

## Quick Opening Closures-A New Stage in Petrochemical Industry

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### Abstract

At new construction and reconstruction of petrochemical production facilities for replacement of bolted equipment covers and hatches are widely used quick opening closures of different design. In this paper are analyzed quick opening closures of covers and hatches as well as pipelines, chambers and apparatuses dead end sections. Their advantages and shortcomings are presented. It is shown that high reliability, fabricability and ease of use requirements are met by new generation quick opening closures—ZKSsh/Zatvor Kontsevoi Sektorny Sheryk=Sector End Closure by Sherik. The closure design makes it possible to fabricate and deliver it both as an equipment component and in the form of a separate finished product to be installed at various vertically or horizontally oriented branch pipes, including in replacement of the existing fixtures in all possible diameter and pressure ranges.

**Keywords:** Petrochemical; Pipeline; Shells; Oil and gas; Petroleum

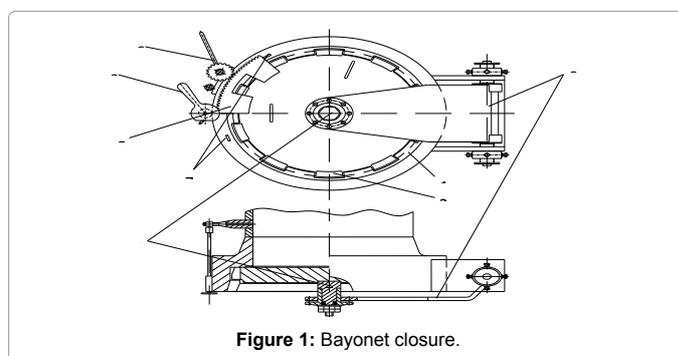
### Introduction

Reliability and productivity of the equipment which proper functioning requires repeated and quick access into their internal space, considerably depends on reliability and duration of opening and closing operations of their covers and hatches. At gas and petrochemical production facilities the pig launching and receiving chambers, dust arresters/collectors, compressor up- and downstream hatches/manholes, strainers (filters–mud traps) and many other types of equipment are equipped with process covers and hatches. Intensive construction, diagnostics, repair and reconstruction of oil and gas chemistry facilities with replacement of their equipment have led to significant growth of hatches number and frequency of their opening/closing. Used for many years fastening to the equipment of frequently opened/closed covers and hatches by means of pins and nuts implies high metal consumption and labor input, is extremely inconvenient in operation, especially on large diameter and high-pressure branch pipes. So, for example, flanged connection of a DN 1400, PN 10.0 MPa apparatus weighs about 8200 kg, and it requires 32 pieces M80 stud bolts about 22 kg each, and for its opening or closing, as a matter of experience, is required not less than one working shift. Therefore, in the last decades in world practice instead of the abovementioned fastening of covers and hatches has started implementation of various design quick opening closures.

### Critical Overview of the Known Quick Opening Closures

Quick opening closures of several types have been developed and are used at present extensively. Below are shown and critically analyzed the most known ones. The bayonet, "oldest" of known ones, was initially created for PN=1,6 MPa [1,2] only. The closure consists of flange 1 with radial teeth evenly located on circle, cover 2 with counter teeth (Figure 1), hinge 3 for cover 2 opening/closing. The cover 2 is installed using hinge to turn around axis 4 in the branch pipe plane. Turning of cover 2 is carried out by the toothed drive: toothed sector 5—toothed key 6. For closing of the closure, the cover is turned around the hinge 3 against the stop, cover 2 teeth are brought to grooves between teeth on branch pipe 1 flange. Then the cover is turned within limiters 7 in the branch pipe plane so that cover teeth come behind branch pipe teeth pressing at the same time the sealing and it is fixed by stopper 8.

The closure is extremely metal-consuming and difficult in



fabrication; seat engagement surface is more than twice less than that of the others. Theoretically the closure, at other things being equal, is less reliable of all the known ones. As has shown operating practice, the closure requires high closing/opening and tightening force, especially at DN  $\geq$  700 mm, and consequently, this can cause scuffing of the sealing element. It is actually impossible to repair the closure without replacement or building-up welding and the subsequent processing of the rubbing elements of main components and parts in a machinery and repair plant. Therefore, bayonet closures found limited application in the Russian practice of pipeline transport. However, Volgogradneftemash JSC despite a.m. shortcomings has decided to apply Scholz (Germany) bayonet closures on new pig launching and receiving chambers DN 300 ... 1400 mm at PN 8,10,12 MPas [3]. These closures have been used at the Nord Stream gas pipeline as well, since then Gazprom PJSC in its pipelines uses bayonet closures.

The segment closure has been developed to accelerate closing/opening of large diameter and high-pressure branch pipes [4] (Figure

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2), first of all, on pig launching and receiving chambers of the main gas pipelines in extremely high demand in 60 ... 80 of the last century—the years of active construction of big scale pipeline systems.

The closure consists of branch pipe with flange 1 with ring boring for flat cover 2 and circular groove for sealing, stopper segments 3 with clamps with hand wheel 4, segments drive hydraulic system 5, cart 6 for cover movement on rails 7. The cart 6 is supplied with assay 8 for suspending the cover to the cart during movement, positioning and installation of cover 2 on the boring. After installation of cover segments are entered into boring by means of hydraulic cylinders, at that the cover is pressed to branch pipe squeezing the sealing cord (it is not shown on the scheme).

This closure has been fabricated in even smaller quantities due to high metal consumption, complexity of fabrication and mounting on the application site, even more difficult operation and insufficient reliability owing to seizing of segments teeth and ring boring under conditions of absence of the packing element which could compensate the wear. Therefore, they were implemented in a few cases only.

The clamp closure is the most widely used closure in the gas and petrochemical industries [5,6] (Figure 3). The closure is simple in production, less metal-consuming, consists of cover 1 suspended on hinge 2, half-clamps 3 screwed up by screws 4 and installed on axes 5 displaced vertically up and down relative to horizontal axis of the end shell 6.

Despite the widest circulation this closure is not deprived of disadvantages. So, for large diameter closures it is necessary to use twin-screw drive system for half-clamps (Figure 3). At that due to difficulty of synchronous rotation of two flywheels of screw pairs 4 of half-clamps drives and, as a result, inequality of forces applied to clamp ends, it is difficult to close the closure quick and safely. Fabrication of half-clamps using welded cheeks 7 for drives and axes reduces their reliability; clamp arrangement considerably increases metal consumption, complicates design and raises the closure price. Besides, wear compensation of branch pipe 8 flange and cover 9 clamps and teeth is not provided and this would be especially necessary in the equipment requiring

frequent opening/closing of covers, hatches and branch pipes causing accelerated teeth and clamps abrasion. Comparative characteristics of closures applied at present in the Russian Federation are provided in Table 1. As a result, all the closures described above get censorious remarks from producing people.

In this situation by Salavatneftemash JSC Engineering Department was developed Sanema closure/end gate [7] (Figure 4). The closure consists of body 1 with flange 2, in the body on hinge 3 is installed cover 4 with O-ring gasket 5. For pulling and creation of initial force for contraction of cover to flange 2 serves traverse 6, equipped with screw 7–nut 8 drive with hand wheel 9.

However, the design was unsuccessful. The closure' metal consumption is unreasonably high due to use of two additional considerably large diameter transition cones and a shell or extended shell instead of two cones with short shells for cover positioning in the apparatus with possibility of its rotation to  $\geq 90^\circ$  angle. The main idea utilized in this design—beneficial use of product pressure to the branch pipe from within to press the cover does not answer the purpose of the closure implementation. As the closure cover opens into the chamber (apparatus) it is not possible to open it when the closure is used on a pig launching and receiving chamber and the chamber contains mud and slurry. Obviously, very difficult is assembly and adjustment of the closure cover to be done from inside the apparatus or in unassembled state at the fabrication plant as other way it is impossible to install the cover. The same disadvantages are inherent to the closure technical maintenance and repair. It is difficult to imagine an oil-patch plumber working in the closed apparatus or the chamber for repair and adjustment of the closure assays. Therefore, all these operations are feasible in a machinery and repair plant only. Besides, use of cover

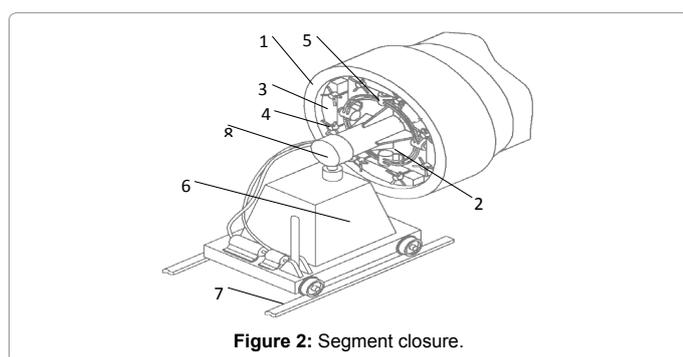


Figure 2: Segment closure.

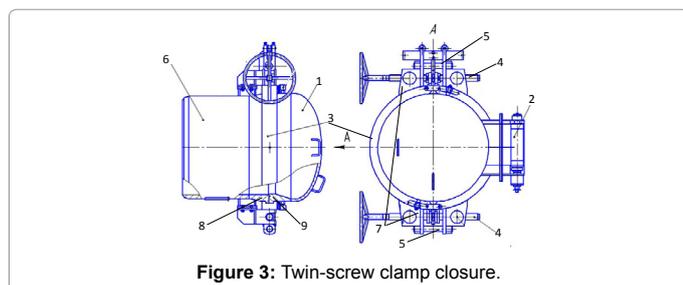


Figure 3: Twin-screw clamp closure.

Closure properties	Closure design		
	Bayonet	Segment	Clamp
DN range, mm	350, 700	1200, 1400	200 and more
Operating pressures P <sub>op</sub> , MPa	6, 6	7, 5; 12	4,0...10
Temperature, °C			
Working medium	- 10...+42	- 60...+80	- 60...+80
Walls, rated	- 60...+50	- 60...+80	- 60...+80
Sealing method	By jamming the sealing gasket		
Opening or closing cycle, no more, min	5	30	15
Working medium	Oil, gas and other products		
Number of loading cycles for the whole service life, not less	--	1000	400
Force on the handle (hand wheel) at opening or closing the closure, N	>150	<150	150
Design	Complicated	Complicated	Simple
Cases of failure, accidents	Yes		
Reliability	Not high		
Possibility of mechanization of the closure opening or closing process	Yes		
Operating convenience <sup>1)</sup>	Convenient <sup>1)</sup>	Inconvenient	Inconvenient <sup>2)</sup>
Fire, explosion safety requirements	Complies		
Serviceability <sup>3)</sup>	Convenient	Inconvenient	Convenient
Availability of a safety device	Yes		
Availability of a device preventing unauthorized operation	No		
Service life, years	30		
Closure mass kg per DN, mm	920/720	3600/1200	710/500

1) Applicable to small diameter closures  
 2) Applicable to twin-screw closures  
 3) Expert assessment

Table 1: Comparative characteristics of closures applied at present in the Russian Federation.

opening inside makes the device explosive dangerous due to possibility of sparking.

Makeev's GRTs JSC jointly with Salavatneftemash JSC has developed a closure [8] (Figure 5), varying from Sanema by the feature that opening 1 in body 2 flange 2 and cover 3 flanges have oval form for cover positioning in the apparatus body. For this purpose, the cover is rotated round horizontal axis 4 on  $\sim 90^\circ$ , attracted to flange and turning truss 5, got in the casing, and then turned back to  $\sim 90^\circ$  and fixed by fixing assy 6. When the closure' internal cavity is filled with condensed mud it is problematically to turn and remove the closure cover. For opening and closing are provided complicated mechanisms. Obviously, the closure is heavier than its analog-Sanema closure and more complicated in fabrication and operation.

The pig launching and receiving chambers with Triply S.r.l. quick opening closures marketed by Stroyimport JSC on the Russian oil and gas equipment market are almost unknown to the Russian specialists. Presence at the power-generating equipment markets in Germany and France4-according to Stoyimport JSC information, delivery of this equipment for a few years for Algeria oil and gas complex cannot be convincing argument at assessment of reliability and operational advantages of Triply S.r.l. quick opening closures. The comparative analysis of merits and demerits of quick opening closures of this company can be carried out only after study of reporting materials and references on their operation at pressures specified by Stroyimport JSC (from 1.6 to 10.0 MPas) and on pipeline diameters (from DN 150 mm to 1400 mm). In absence of the mentioned materials there is no point in any discussion.

Regarding Omni Tekhnologii JSC offer [9], which has included, according to its booklets, into its product slate chambers developed by Russian engineering organizations using closures of an European engineering company (apparently, are meant Pipeline Engineering ROC II quick opening closures), several years already specializing in the manufacture of these type of equipment and which has submitted the patent application, may be noted the following. The closure (Figure 6) regarding cover/bottom latching elements is analogous to ZKSsh closure (described hereafter). The locks drive mechanism used to push them into ring boring is different-namely similar to the

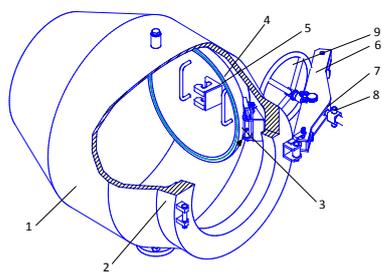


Figure 4: Sanema closure.

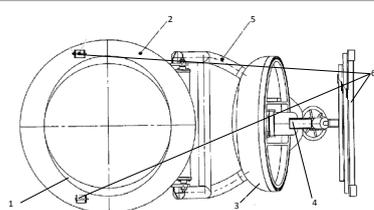


Figure 5: Makeev's GRTs JSC closure.

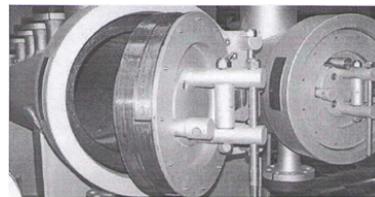
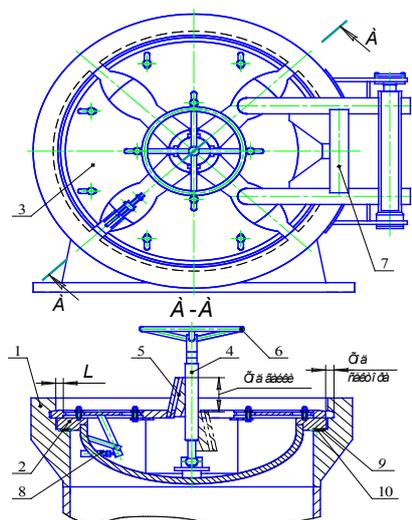


Figure 6: Quick opening face end closure.



Figure 7: GD Engineering quick opening closure.



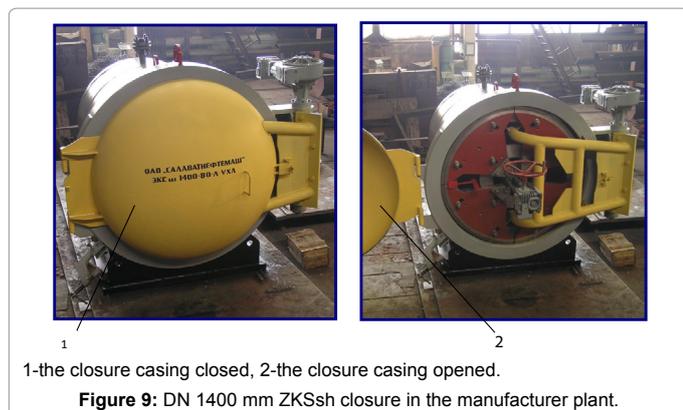
1-flange; 2-cover; 3-sector; 4-screw; 5-nut; 6-hand wheel; 7-swiveling device; 8-safety device; 9-seal ring; 10-cup.

Figure 8: Sector closure.

bayonet closure'. To push latching elements up to required depth into the body ring boring, to press at the same time the sealing by turning to the specified small angel the lever shown on figure can be carried out only for small diameters closures for pressures declared by Omni Technology JSC.

Regarding capabilities mentioned by the company in the field of specialized design and fabrication of quick opening closures for pipelines up to 60 inches, they seem to be feasible in case of full utilization of solutions implemented in ZKSsh closures on the basis of mutual agreements. Rationality and competitiveness of quick opening closures [10] by GD Engineering offered by the IMS company causes many questions, especially in case of using at high pressures and diameters (Figure 7).

In case the stopper ring (tape, belt) used for fixing of cover in the body (elbow) will be of big thickness/height-and it is obvious that this will be the case-it will be extremely difficult to close/open the cover; and a device, raising the finish product price, namely-a reducer will be required. Installation of stopper ring at an angle-the main novelty



Variables	Closures design	
	Sanema	ZKSsh
DN range, mm	200...1400	200...1600 and more
Operating pressures P <sub>op</sub> , MPa	8, 0...10, 0	0,6...16,0
Temperature, C:		
- working medium;	- 60...+80	- 60...+80
- walls, rated	- 60...+80	- 60...+80
Sealing method	Tightening of the cover by a screw and pressing by medium pressure	By jamming the sealing coupled to cup-type seal.
Opening or closing cycle, no more, min	20	7
Working medium	Gas	Oil, gas and other products
Number of loading cycles for the whole service life, not less	400	1000
Number of loading cycles for the whole service life, not less	--	150
Design	Very complicated	Medium-complicated
Cases of failure, accidents	--	--
Reliability	High	High
Availability of mechanization of the closure opening or closing process	Yes	
Operating convenience*	Very inconvenient	Friendly
Fire, explosion safety requirements	Not complies	Complies
Serviceability*	Inconvenient	Convenient
Availability of a safety device	Yes	
Availability of a device preventing unauthorized operation	No	Yes
Service life, years	30	
Closure mass kg per DN, mm	1240/500	790/500

\*- expert assessment

**Table 2:** Comparative analysis of characteristics of Salavatneftemash JSC Sanema closure and our ZKSsh closure.

in design-causes force and the moment turning out the stopper-tape outside, and it is possible to compensate this also only by increasing thickness of the stopper ring and bearing area of the cover and the body.

Apparently, due to these problems the company does not provide photos of large diameter closures for high working pressures. Besides,

the design is complicated, expensive materials are being needed and manufacturing techniques are complicated, thus, it cannot be reliable as it is based on use of elastic stopper rings and that makes the closure unreliable in case of frequent opening and closing.

### The New ZKSsh Quick Opening Closure

In the situation of lack of closures both reliable and simple to fabricate, we have developed ZKSsh series quick opening sector closure (sector end gate) [11,12] taking into account the Russian manufacturers and operators preferences. Schematic image and photo of a closure mounted on horizontal "apparatus" in the manufacturer plant (Figures 8 and 9). The closure consists of branch pipe 1, cover 2 with elements of its latching in the form of sectors 3, sectors drive in the form of screw 4-nut 5 assy with hand wheel 6, cover swiveling device 7, safety device 8, paired packing elements–cup 10/cord 9.

The closure functions as follows: Sectors 3 are moved forward and back by force created on inclined T-shaped nut 5 grooves at its moving along the screw 4 due to rotation of the last. Such arrangement makes sectors permanently arrested. Besides, unlike the standard solutions, closure sealing is designed in the form of a cup packing 10 with double packing cord sealing 9 securing tightness of the system in case of some wear of sectors teeth and ring bore as well.

From dust, mud and unauthorized operation the closure is protected by casing. Sectors of large diameter closures DN ≥ 700 mm are prefabricated as composite assy allowing replacement of worn-out tooth without replacement of other parts. And technical maintenance and repair of closure are easily feasible by the operating company personnel given that sealing elements and teeth have been delivered by the manufacturer.

As for the DN ≤ 500 mm closures, sectors opening/closing is carried out by flywheel within 5 minutes without application of serious efforts. DN ≥ 700 mm closures can be supplied with additional reducing key on the basis of worm gear or waveform gear reduction unit driven from an electrically safe device. Opening or closing time of a geared closure makes 3 minutes and without gear–up to 7 minutes. ZKSsh closures can be operated on gas, crude oil and petroleum product pipelines and on any other equipment for quick opening or closing of different dead end pipes, branch pipes, hatches, etc. and they are sized for DN ≥ 200 mm pipelines at any pressure. In the photo (Figure 9) is shown a DN 1400 mm, PN 8 MPas closure in the closed state with the opened and closed casing in the manufacturer plant. Comparative analysis of characteristics of Salavatneftemash JSC Sanema closure and our ZKSsh closure is provided in Table 2.

The table data demonstrate indisputable advantages of ZKSsh quick opening closure. Regarding its design the ZKSsh closure seems to be a bit more complicated, than the most widespread and simple one of the above described devices–namely clamp closure, but as shows operating experience, it is vastly superior to all the closures fabricated formerly, is convenient in technical maintenance and operation.

Closure tests have shown its high reliability, safety and convenience in operation. The closure design makes it possible to fabricate and deliver it both as an equipment component and in the form of a separate finished product to be installed at various branch pipes, including in replacement of the existing ones - clamp and bayonet closures or flanged connections, for example. The product is less metal-consuming and is maintenance friendly. Thus, from this short overview follows that regarding reliability, operation convenience, repairability the quick opening sector closure designed by Dr. Ilmer Yu. Khasanov is the most attractive one.

## Conclusion and Future Prospects

Now has started work on design and manufacturing techniques improvement and promoting of the closure as well. It is supposed to offer the closure to oil and gas production, oil and gas transporting, oil processing and petrochemical companies for equipment of revamped and new facilities in replacements of flange, clamp, etc. types of closures.

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