



High voltage cable transit design manual

FOR OFFSHORE POWER APPLICATIONS

Standardize with a complete sealing solution

Roxtec provides the offshore power industry with safe solutions for cable entry sealing, cable management and vibration damping. Standardization with our seals means efficient design, quick installation and certified protection.

This design manual has been developed with inputs from our own experiences from installations onsite as well as with inputs from various actors in different countries involved in the construction and operation of

an offshore substation. It is built on knowledge within everything from design, construction and installation through to operations and maintenance.

Project experience

Thanks to the lessons learned in more than 40 offshore wind projects and with more than 20 years of experience from the offshore oil and gas and marine industries, the Roxtec design team has created the design manual to simplify and clarify the different Roxtec solutions that are used in existing offshore substations/converter stations. The design and construction phase of a project is complex and includes many different actors with different perspectives to be considered. Experience shows that communication between the involved parties early in the design phase is crucial to achieve safe cable transit installations.

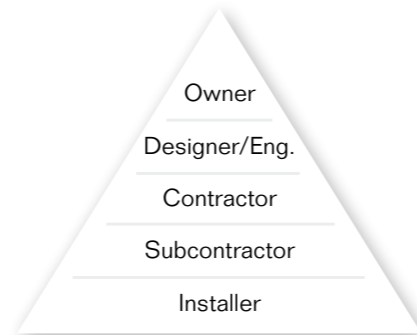
In order to have cables going straight through the transits the following is to be considered:

- Space for cable routing
- Minimum cable bending radius
- "Footprint" of equipment: Transformers and GIS
- Distance between deck/bulkhead and equipment

Cost of the different solutions

A challenge for the offshore wind industry is how to reduce cost in the projects. The picture on page 4 clearly presents the cost difference of the different solutions supplied by Roxtec. By choosing the right solutions cost-savings can be made, but it requires communication and careful planning by all involved parties.

Safety and total cost of ownership as well as simplicity and speed of installations in order to utilize the weather window have also been considered when developing the different sealing solutions.



DNV approved system

Lessons learned in previous projects

Safe cable routing, installation and sealing of HV cables can be a complicated process. Large rigid single core power cables are not easy to handle, especially not in areas with limited space and during time pressure. In order to have a safe and smooth process, the following actors need to be involved in the design and installation process.



Objectives to be considered:

OWNER & OPERATOR

- Safety
- Possible upgrade and service and maintenance of cable transits during project life cycle
- Standardized sealing solutions

DESIGNER & SHIPYARD

- Design of cable routing on offshore substation
- Sufficient space for the cable routing
- Sufficient space between deck and equipment such as GIS or transformer
- Standardized opening sizes
- Weight
- "Footprint" of GIS and transformer

CABLE INSTALLER

- Minimum cable bending radius of cables
- Careful positioning of cables in cable transits
- Clamping of cables during installation
- Terminations and connectors on cables to be installed before or after cable going through transit

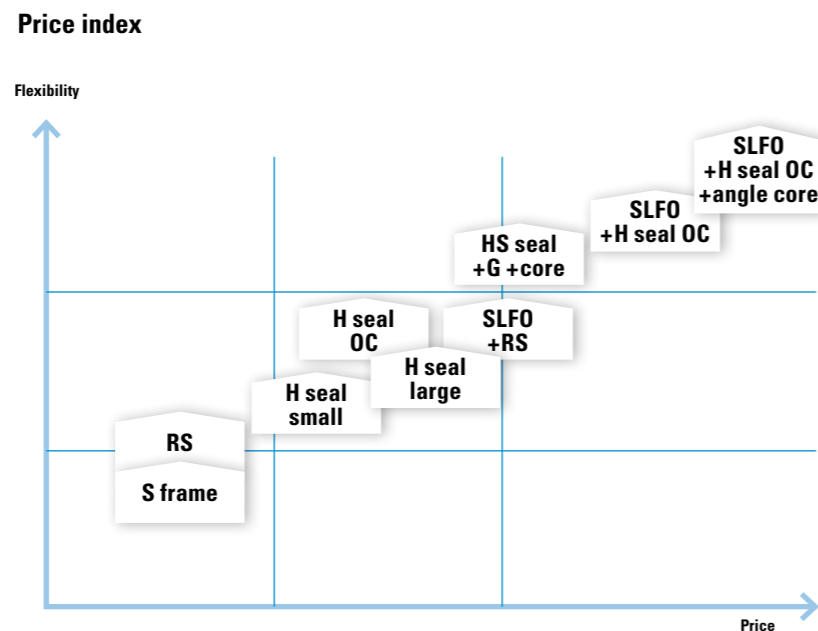
Basic project requirements

FUNCTIONAL

- A0/A60 (fire demand)
 - Above/below deck
 - Bulkhead
- IP 67 (water-tightness)
- Stainless steel/mild steel
- Cable sizes up to 128 mm
- Manage tolerances of cable position (+/- 15 to 30 mm)
- Manage large connectors
- Low weight

To be considered before choosing the solution

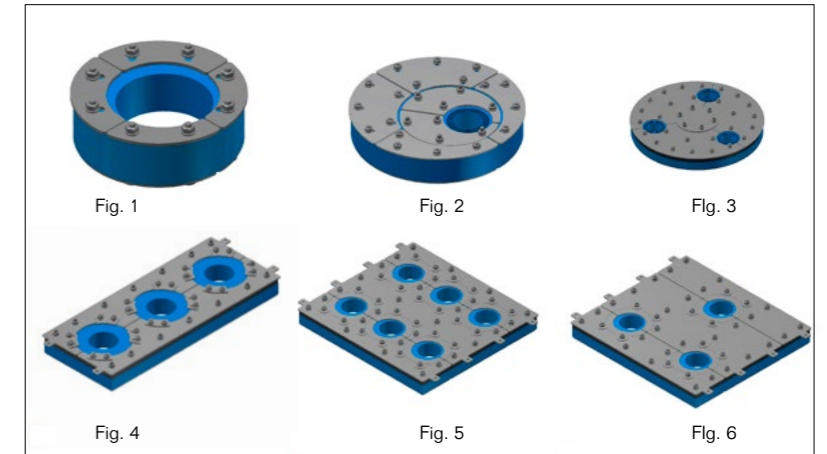
- Certifying authority
- Technical requirements
- Hole pattern/interface solutions
- Material – stainless steel or mild steel
- Cable diameters
- Cable types
- Tolerance in moving cables
- Distance between switchgear connectors and deck
- Bolted or welded solution
- Connector size
- Connector feeding through opening
- Maximum bending radius of cable
- Weight of system due to installation principle
- Marking
- Kit packing
- Installation training
- Final inspection



Product information

H seals, round or rectangular seals

- Customized seals based upon a standard design
- With Multidiameter™, the Roxtec solution for adaptability to cables of different sizes based on sealing modules with removable layers, or fixed diameter for cables
- 60-65 mm thick rubber parts in Roxylon™
- 5mm acid proof stainless steel parts (non-magnetic)
- Fasteners in acid proof stainless steel
- Off-center design for increased flexibility of cable position
- Additional holes for grounding cables possible



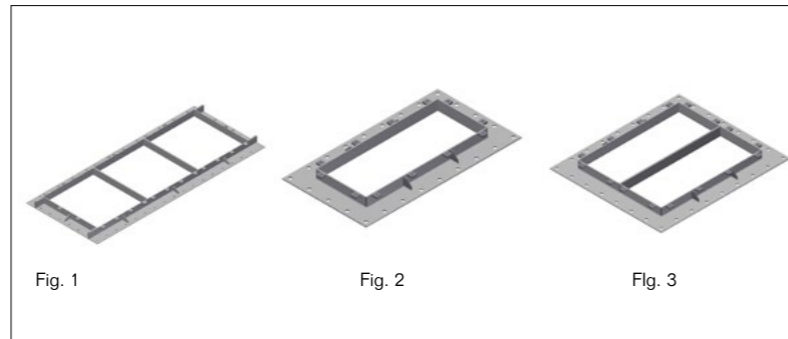
SLFO sleeve plates for round seals

- Customized sleeves based upon a standard design
- Openable design for bolting
- 4mm acid proof stainless steel (non-magnetic) to keep weight down
- Incl. gaskets and seal holders
- 20 mm mounting hole for M8 fasteners for increased flexibility
- Additional grounding of steel parts available



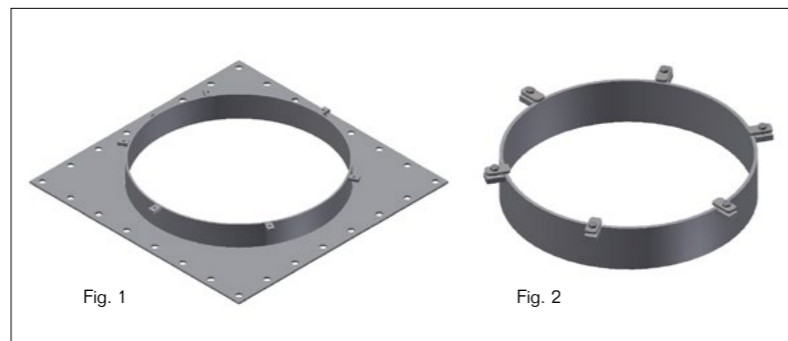
GOH frames for rectangular seals

- Customized frame based upon a standard design
- Openable or closed design for bolting
- Closed design for welding
- 6/10 mm acid proof stainless steel (non-magnetic) for bolting
- 6/10 mm mild steel primed with acid proof stainless steel (non-magnetic) partition wall for welding
- Incl. gaskets and seal holders
- 20 mm mounting hole for M8 fasteners for increased flexibility
- Additional grounding of steel parts available

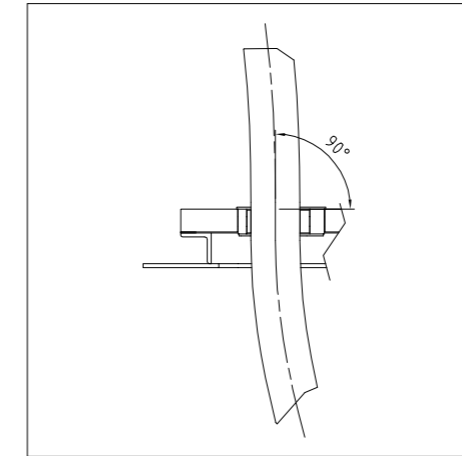


SL/SLF sleeves for round seals

- Customized sleeves based upon a standard design
- Closed design with flange for bolting
- Sleeve without flange for welding
- 6 mm acid proof stainless steel (non-magnetic) for bolting
- Incl. gaskets and seal holders
- 20 mm mounting hole for M8 fasteners for increased flexibility
- 6 mm mild steel primed for welding
- Additional grounding of steel parts available

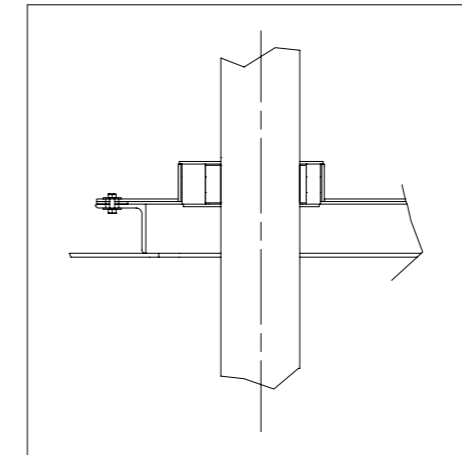


Cable routing and structure interface



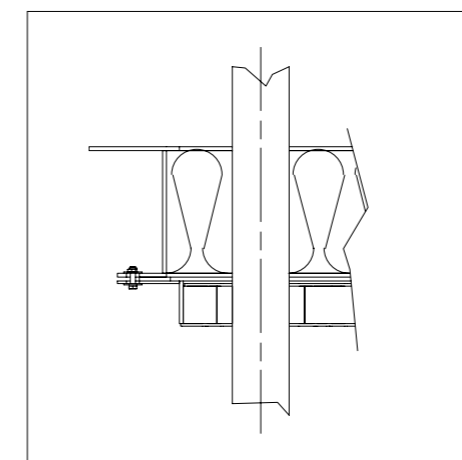
Cable routing

- Cable needs to be routed perpendicularly to the seal when it passes through



Structure above deck

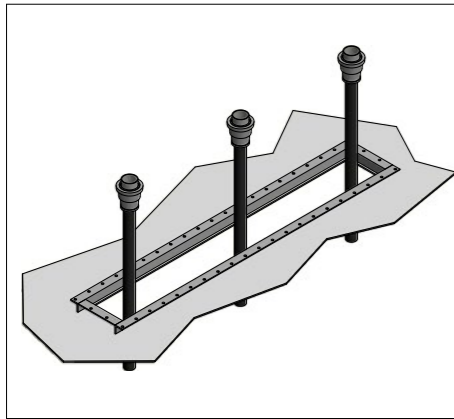
- 80x80 profiles
- 20 mm holes, 25 mm from outer edge
- Cc distance 90-110 mm for M8 fasteners



Structure below deck

- Min 200 mm deep profile with 80 mm flange
- 20 mm holes, 25 mm from outer edge
- Cc distance 90-110 mm for M8 fasteners
- A-class insulation inside box 100kg/m3

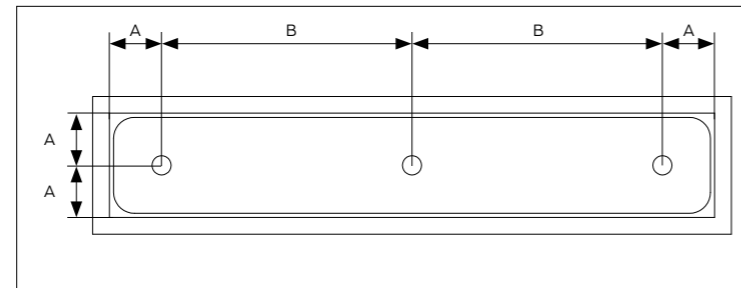
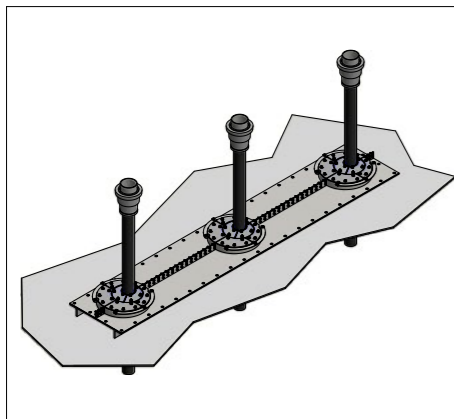
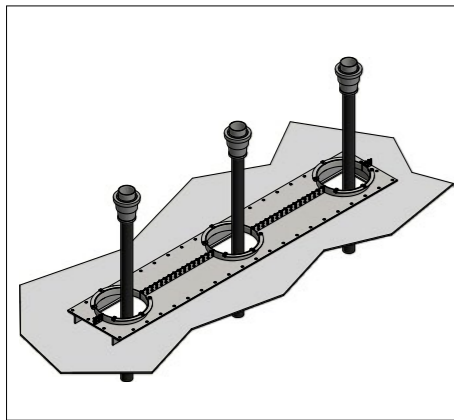
HVT 1: Above deck, cc ~800-1300 mm



- GIS/trafo with ~800-1300 mm between connectors
- Installation side above deck
- Interface is 80x80 angle profiles with 20 mm holes

Example of suitable products:

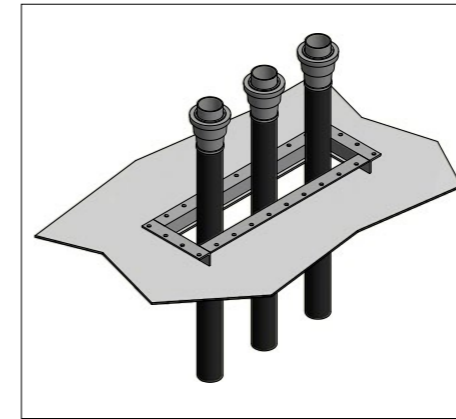
- H1-400/119-145/65/F4/OC0-60
 - round sealing with Multidiameter™
 - +/-60 mm adjustment for each single cable position
 - H2-400 version with additional hole for grounding cable
- SLFO 3x400
 - openable sleeve plate for bolting
 - +/-20 mm adjustment for frame position



Aperture dimensions (mm)



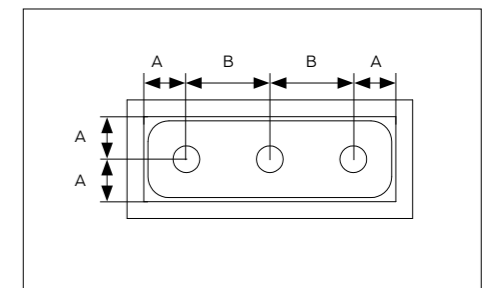
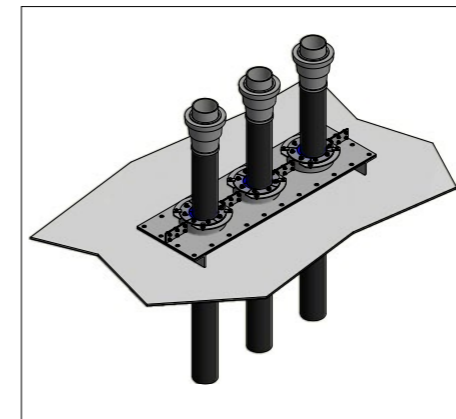
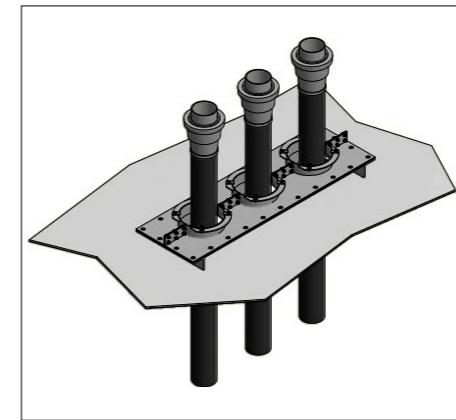
HVT 2: Above deck, cc ~400-800 mm



- GIS with ~400-800 mm distance between connectors
- Installation side above deck
- Interface is 80x80 angle profiles with 20 mm holes

Example of suitable products:

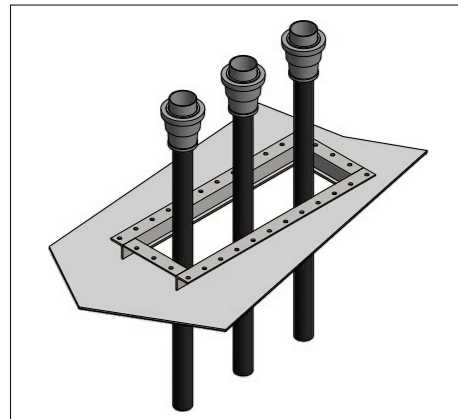
- H1-225/93-119/65/F4/OC0-15
 - round sealing with Multidiameter™
 - +/-15 mm adjustment for each single cable position
 - H2-225 version with additional hole for grounding cable
- SLFO 3x225
 - openable sleeve plate for bolting
 - +/-20 mm adjustment for frame position



Aperture dimensions (mm)



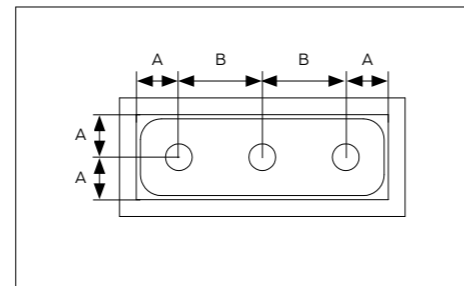
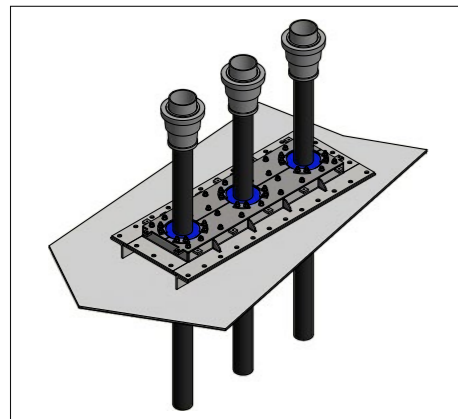
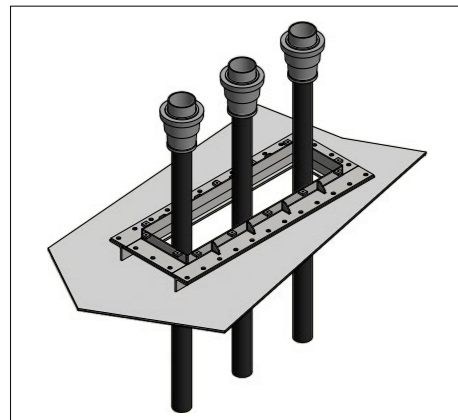
HVT 3: Above deck, cc ~200-500 mm



- GIS/trafo with ~200-500 mm distance between connectors
- Installation side above deck
- Interface is 80x80 angle profiles with 20 mm holes

Example of suitable products:

- H3-1020x290/3x170/60/F3 + CORE 170/92/OC0-10
 - rectangular seal with cores for fixed cable diameters
 - +/-10 mm adjustment for each single cable position
 - Additional hole for grounding cable
- GH frame
 - closed frame for bolting
 - +/-20 mm adjustment for frame position

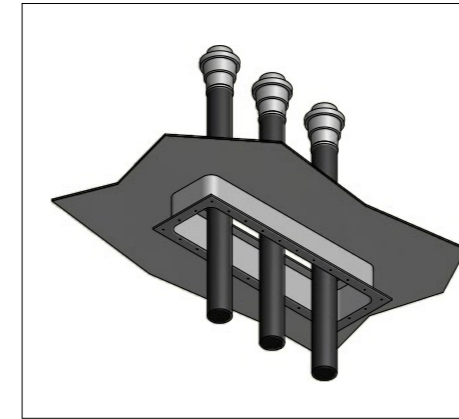


Aperture dimensions (mm)

A
min 150

B
200-500

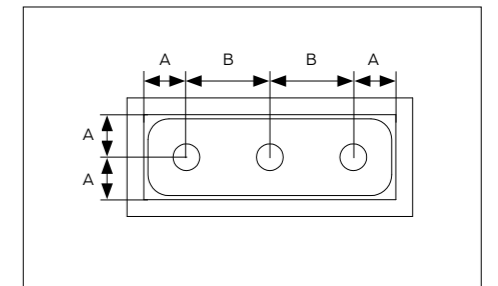
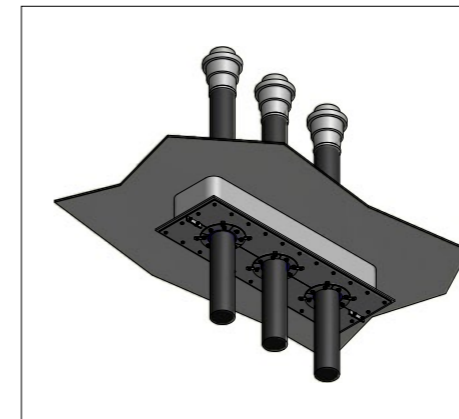
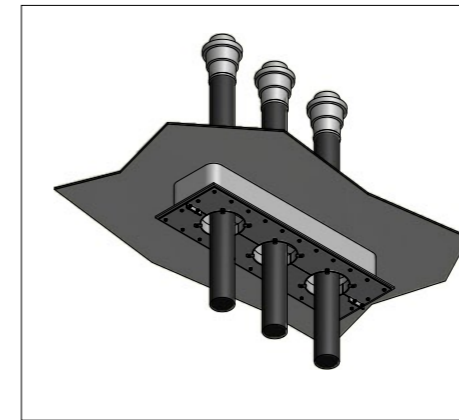
HVT 4: Below deck, cc ~400-800 mm



- GIS with ~400-800 mm distance between connectors
- Installation side below deck
- Interface is min 200 mm deep box with 80 mm flange and 20 mm holes

Example of suitable products:

- H1-225/93-119/65/F4/OC0-15
 - round sealing with Multidiameter™
 - +/-15 mm adjustment for each single cable position
 - H2-225 version with additional hole for grounding cable
- SLFO 3x225
 - openable sleeve plate for bolting
 - +/-20 mm adjustment for frame position
 - Insulation for filling box internally

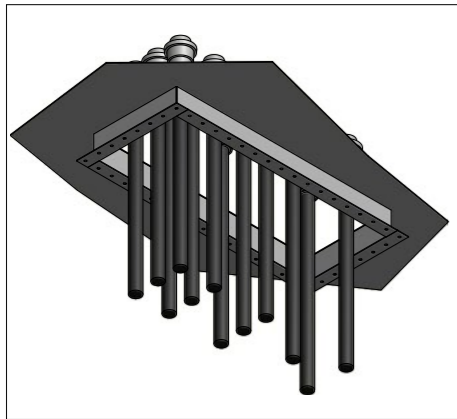


Aperture dimensions (mm)

A
min 200

B
400-800

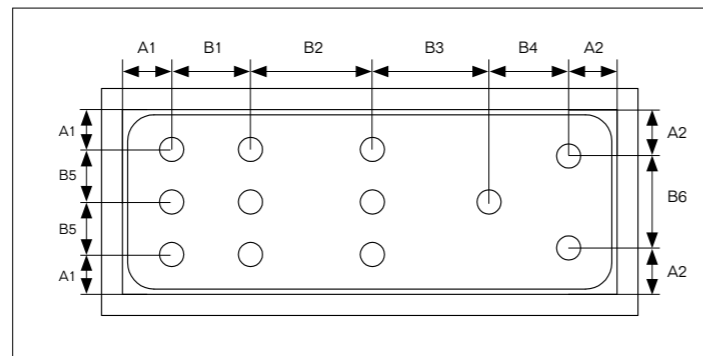
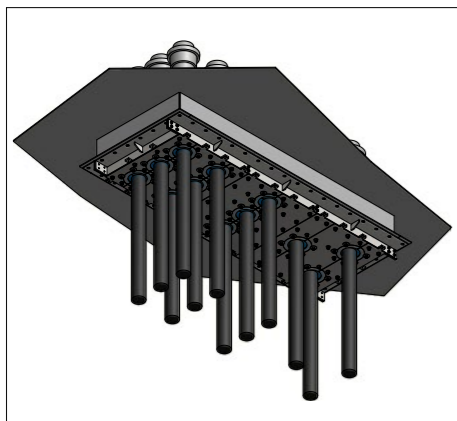
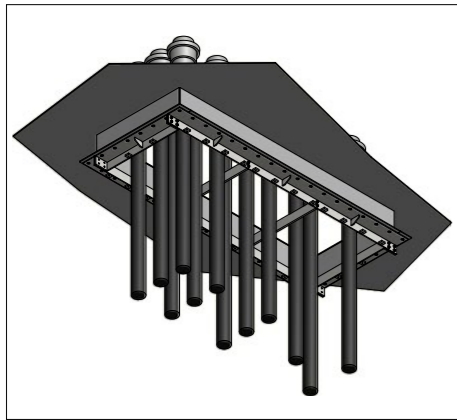
HVT 5: Below deck, cc ~150-500 mm



- GIS with ~150-500 mm distance between connectors
- Installation side below deck
- Interface is min 200 mm deep box with 80 mm flange and 20 mm holes

Example of suitable products:

- H3-600x800/3x170/60/F3 + CORE 170/92/OC0-10
 - rectangular seal with cores for fixed cable diameters
 - +/-10 mm adjustment for each single cable position
 - H3, H6, H9 or H12 seal depending on footprint of GIS
 - Additional hole for grounding cable available
- GOH frame
 - Openable frame for bolting
 - +/-20 mm adjustment for frame position
 - Insulation for filling box internally

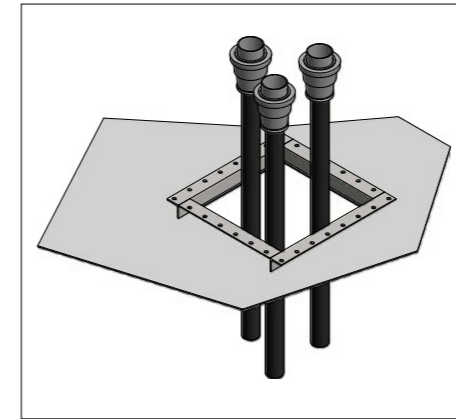


Aperture dimensions (mm)

A1-A2
min 150

B1-B6
Foot print of the GIS, ~150-500

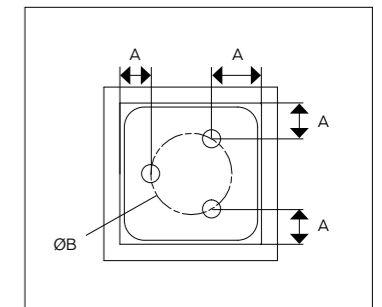
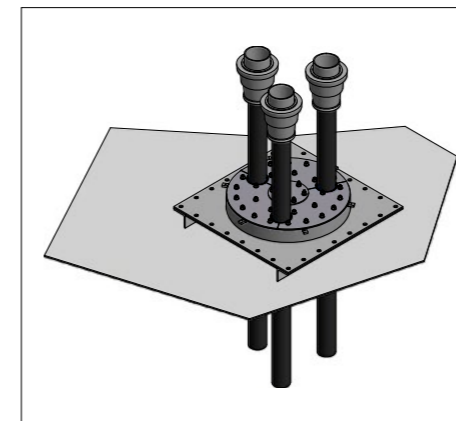
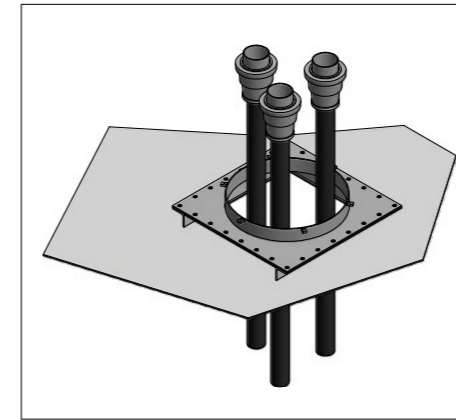
HVT 6: Above deck, trefoil



- GIS/trafo with ~400 mm diameter trefoil position of connectors
- Installation side above deck
- Interface is 80x80 angle profiles with 20 mm holes

Example of suitable products:

- H3-600/93-119/60/F3
 - round sealing with Multidiameter™
- SLF 600
 - Closed sleeve plate for bolting
 - +/-20 mm adjustment for frame position

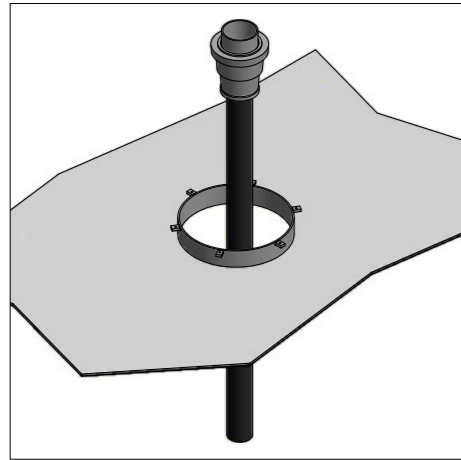


Aperture dimensions (mm)

A
min 150

ØB
200-450

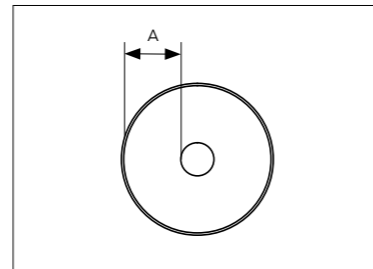
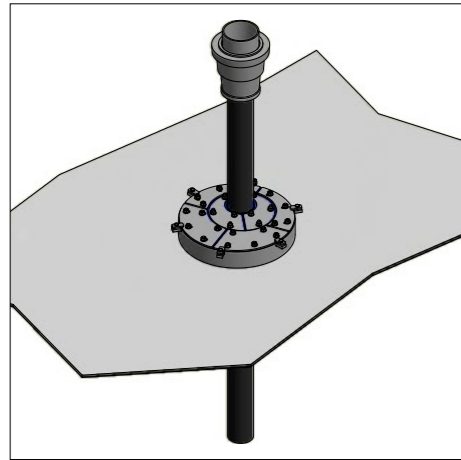
HVT 7: Above deck, single cable



- GIS single cable/connectors
- Installation side above deck
- Interface is round opening for welding of sleeve

Example of suitable products:

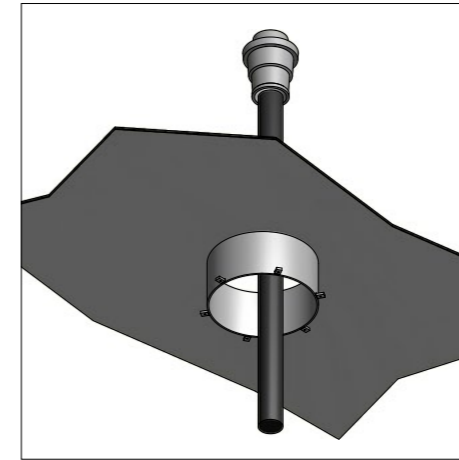
- H1-400/119-145/65/F4/OC0-60
 - Round sealing with Multidiameter™
 - +/-60 mm adjustment for cable position
- SL 400
 - Closed sleeve for welding



Aperture dimensions (mm)

A
min 50

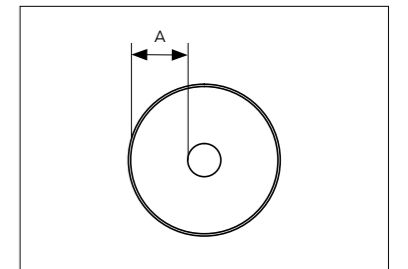
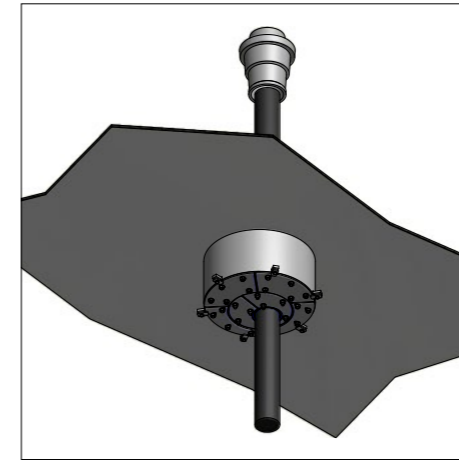
HVT 8: Below deck, single cable



- GIS single connectors
- Installation side below deck
- Interface round opening for welding of sleeve

Example of suitable products:

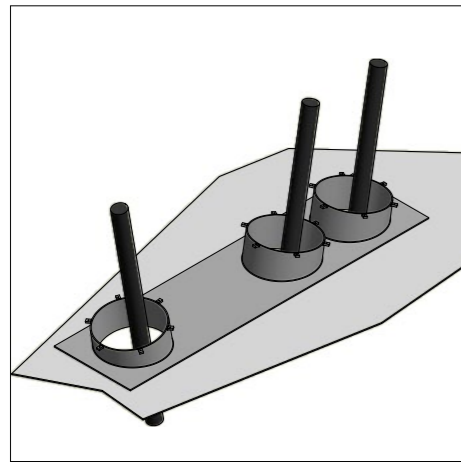
- H1-400/119-145/65/F4/OC0-60
 - round sealing with Multidiameter™
 - +/-60 mm adjustment for cable position
- SL 400
 - Closed sleeve min 200 mm deep for welding
 - Insulation for filling sleeve internally



Aperture dimensions (mm)

A
min 50

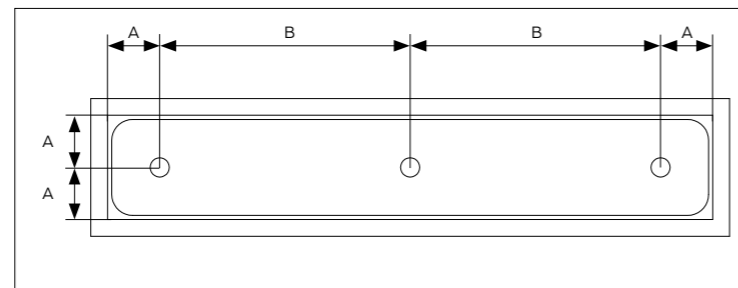
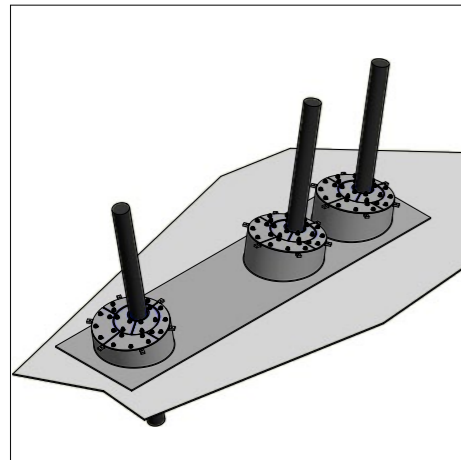
HVT 9: Above deck, angle cables



- Deck penetration with angle cables
- Installation side above deck
- Interface is 80x80 angle profiles with 20 mm holes

Example of suitable products:

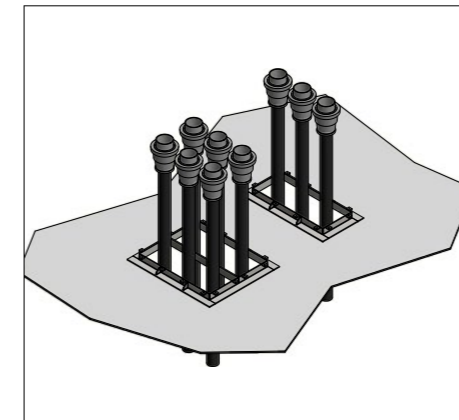
- H1-400/119-145/65/F4/OC0-60 sealing with Multidiameter™
 - round sealing with Multidiameter™
 - +/-60 mm adjustment for each single cable position
 - H2-400 version with additional hole for grounding cable available
- SLF 3x400
 - Closed sleeve plate for bolting
 - +/-20 mm adjustment for frame position



Aperture dimensions (mm)

A	B
min 250	min 500

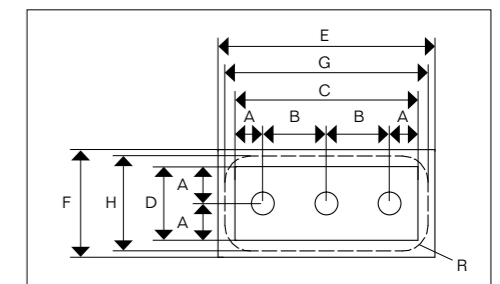
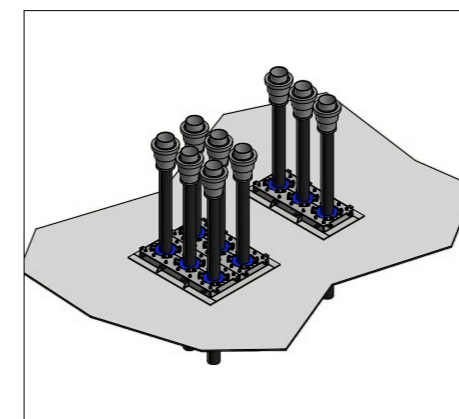
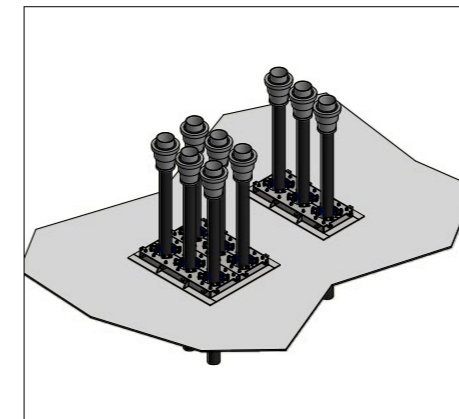
HVT 10: Above deck or bulkhead, multiple cables, cc ~100-250 mm



- Deck/bulkhead penetration
- Installation side above deck
- Interface only opening for welding of frame
- Standard sizes of frame and outer dimensions of rectangular seal

Example of suitable products:

- H3-720X290/170/60/F3 + CORE 170/92/OC0-10
 - rectangular seal with cores for fixed cable diameters
 - +/-10 mm adjustment for each single cable position
 - Additional hole for grounding cable available
- G PS 720x290 (xN)
 - Closed frame for welding
 - Installation tool for positioning of cable during routing

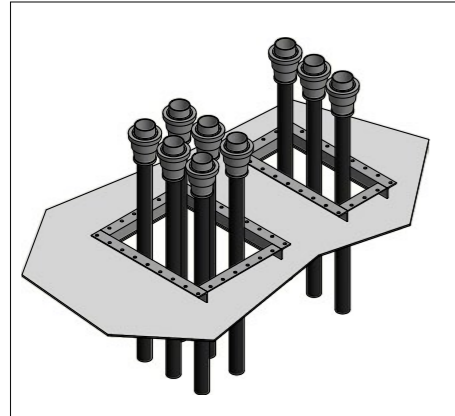


Aperture dimensions (mm)

Openings	A	B	C	D	Frame			Aperture		
					E	F	G	H	R	
x1	min 100	100-250	722	292	854	424	800	375	max 100	
x2*	min 100	100-250	722	594	854	726	800	680	max 100	
x3*	min 100	100-250	722	896	854	1028	800	980	max 100	
x4*	min 100	100-250	722	1198	854	1330	800	1280	max 100	

* 10 mm partition wall between openings

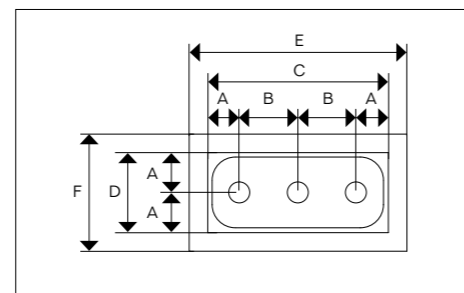
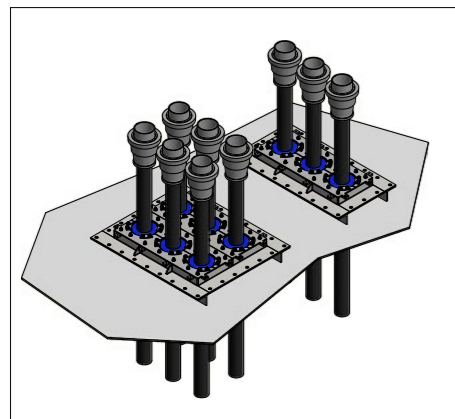
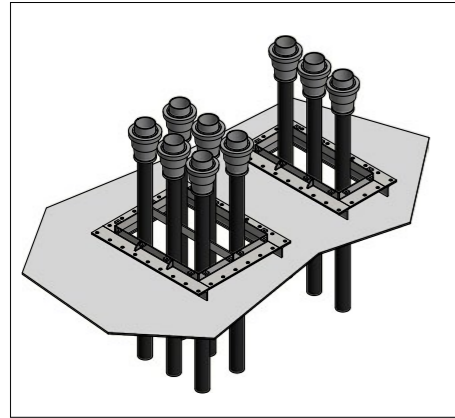
HVT 11: Above deck or bulkhead, multiple cables, cc ~100-250 mm



- Deck/bulkhead penetration
- Installation side above deck
- Interface is 80x80 angle profiles with 20 mm holes
- Standard sizes of frame and outer dimensions of rectangular seals

Example of suitable products:

- H3-720X290/170/60/F3 + CORE 170/92/OC0-10
 - rectangular seal with cores for fixed cable diameters
 - +/-10 mm adjustment for each single cable position
 - Additional hole for grounding cable available
- GH PS 720x290 (xN)
 - Closed frame for bolting
 - +/-20 mm adjustment for frame position
 - Installation tool for positioning of cable during routing

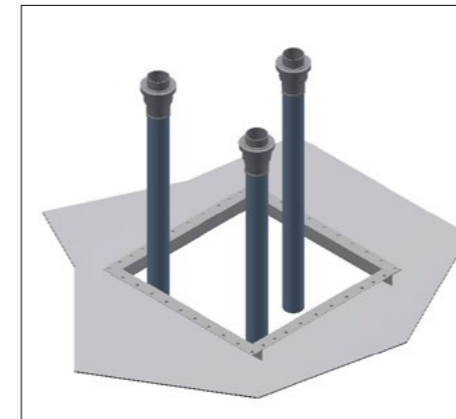


Aperture dimensions (mm)

Openings	Frame					
	A	B	C	D	E	F
x1	min 100	100-250	744	344	934	504
x2*	min 100	100-250	744	646	934	806
x3*	min 100	100-250	744	948	934	1108
x4*	min 100	100-250	744	1250	934	1410

* 10 mm partition wall between openings

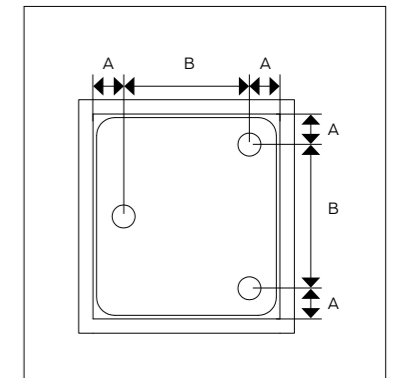
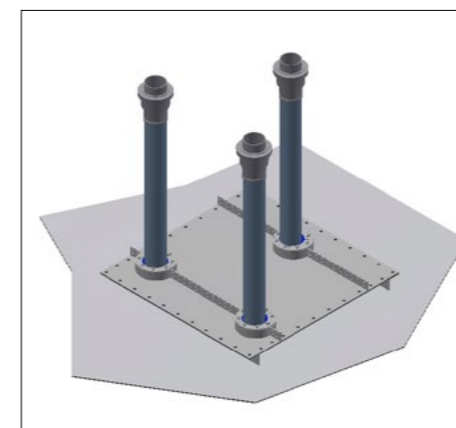
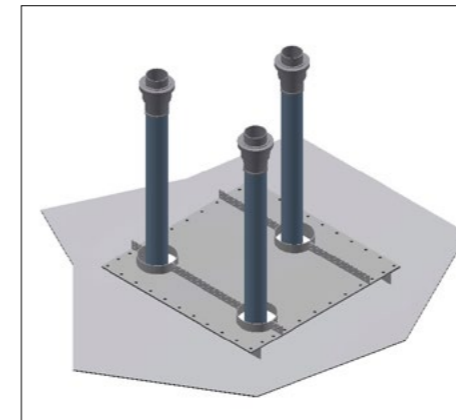
HVT 12: Above deck, large trefoil diameter



- GIS/trafo with large diameter of trefoil position of connectors
- Installation side above deck
- Interface is 80x80 angle profiles with 20 mm holes

Example of suitable products:

- H1-225/93-119/65/F4/OC0-15
 - round sealing with Multidiameter™
 - +/-15 mm adjustment for each single cable position
 - H2-225 version with additional hole for grounding cable
- SLFO 3x225
 - openable sleeve plate for bolting
 - +/-20 mm adjustment for frame position



Aperture dimensions (mm)

A	B
min 150	300-1200



References

Owner/Operator

ABB, ABB/Tennet, Belwind, C-Power NV, DONG, DONG/Scottish Power/Iberdrola, EnBW, ENECO, ENECO - Van Oord, EWE/Vattenfall, Eon, Eon/DONG/Masdar, E.ON AG, E.ON UK, Global Tech 1, RWE, RWE Innogy, StatKraft/Statoil, Typhoon - Van Oord, TenneT, Trianel, Tennet Offshore, Riffgat, Vattenfall, WPD AG, WindMW.

Roxtec Customer

Alstom Grid, Alstom Grid GmbH, Alstom Semco Maritime, Areva/Bradgate, Areva/Alstom Grid, Bladt Industries, Bladt Industries - ABB Denmark, Croon Elektrotechnik, Dubai Dry Docks, Fabricom - Hoboken, Harland & Wolf, Heerema, Heerema &, Istimewa Elektro, Hollandia & Structon, HSM Offshore & SPIE - Tideaway - Smulders, Keppel Verolme & Croon Elektrotechnik, Nordic Yards, SAM Electronics GmbH, Semco Maritime, SEPAM, Siemens AG, STX France, Weserwind GmbH, Wood Group.



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