

**Extended Sleeve Products Allow Control and Monitoring of Process Fluid Flows Inside Shielding,  
Behind Walls and Beneath Floors - 13041**

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**ABSTRACT**

Throughout power generation, delivery and waste remediation, the ability to control process streams in difficult or impossible locations becomes increasingly necessary as the complexity of processes increases. Example applications include radioactive environments, inside concrete installations, buried in dirt, or inside a shielded or insulated pipe. In these situations, it is necessary to implement innovative solutions to tackle such issues as valve maintenance, valve control from remote locations, equipment cleaning in hazardous environments, and flow stream analysis. The Extended Sleeve family of products provides a scalable solution to tackle some of the most challenging applications in hazardous environments which require flow stream control and monitoring.

The Extended Sleeve family of products is defined in three groups: Extended Sleeve (ESV), Extended Bonnet (EBV) and Instrument Enclosure (IE). Each of the products provides a variation on the same requirements: to provide access to the internals of a valve, or to monitor the fluid passing through the pipeline through shielding around the process pipe. The shielding can be as simple as a grout filled pipe covering a process pipe or as complex as a concrete deck protecting a room in which the valves and pipes pass through at varying elevations. Extended Sleeves are available between roughly 30 inches and 18 feet of distance between the pipeline centerline and the top of the surface to which it mounts. The Extended Sleeve provides features such as +/- 1.5 inches of adjustment between the pipeline and deck location, internal flush capabilities, automatic alignment of the internal components during assembly and integrated actuator mounting pads. The Extended Bonnet is a shorter fixed height version of the Extended Sleeve which has a removable deck flange to facilitate installation through walls, and is delivered fully assembled. The Instrument Enclosure utilizes many of the same components as an Extended Sleeve, yet allows the installation of process monitoring instruments, such as a turbidity meter to be placed in the flow stream.

The basis of the design is a valve body, which, rather than having a directly mounted bonnet has lengths of concentric pipe added, which move the bonnet away from the valve body. The pipe is conceptually similar to an oilfield well, with the various strings of casing, and tubing installed. Each concentric pipe provides a required function, such as the outermost pipes, the valve sleeve and penetration sleeve, which provide structural support to the deck flange. For plug valve based designs, the next inner pipe provides compression on the environmental seals at the top of the body to bonnet joint, followed by the innermost pipe which provides rotation of the plug, in the same manner as an extended stem. Ball valve ESVs have an additional pipe to provide compressive loading on the stem packing.

Due to the availability of standard pipe grades and weights, the product can be configured to fit a wide array of valve sizes, and application lengths, with current designs as short as seven inches and as tall as 18 feet. Central to the design is the requirement for no special tools or downhole tools to remove parts or configure the product. Off the shelf wrenches, sockets or other hand tools are all that is required. Compared to other products historically available, this design offers a lightweight option, which, while not as rigidly stiff, can deflect compliantly under extreme seismic loading, rather than break. Application conditions vary widely, as the base product is 316 and 304 stainless steel, but utilizes 17-4PH, and other allows as needed based on the temperature range and mechanical requirements. Existing designs are installed in applications as hot as 1400°F, at low pressure, and separately in highly radioactive environments. The selection of plug versus ball valve, metal versus soft seats, and the material of the seals and seats is all dependent on the application requirements.

The design of the Extended Sleeve family of products provides a platform which solves a variety of accessibility problems associated with controlling process flow streams in remote, hard to reach locations in harsh environments. Installation of the equipment described has shown to allow access to flow streams that otherwise would require exceptional means to access and control. The Extended Sleeve family of products provides a scalable solution to both control and monitor process fluid flow through shielding, walls or floors when direct connection is advantageous.

## **INTRODUCTION**

Throughout power generation, delivery and waste remediation, the ability to control process streams in difficult or impossible locations becomes increasingly necessary as the complexity of processes increases. Example applications include radioactive environments, inside concrete installations, pipes buried in dirt, inside a shielded or insulated pipe, among others. The presence of radiation results in degradation of polymeric materials as well as risks to employees working within close proximity. In order to protect the employees from the radiation, large concrete structures are erected and installed to contain the radiation. In other instances, it may only be necessary to shield the process pipes with a radiation shielding compound or grout. In process pipes buried in dirt it may be necessary to ensure process fluids remain in a liquid form by placing them below permafrost. In any of these situations, it is necessary to implement innovative solutions to tackle such issues as valve maintenance, valve control from remote locations, equipment cleaning in hazardous environments, and flow stream analysis. The Extended Sleeve Family of products provides a scalable solution to tackle some of the most challenging applications in hazardous environments which require flow stream control and monitoring.

## **THE CHALLENGE**

Much of the required basis for the Extended Sleeve family of products was developed through the incorporation of several specifications for equipment that, in some respects, did not commercially exist. The following list summarizes the driving specification requirements:

- NQA-1 Quality Program
- Constructed from 316 or 304 stainless steel

- Top entry valve design
- Uniform design for both manual and automated packages
- Seat and seal adjustments made outside containment
- Seat and seal replacement from outside containment
- Ability to bag the removable components as they are removed to manage process fluids
- Ability to grout around equipment passing through walls and floors
- Ability to flush internal annuli
- No required tools to reach down inside the assembly (no downhole tools)
- Must reach through floors and walls, upwards of 18 feet from process pipe
- Utilize only standard mechanics type tools; no special tools
- Design must utilize common components as much as possible
- Detection method of leaks around sealing members
- Ability to drain the extension

Some of these requirements are geared towards making the installation of the product as hassle free as possible, such as the use of only standard tools, and the drive to communize as much as possible between different designs. Many other requirements satisfy technical requirements, such as lengths of the extensions or operational aspects such as replacement of seats and seals outside containment. The breath of requirements applied necessitated the design and commissioning of a new product family to tackle the challenge.

The Extended Sleeve Family of products can be broken down into three groups: Extended Sleeves, Extended Bonnets and a subset of the Extended Sleeve, the Instrument Enclosures. Each design provides the ability to overcome unique requirements to control and monitor the process fluid. Common to all designs is the use of concentric pipe to facilitate moving the fasteners and control away from the process stream. Through nesting commercially available schedules of pipe, the functions of top cap bolting, packing compressing fasteners, operating the valve and others can be removed from the near vicinity of the process media (Figure 1). This design is conceptually similar to an oil or gas well which utilizes various strings of casing, pipe and tubing, each run inside the other to provide access to the hydrocarbons in the subterranean reservoir. In the case of such a casing string, the tubing may not be run all the way to the surface, but my instead be hung off at a predetermined location. In much the same manner, the designs allow field welded joints to minimize the length of pipes that must be coordinated at the accessible end of the equipment.

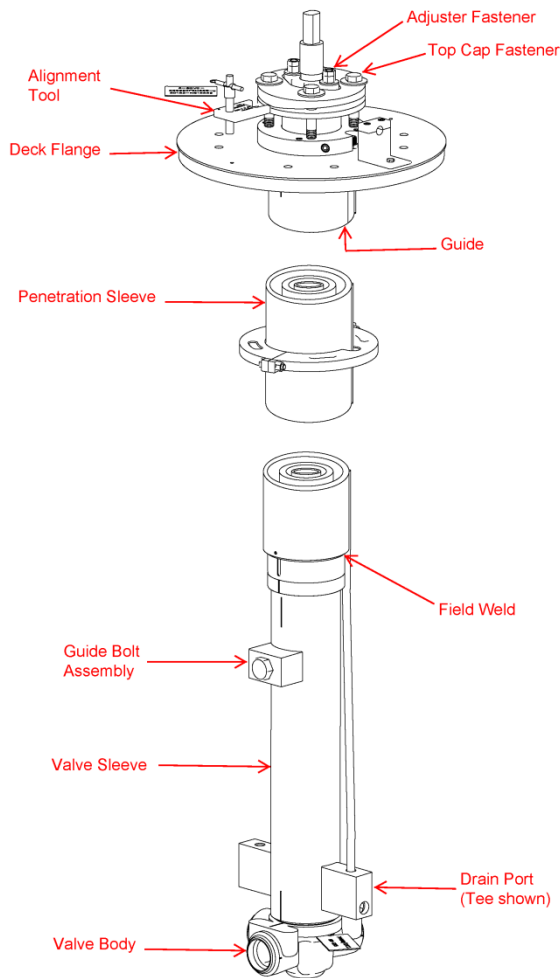


Figure 1: Extended Sleeve Plug Valve

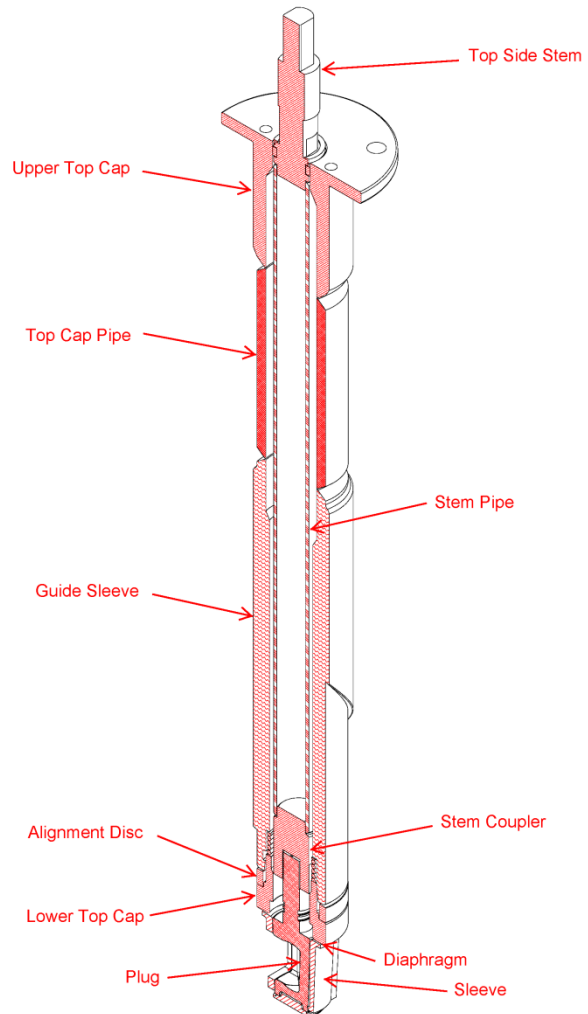


Figure 2: Extended Sleeve Valve: Top Cap and Stem Fabrications

## EXTENDED SLEEVE VALVES (ESV)

The initial design and the most complex product, the extended sleeve is the most feature rich product currently available. Due to the nature of the design, alignment between the concentric components is of critical importance. A rotational alignment error beyond the design tolerance could result in damage to the sealing members during installation. Depending on the length of the extension and the method of installation, it may not be readily apparent if the seals have been compromised until the system is pressure tested. As a result, there are several design features which directly address rotational alignment and ensure the product can only assemble in the correct manner.

The *Valve Body* is factory welded to the *Valve Sleeve* which has the *Drain Ports* and *Guide Bolt Assembly* welded to the exterior, as shown in Figure 1. This fabrication is ready to be welded in line ahead of installing the rest of the extension, minimizing the equipment on the floor during initial erection of the piping in the facility. On the other end is the *Deck Flange*, which is factory welded to the *Penetration Sleeve*, and includes a *Guide* to transition the ledge created by the bore through the *Deck Flange* being

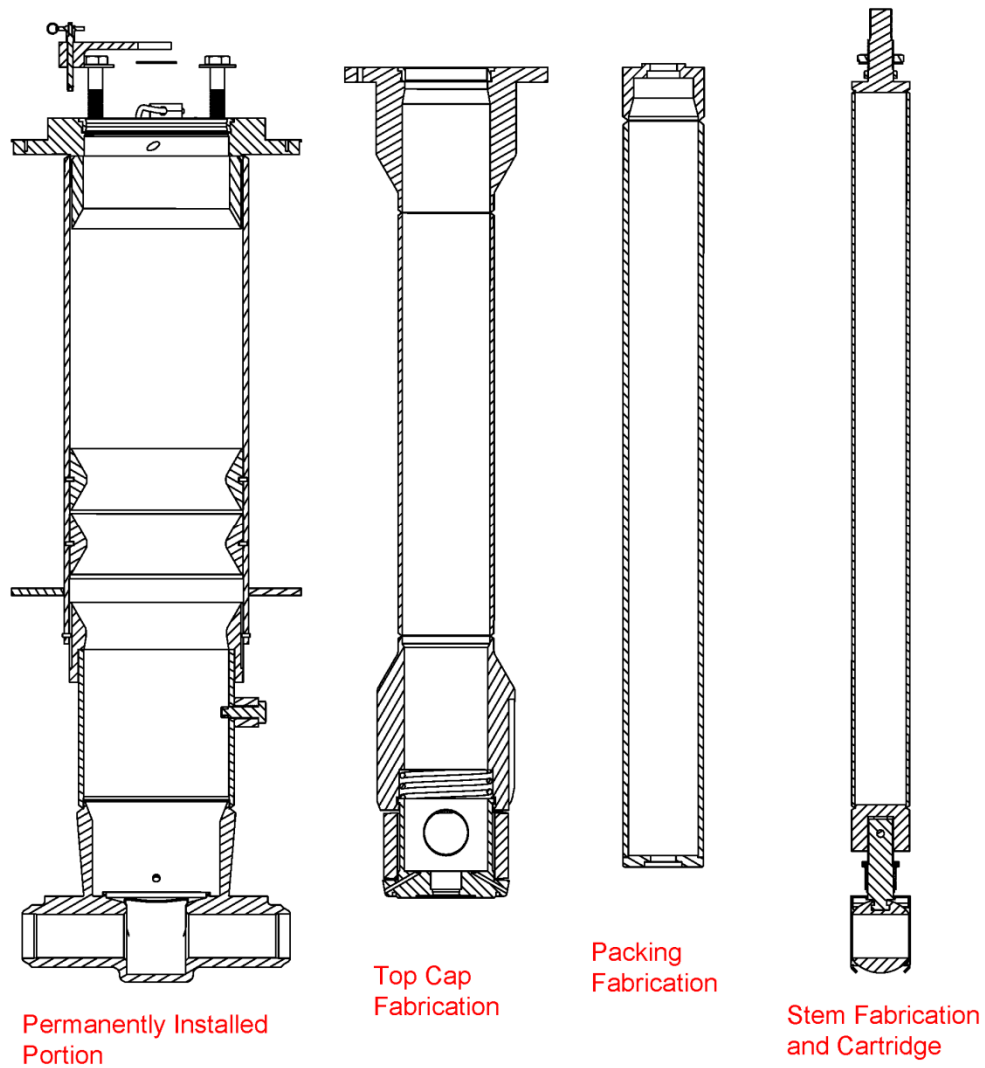
smaller than the inside diameter of the *Penetration Sleeve*. Once the *Valve Body* is installed in the process line, the *Penetration Sleeve* is passed through the floor or wall until it overlaps the top of the *Valve Sleeve*. Two set screws in the *Penetration Sleeve* align in opposing slots at the top of the *Valve Sleeve*, ensuring the bolt patterns and leak detector holes align properly with the appropriate geometry at the *Valve Body*. Once the *Valve Sleeve* and *Penetration Sleeve* are determined to be concentric and collinear, the two can be field welded together at the interface. The *Deck Flange* will be flush against the wall or floor and can be bolted or welded in place. If the design has the optional leak detector included, the *Leak Detector Tube* can now be installed between the *Tee Drain Port* and the hole in the *Deck Flange*, welding both ends.

The remaining components are all field replaceable and vary slightly between the plug valve and ball valve version of the product. The plug valve design has a *Top Cap Fabrication* and a *Stem Fabrication*, which nest inside one another, as shown in Figure 2. The lower portion of the *Top Cap Fabrication* is the *Guide Sleeve*, which has a helical recess machined into the exterior. This recess interfaces with the end of the *Guide Bolt*, to ensure the proper rotation is achieved prior to the *Plug* entering the *Valve Body* bowl. Hanging from the inside of the *Guide Sleeve* is the *Lower Top Cap* which is surrounded on the neck by the saddle shaped *Alignment Disc*. This assembly ensures that in cases of misalignment, up to 5 degrees, between the centerline of the *Penetration Sleeve* and the centerline of the *Valve Sleeve*, the *Diaphragm* receives adequate compression from the off axis compression force. The *Diaphragm* is one of several seals that keeps process fluid from leaking beyond the pressure boundary of the valve.

At the top of the *Top Cap Fabrication* is a hole for the *Alignment Tool* which attaches to the top of the *Top Cap Fabrication* and holds a tapered portion of the *Stem Extension* from rotation during installation. This provides the final alignment guidance. In summary, alignment is provided by the combination of the *Alignment Tool* which maintains rotation between the polymeric *Sleeve* and the *Guide Sleeve* through the *Top Cap Fabrication* and the *Stem Fabrication* and the *Guide Sleeve* which is rotationally aligned within the *Valve Sleeve* through the interaction of the *Guide Bolt* and the *Guide Sleeve*, ensuring the proper assembly of the equipment.

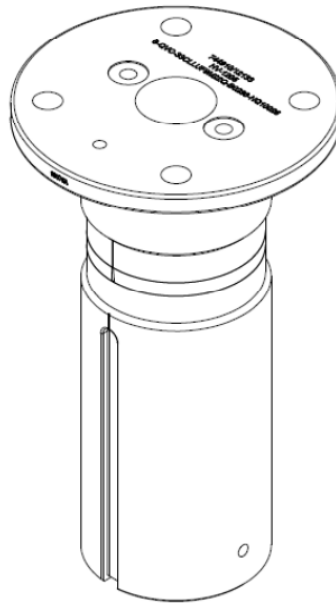
Once installed, *Top Cap Fasteners* and *Adjuster Fasteners* apply compression to the *Top Cap Fabrication* and *Stem Fabrication*, maintaining compression on the *Diaphragm* to resist external leakage from the valve pressure boundary and on the *Stem*, and to ensure the *Plug* remains engaged in the taper of the *Valve Body* (Figure 1).

In addition to the features described for the Plug Valve Extended Sleeve Valve, the Ball Valve Extended Sleeve Valve has an additional pipe, as shown in Figure 3, part of the *Packing Fabrication* that is located between the *Stem Fabrication* and the *Top Cap Fabrication*. The *Stem Fabrication* has a *Stem Nut* on top that helps drive the lower portion of the *Packing Fabrication* down onto the *Packing Gland*, ensuring the *Stem Packing* is adequately compressed.



**Figure 3: Extended Sleeve Ball Valve: Fabrications**

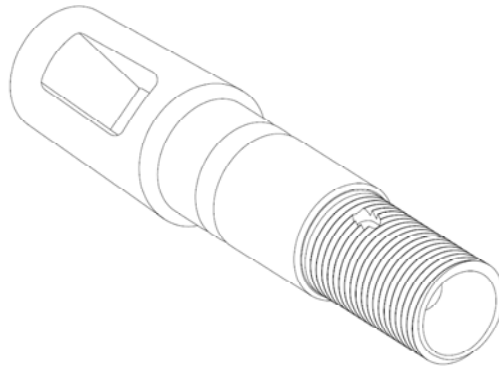
In some situations, the overall stack up of components on an Extended Sleeve Valve will result in the full helical *Guide Sleeve* resulting in a *Guide Assembly* that is too high on the outside of the *Valve Sleeve* for clearance underneath a floor or inside a wall penetration. The Extended Bonnet *Guide Sleeve* can be used in these cases, as shown in Figure 4, which rather than being helical and self-aligning, only provides a single slot for the *Guide Bolt* to pass through. This method still provides positive rotational alignment, but does not self-feed and requires manual rotation to find the slot.



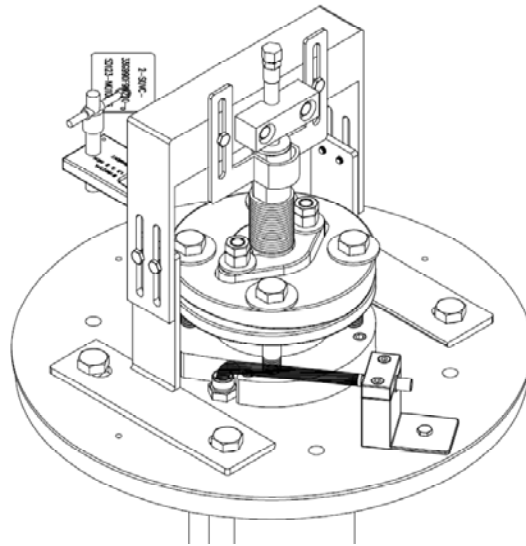
**Figure 4: Extended Bonnet Valve: Guide Sleeve**

#### **INSTRUMENT ENCLOSURES (IE)**

In order to maintain a consistent product, the instrument enclosures rely on many of the same components as the Extended Sleeve. This allows an Extended Sleeve Plug Valve to be changed out to be an Instrument Enclosure by only changing the replaceable components. The only requirement is that the two valve extensions be designed to be the same nominal length (between the centerline of the *Valve Body* and the top of the mounting deck or outside of the wall). For the example of a turbidity meter, the *Plug* is modified to have a thicker stem with a hole bored down through the center, as shown in Figure 5. The *Stem Extension* attaches to the *Plug* via threads and set screws instead of a pin with E-clips and the turbidity sensor passes down through the seals on the interior of the *Plug* stem bore to sit in the waterway of the *Plug*. To ensure the turbidity sensor does not eject from the assembly under pressure, there is a bracket assembly, shown in Figure 6, attached to the *Deck Flange* which holds the turbidity sensor in place. This allows for field replacement of the turbidity instrument without disassembly of the Extended Sleeve as well.



**Figure 5: Instrument Enclosure: Modified Plug**



**Figure 6: Instrument Enclosure: Top Side Brackets**

### **EXTENDED BONNET VALVES (EBV)**

The Extended Bonnet provides access to valves and process streams when the extension is less than 25 inches approximately, partially based on the size of the process line. The design, as shown in Figure 7, provides similar benefits to the full Extended Sleeve product. The Extended Bonnet Valve is provided in a fully fabricated state, so it ships as a completed unit. It is common for the Extended Bonnet valves to be installed in pipelines prior to shielding or insulation, which makes it advantageous for the product to be installable fully assembled. Depending on the sealing material and the presence of a butt-welded interface, it may be easiest to disassemble the Extended Bonnet Valve to minimize the risk of damage to the sealing members from weld heat. The Extended Bonnet does not have a *Penetration Sleeve*; instead the *Valve Sleeve goes all the way to the underside of the Deck Flange, where the Interface Flange is attached* (Figure 8). All Extended Bonnet Valves use the short *Guide Sleeve*, which requires manual rotation to align. As the designs compact in length, the pipes in the *Stem Fabrication* and *Top Cap Fabrication* disappear and ultimately, the *Guide Assembly* may also disappear, as the *Guide Bolt* moves upward relative to the *Deck Flange*. However, in these short situations, the process pipe is visible and it

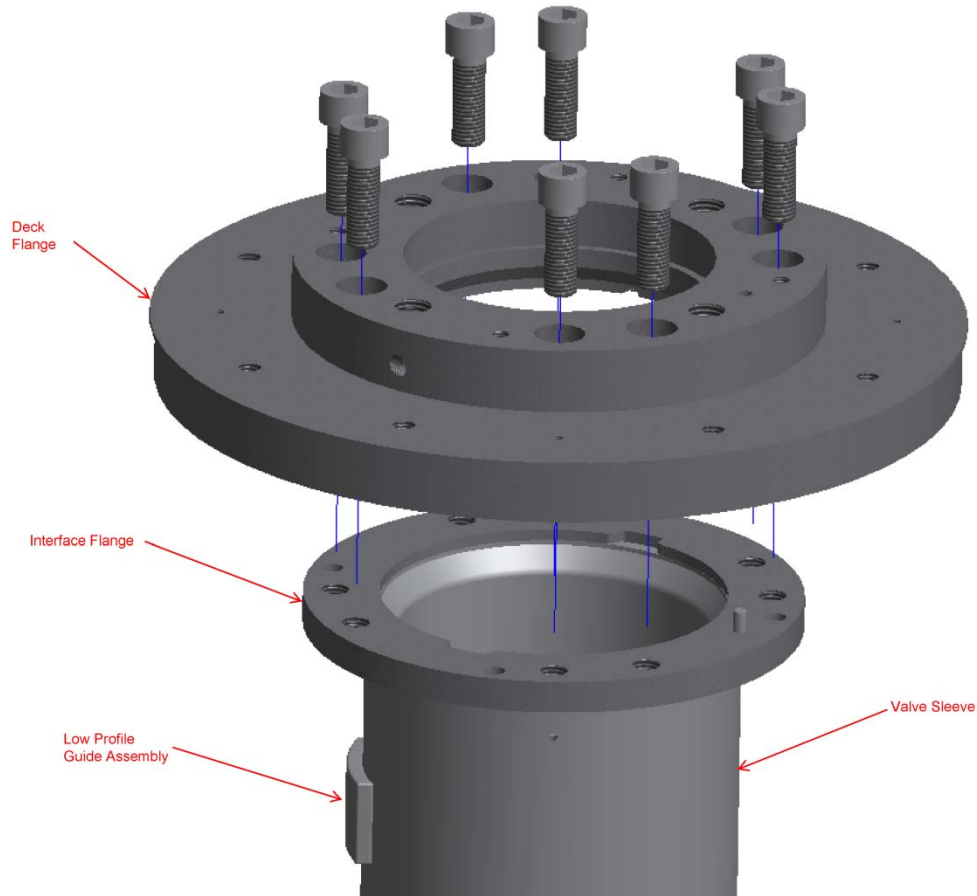


is convenient to look into the valve body for alignment requirements. Plus, during installation, the resistance of a misaligned valve *Sleeve* is readily apparent.



**Figure 7: 1/2" EBV at Final Inspection**

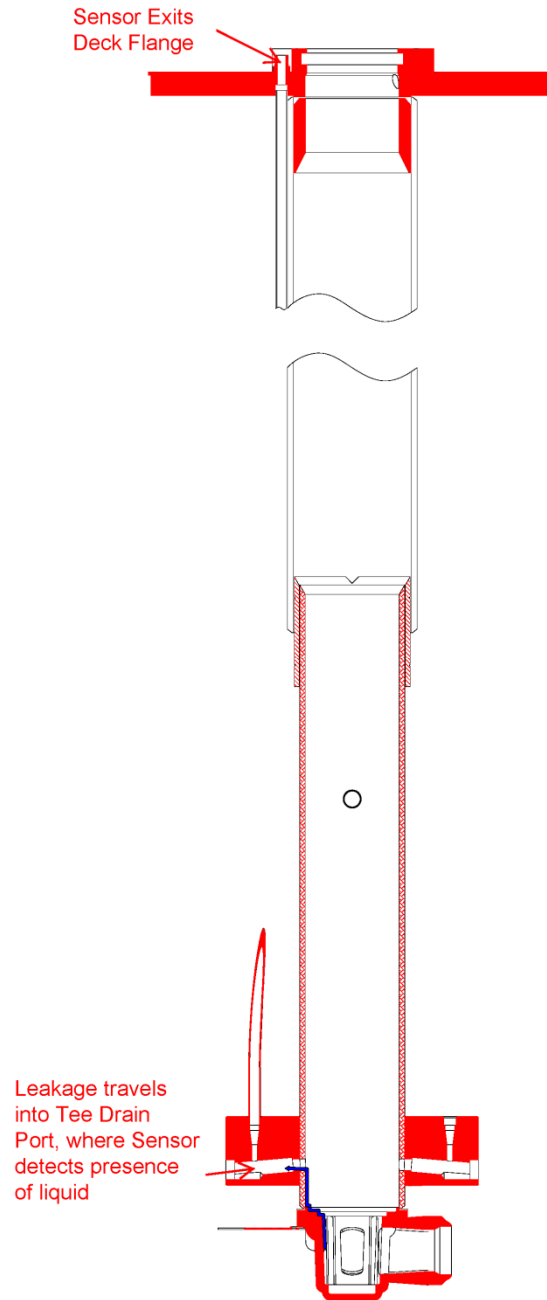
To accommodate small diameter penetrations in walls and floors the *Deck Flange* on Extended Bonnet Valves is bolted to the *Interface Flange*. This allows the *Deck Flange* to be unbolted and removed during installation, as shown in Figure 8, allowing the assembly to install through a penetration much smaller than the outside diameter of the *Deck Flange*. Additionally, the heavy hex head of the *Guide Bolt* and the *Guide Block* are exchanged for a *Low Profile Guide Assembly* (Figure 8), which provides a lower outside profile for tight clearance applications, as required.



**Figure 8: Extended Bonnet Valve: Removable Deck Flange**

#### DESIGN FEATURES

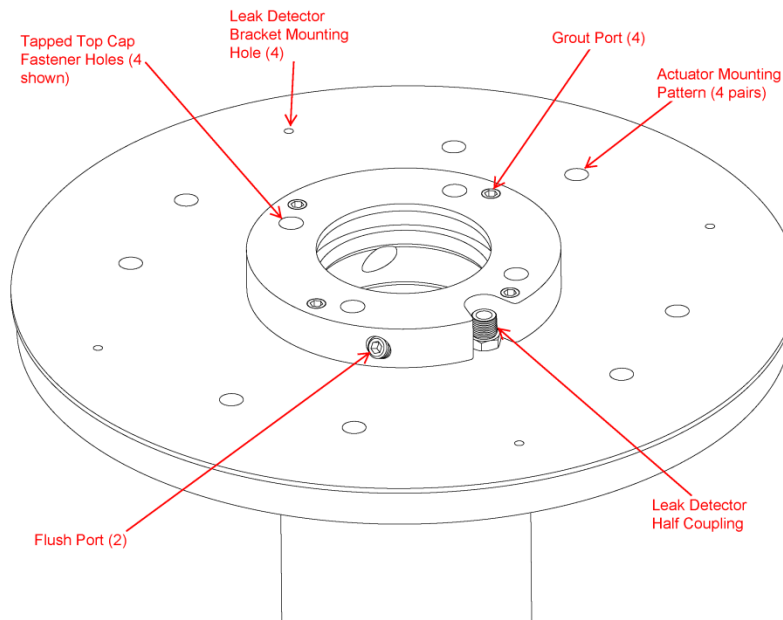
Extended Sleeve based products can be fitted with a leak detection sensor which allows for identification of a leak through the *Diaphragm*, as shown by the blue arrow in Figure 9. The *Leak Detector* is installed down through the half coupling in the *Deck Flange* and into the *Tee Drain Port* where it seats in a taper. The tip of the *Leak Detector* uses a heated thermocouple junction to provide a change in resistance when the tip is in the contact with liquid. A mounting clip is provided on the *Deck Flange* to facilitate mounting the LEMO style connector.



**Figure 9: Extended Sleeve Valve: Leak Detector**

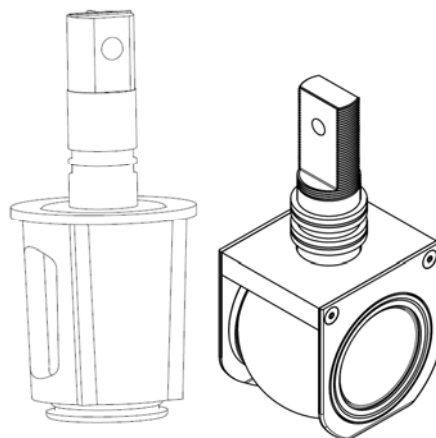
All versions of the product can have *Drain Ports* installed on the outside of the *Valve Sleeve*, shown in Figure 1 (tee style) and Figure 7 (standard style), above. These can be simple half coupling style fittings which typically socket weld to 1/2" Sch 40 pipe, or for Extended Sleeve products, a larger *Tee Drain Port* when leak detection is configured. The presence of the *Drain Ports*, in either style, allows the placement of the *Flush Ports* in the hub of the *Deck Flange*, identified in Figure 10. These drilled holes are fitted with 1/2"-13 threads to allow closure with a plug, as well as piping in the event a flush is desired inside the *Valve Sleeve / Penetration Sleeve* along the outside of the *Top Cap Fabrication*. Four *Grout Holes*, as

shown in Figure 10, are also drilled to ½”-13 threads to allow plugging once grouting is complete. This region of the sleeve is where leakage will appear in the event the *Diaphragm* leaks.



**Figure 10: Extended Sleeve Valve: Flush and Grout Ports**

One overriding requirement is to avoid the need for down-hole tools, that is, tools which must reach down the interior of the extension to remove any sort of component or to make adjustments. In both the plug valve and the ball valve, the seats, seals and closure members are captured in a cartridge style configuration, shown in Figure 11. This ensures that during removal, all components will pull out of the valve body and extension without issue. As the fasteners are installed at the top of the extension, they require standard sockets or wrenches to operate.

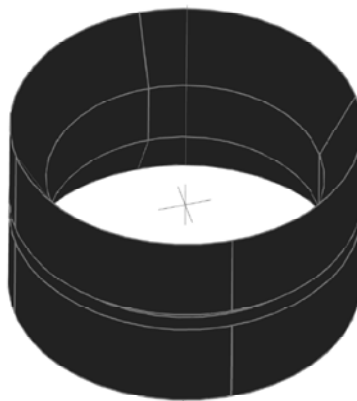


**Figure 11: Cartridge Plug and Ball Fabrications**

Due to the variations in installation environments, specifically for Extended Bonnets which may protrude from a pipeline, the product must provide a means to mount an actuator or other top works. The *Deck Flange* provides a circular, flat, pre drilled, platform to mount various top works equipment (Figure 10).

Variations in installation environment necessitate the ability of the Extended Sleeve Products to scale in length. This is configured during the structuring of the product and essentially adds length to the three or four pipes which connect the *Valve Body* to the *Deck Flange*, that is, the *Penetration Sleeve*, *Stem Pipe*, *Top Cap Pipe*, and *Packing Pipe*, as applicable. There are practical limits to how tall an Extended Sleeve can be made, based on the wind up in the *Stem Extension*, and structural deflection issues under seismic conditions. These can be partially mitigated with thicker wall pipe and other designed stiffening features, as required. In addition, the Extended Sleeve family of products can be configured for valve sizes from 1” (used on all smaller sizes as well) up to 6” currently. The design is scalable to larger valves as needed.

Due to the requirement for floor and wall installations, the design must be capable of installing and operating both vertically and horizontally. In a vertical installation, it is easy to visualize the internal components rising out of the *Penetration Sleeve* perfectly centered and not contacting other components, in a perfect world. This is not likely, but far from the horizontal case where the entire removable assembly rests on the underside of the *Penetration Sleeve* and *Valve Sleeve* during installation and removal. The primary concern is the presence of ledges, grooves or other geometry on the inside that could cause the removable assembly to catch or hang up during installation and removal. To minimize this risk, the Extended Sleeve has a *Centralizer*, see Figure 12, installed approximately every six feet to help keep the removable assembly near the center of the *Penetration Sleeve*. Additionally, any transition on the interior of the *Penetration Sleeve* or *Valve Sleeve* is blended between the two surface with a conical surface to remove the step. The end result is the removable components can be installed and removed from the installation with minimal conflict with the installed base.



**Figure 12: Centralizer**

Differing service conditions require different design modifications. Applications up to 1400°F, at low pressure, are within the scope of the design. To go to such high temperature applications, the alloys of the valve itself and the bottom portion of the extension must be specially engineered for the application. Additionally, certain components, such as the *Alignment Disc* may need to become taller to maintain

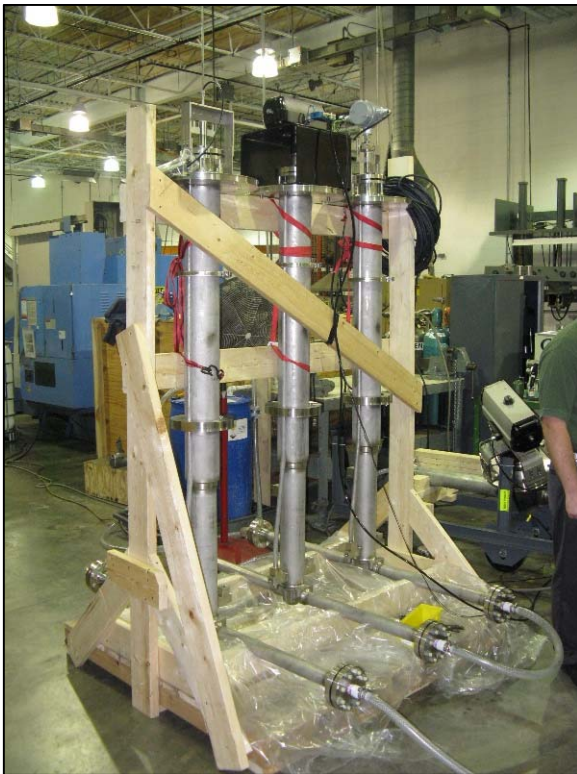
adequate strength at the elevated temperature. However, even as the design is modified to extreme temperatures, it retains the same operation and maintenance features.

## PRODUCT QUALIFICATION / TESTING

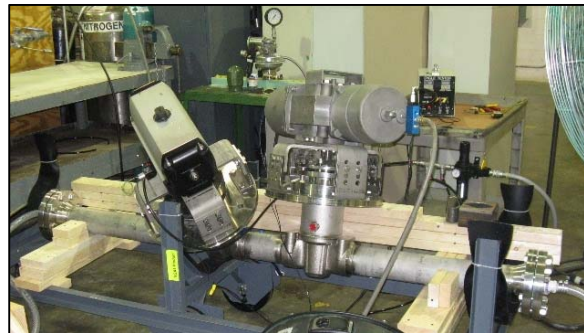
In order to confirm the products ability to withstand environmental and performance related loads, several tests were performed. Cycle testing combined with seismic qualification provided the basis for the testing completed. In order to envelope as much of the product as possible, the following equipment was tested:

- One 6' tall 2" ESV w/ Leak Detector
- Two 6' tall 2" ESV w/ two different turbidity sensors
- Two 9" tall 4" EBV close coupled (one vertical, one at 45 degrees), one actuated, one gear
- One Standard 2" Top Entry Cartridge Ball Valve, actuated
- One Standard 4" Plug Valve, actuated

Testing involved initial pressure testing to confirm there was no leakage, followed by 20,000 cycles with a nuclear process simulant solution. Figure 14 and Figure 13 show the products undergoing cycle testing. A second seat test was performed on the product before being shipped to a seismic facility. The entire set of equipment was tested on a shake table to 3 g's triaxially, as shown in Figure 16, successfully holding pressure during and after the shake test. Pressure testing was performed in accordance with API 598.



**Figure 14: Extended Sleeves and Instrument Enclosures setup for Cycle Testing**



**Figure 13: Close coupled Extended Bonnets setup for Cycle Testing**



**Figure 15: Equipment Installed adjacent to containment**





**Figure 16: Run 1 for seismic shake test**

Current field installations include a wide array of product:

- 2", 2-way, vertical plug ESVs 6 feet tall, nominally
- 3", 2-way, vertical plug ESVs 6 feet tall, nominally
- 2", 2-way ESV Instrument Enclosures, 6 feet tall, nominally
- 2" and 3", 3-way, plug ESV between 6 feet and 18 feet tall, nominally
- 2" and 3", 2-way ESV with EBV alignment, 6 feet, nominally
  
- 1/2" – 6", 2-way, vertical and angled installed plug EBVs between 7 inches and 23 inches tall (example in Figure 15)
- 2", 2-way, thru wall EBVs between 18 and 30 inches tall
- 1/2" and 1-1/2", 3-way, vertical EBV between 8 and 20-1/2 inches tall
  
- 2" – 3", 2-way, horizontal ball ESVs around 6 feet tall, nominally

Figure 15 shows a standard plug valve next to an Extended Bonnet Valve inside a shielded pipe. Figure 17 and Figure 18 show the typical installation of a 3" Extended Sleeve Valve. All equipment currently produced and installed was governed by a NQA-1-2004 quality assurance program to ensure the highest level of quality and reliability.



Figure 17: ESV installation from below the deck



Figure 18: ESV Installation from above the deck

## CONCLUSION

The Extended Sleeve Family of Products was developed as a scalable platform to solve a range of accessibility challenges in harsh environments. Coupled with a beneficial set of features, the product has provided a product suite that allows accurate control of process streams and monitoring of fluid properties in some of the harshest nuclear environments.