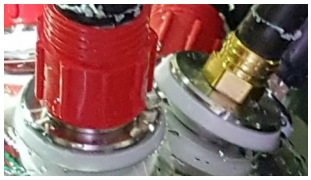
5.	After vacuum escaped, lift up top hemisphere, turn it around and place it onto a suitable stand (next to the remaining semi hemisphere if there is a connection between them). Remove carefully any remaining TEROSTAT sealant tape from the cutting area of the two hemispheres.	 TIP: top hemisphere should be lifted up vertically in order to avoid any damadges around the edges of the hemispheres.	

6. Installation of bulkhead connectors

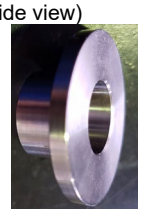
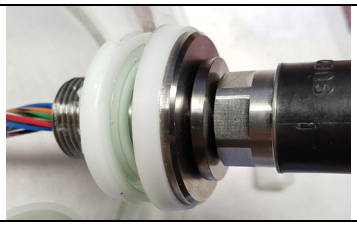
Installation into drill holes with ground flat

1.	Make sure you have all parts for the bulkhead assembly at your disposal (bulkhead, adapter plate with o-ring, plastic shaped washer, washer, disc spring, nut). Make sure that the tread of the bulkhead is at least 35 mm.		
2.	Clean all parts of connector and glass sphere thoroughly. Pay special attention to the surface around the boreholes as it must be free of any scratches.		
3.	Put the adapter plate over the bulkhead and fit everything into the borehole whereas the side with the o-ring of the adapter plate points towards inside the glass sphere. TIP: Use MOLYKOTE 111 (or similar) to grease the o-ring of the adapter plate.		
4.	Put the shaped washer followed by the washer over the bulkhead and make sure that the bulge of the shaped washer points towards the glass sphere. Put the disc spring followed by the nut over the bulkhead and make sure that the bulge of the disc spring points towards the nut.		
5.	Tighten the nut by hand to take up any slack. The o-rings should be compressed, then, using a torque, tighten nut until disc spring is compressed and the connector is fixed. We recommend using a force of 6 to 8 Nm (7/16” standard thread) for clean and free of grease threads.	 TIP: you may use a low strength threadlocker (e.g. loctite 222) for the nut.	

Installation into bulkhead connector adaptors

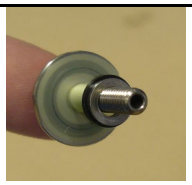
1.	Ensure that the bulkhead connector adaptor(s) appropriate for your bulkhead connector(s) is correctly installed on the VITROVEX glass enclosure.	7/16” Bulkhead connector adaptor 	5/8” Bulkhead connector adaptor 	3/4” Bulkhead connector adaptor 	
	Bulkhead connector with 1/2'' and 7/16'‘ thread could alternatively be mounted into a 5/8” bulkhead connector adapter using corresponding thread reducer and sleeve nut. See next chapter below for further information.				
2.	Ensure that the respective threads are clean and apply light greasing with Molykote 111 to the O-ring of the connector.				
3.	Screw the bulkhead connector into the adaptor finger-tight first and fully tighten it with a torque of 4 - 4,5 Nm.				

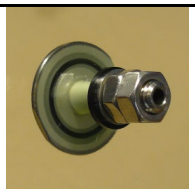
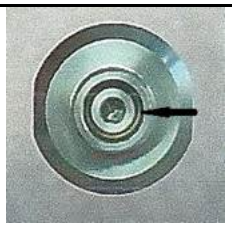
Installation into bulkhead connector adaptors using thread reducers

1.	Ensure that the bulkhead connector adaptor(s) appropriate for your bulkhead connector(s) is correctly installed on the VITROVEX glass enclosure and that you have the corresponding thread reducer and sleeve nut handy.	5/8" Bulkhead connector adaptor 	Thread reducer (side view) 	Thread reducer (bottom view) 	Sleeve nut 
	Bulkhead connector with 7/16'', 5/8" and ¾" thread could alternatively be mounted straight into corresponding bulkhead connector adapters. See previous chapter below for further information.				
2.	Ensure that the respective threads are clean and apply light greasing with Molykote 111 to the O-ring of the connector and to the O-ring of the thread reducer.				
3.	Push the thread reducer over the connector and insert the entity into the adaptor.				
4.	Finger-tighten the connector from inside the glass enclosure with the sleeve nut first and fully tighten it with a torque of 3 – 3,5 Nm.				

7. Installation of vacuum ports

Installation of traditional vacuum ports (P/N VP & VPL)

1.		Inspect drill hole and vacuum port with o-ring(s) carefully for any damages, it is recommended to lubricate the o-ring(s) slightly before use. !!! Do NOT install a vacuum port, if spot face or edges around the drill hole show any sign of damages such as scratches or chipping.
2.1		For P/N VP: Lubricate O-Ring ø10,82 x 1,78 slightly and put it into the groove.
2.2.1		For P/N VPL: Lubricate O-Ring ø 8 x 1,5 slightly and put it into the groove.
2.2.2		Lubricate O-Ring ø14 x 1,5 slightly and put it into the groove.
2.		Carefully place the vacuum port into the drill hole so that the o-ring is seated on top of the spot face and while holding it in place, follow the two steps below:
3.		(1) Pull the plastic washer over the threaded shaft…
4.		(2) …followed by the stainless-steel washer and push both gently towards the glass.

5.		Place M5 stainless steel nut onto the threaded shaft and lightly tighten it. When the whole assembly is nearly fixed, center the vacuum port and finally tighten it using a force of 1Nm.
6.		Counter with second M5 stainless steel nut.
7.1		For P/N VP: Place (lubricated) o-ring size 3x1 over the shaft of the Allen screw and insert the Allen screw into the appropriate opening on top of the vacuum port.
7.2.1		For P/N VPL: Fit o-ring size 6x1,5 into the lower groove of the Allen screw.
7.2.2		Place (lubricated) o-ring size 4x1 over the shaft of the Allen screw and insert the Allen screw into the appropriate opening on top of the vacuum port.
8.		Tighten the Allen screw with a force of 0.2 Nm. Alternatively, you can tighten the Allen screw with the following procedure: Insert the screw with o-ring until you just feel the screw starts to touch the o-ring. Then turn the screw another 270 to 300 degree to tighten it. The variation (30°) depends on your sensibility to recognize the point when the screw starts to touch the ring. If only two fingers are used to hold the screwdriver while softly screwing the Allen screw in, it should be quite easy to determine the point where the resistance starts.
9.1		For P/N VPL: Install the o-ring size 10x1 at the outside of the vacuum port into the groove provided for that purpose.

Installation of self-sealing vacuum ports (P/N VPS & VPR)

1.		Inspect drill hole and vacuum port (vp) with o-ring(s) carefully for any damages, it is recommended to lubricate the o-ring(s) slightly before use. Do NOT install a vp, if spot face or edges around the drill hole show any sign of scratches or chipping.
2		Lubricate O-ring slightly and place it carefully into groove.
3		Place the vp carefully into the drill hole so that the o-ring is seated on top of the spot face. While holding it in place, follow the two steps below:
4		(1) Pull the plastic shaped washer over the threaded shaft…
5		(2) …followed by the stainless-steel washer and push both gently towards the glass.
6		(3) …followed by the stainless-steel disk spring (Belleville washer) with the concave side first, and push both gently towards the glass.
7		(4) Place stainless steel nut (7/16 for VPS / M5 for VPR) onto the threaded shaft and lightly tighten it. (5) When the whole assembly is nearly fixed, center the vp and finally tighten it using a force of 6-8 Nm.

8. VITROVEX Protective shells

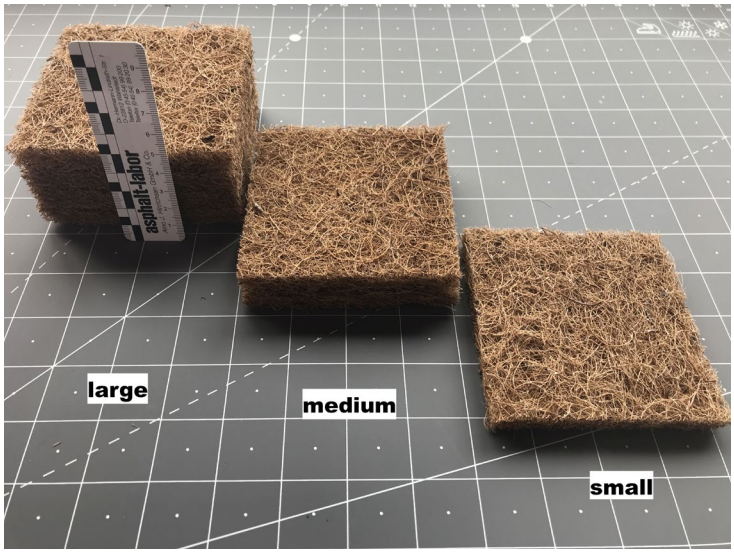
Protective shells for VITROVEX spherical glass housings are available for impact protection, stowing and ease of handling. They are made of LDPE (low-density polyethylene) in bright orange colour and are neutrally buoyant. Protective shells are offered in smooth or ribbed design.

Protective shells of ribbed design are often used in moorings or application with a large likelihood for impact whereas smooth protective shells usually used when spheres are mounted directly on underwater equipment such as landers or when the protective shell needs to be modified in order to accommodate (oversized) connectors, transducers, etc. or to provide view holes for cameras, lights etc. respectively.

There is no difference in terms of hydrodynamics or net buoyancy between ribbed and smooth protective shells.

Technical drawings (STEP files) for protective shells are available for download. Please check www.vitrovex.com

Each protective shell consists of two flanged halves secured by stainless steel bolts with washers and self-locking nuts. Synthetic fibre pads between the glass sphere and the shell absorb shock and retain the sphere in its position.



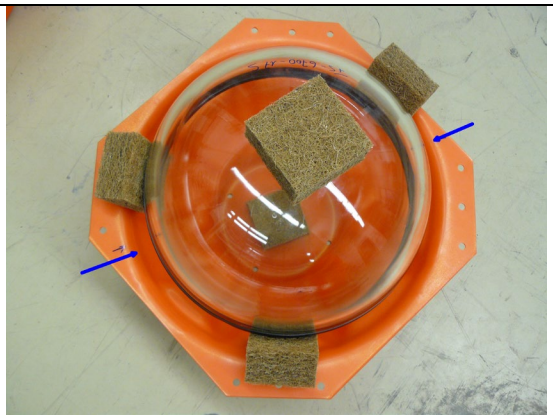
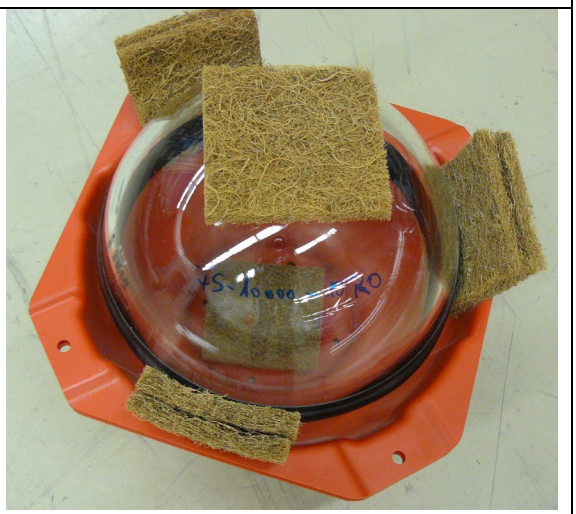
All fibre pads are square shaped (100mmx100mm), only the height is different.

Large: 50mm (P/N PAD-100-50)

Medium: 25mm

Small: 12.5mm

Number of fibre pads for protective shells

17” spheres with smoothed hard hats: (2x medium)	17” spheres with ribbed hard hats: (1x medium, 5x large)
	
• 1 medium at the bottom • 1 medium at the top	• 1 large and 1 medium at the bottom • 3 large around equator • 1 large at the top Note: Fibre pads shall be placed next to the recess of the hard hat and NOT inside (marked with an blue arrow in the figure beside)
13” spheres with ribbed hard hats: (4x small, 1x medium)	10” spheres with ribbed hard hats: (2x small, 3x medium)
	
• 1 medium at the bottom • 3 small around equator • 1 small at the top	• 1 small at the bottom • 3 medium around equator • 1 small at the top

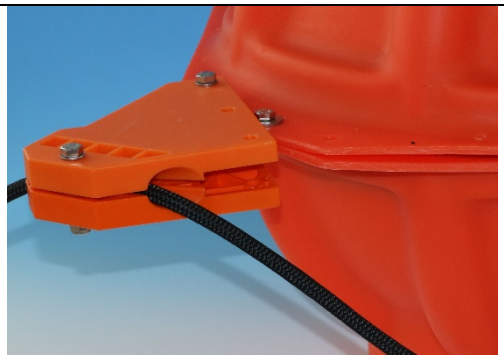
9. VITROVEX mooring system

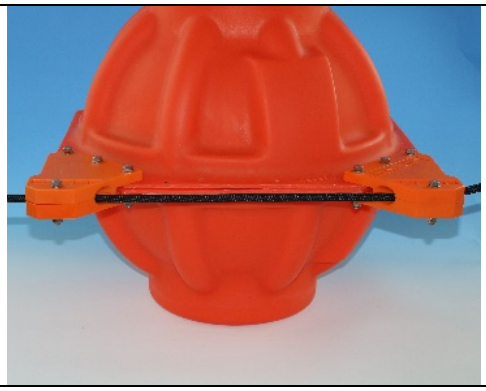
The VITROVEX mooring system is a set of up to five VITROVEX 17” floatation spheres attached to a braided fibre rope (P/N EDDYROPE) with swivelling mounting brackets (P/N EDDYGRIP-XX) to support field installations. Buoyancy clusters can be prepared and attached at the appropriate locations along the mooring just right before deployment.

Spheres rotate along the rope rather than being fastened, which significantly reduces drag on the mooring line.

The attachment of VITROVEX floatation spheres to a VITROVEX mooring system is explained below.

Attachment of VITROVEX floatation spheres to a VITROVEX mooring system

1		Prepare the assembly by laying down the EDDYROPE and each pair of EDDYGRIP in front of the corresponding floatation sphere(s). Do NOT remove the fastening screws of the protective shell.
2		Unscrew all bolts from the EDDYGRIPS and put them aside. Take off the upper halve of each EDDYGRIP and insert the EDDYROPE in the pipe recess of the lower halve of the each EDDYGRIP. Place the upper halve back and lock both halves in position (do not fastening yet) with the single bolt near the rope.
3		The bolts (M8x55, half or full thread) are made of AISI 316L stainless-steel.
4		Attach one of the EDDYGRIPs to the protective shell right behind the fastening bolt of the protective shell and lock it in position there with a bolt. The protective shell has to remain closed i.e. the fastening bolt of the protective shell must not be loosed.

5		Now, disconnect the fastening bolt of the protective shell. If the protective shell has been opened, make sure that the fibre pads are in their intended position before you slide over the EDDYGRIP. 
6		Slide the EDDYGRIP over the protective shell and attach the remaining two bolts for the EDDYGRIP. Fastening all bolts and check for the EDDYROPE to be free to move.
7		Repeat steps 4 to 6 for the other EDDYGRIP.
8		Repeat steps all steps for each sphere along the mooring line and make a final check for the EDDYROPE to be free to move across all spheres.

10. References

Information drawings

(1) VITROVEX instrument spheres – configuration options

(2) VITROVEX floatation spheres – configuration options

(3) VITROVEX protective shells

(4) VITROVEX vacuum port extensions

(5) VITROVEX mooring system (5tons)

(6) VITROVEX mooring system (12tons)