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A POSSIBLE APPROACH OF DEVELOPING THE NEW PRODUCT BASED ON EXPERIMENTAL RESEARCH - CONTRIBUTION OF DEVELOPING DOMESTIC GREASE FOR SEALING ON NATURAL GAS PIPELINE VALVES –

Željko M. Aleksić B.Sc.Mech.Eng. , NIS-GAS ,21000 Novi Sad ,Narodnog fronta 12 , Serbia and Montenegro

Absract

In this paper notice is given to the significant importance of sealing and lubricating, as specific tribological phenomena, for valves installed on natural gas pipelines which have the possibility of primary and secondary sealing system specially designed for that purpose and applied on plug and ball valves. Research program has been developed based on domestic product, in order to investigate appliance and usability and the result of the second stage is presented, with the aim of developing fabrication of the product.

Key word:. *pipeline, valves, sealing, greasing, experiment;*

1. INTRODUCTION

One of the main elements of the system for transportation and production of natural gas are the plug valves and ball valves, the main function of which is to cut off the flow or to separate parts of the pipeline installation. Certain types of these valves have the design capability of applying primary and secondary sealing and lubrication.
Basic characteristics of the lubrication system:

1. Primary sealing system

Typical representatives of this type of system are plug valves.

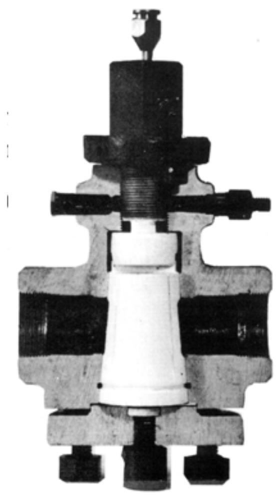


Figure 1: *Cross section of the plug valve with the lubricating capability - Hyperseal*

Four types of this kind of valves can actually be seen in practice:

- Plug valves
- Hyperseal i.e. the valve with the down inlet (invert plug valve)

- Valves in dynamical balance
- Cylindrical plug valves

Functioning principle:

By injecting the sealing and lubricating medium under high pressure (~700 bar), on the previously determined points with the lubricators (fittings) placed on the valve housing and on the plug axis, the coating of the plug surface with the sealing and lubricating medium as well as the cone plug housing in the valve seat is performed through the system of inner channels and grooves, which makes them slide and enable easier rotation at the reduced rotary force.
The use of the sealing lubricant under pressure results in lifting of the cone plug form its cone seat on the majority of cone valves.
The most important feature of sealing lubricant is that it acts as a seal; the sealing lubricant should fill-in the gap between the plug and the valve seat in the housing in order to prevent the valve leaking and to avoid the direct metal-to-metal contact.
The frequency of re lubrication depends on the resistance of the sealing medium to washing out and extrusion.

2. Secondary sealing system

Typical representatives of this type of system include ball valves.

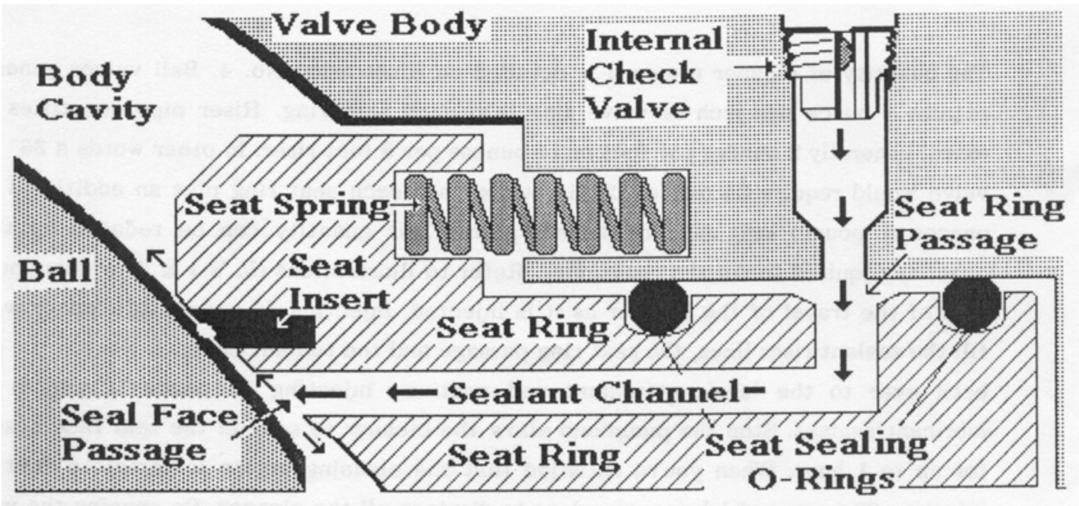


Figure 2: Secondary sealing system

Functioning principle:

This system of additional lubrication is used in case of damage to the sealing rings, primary sealing system or the ball itself, produced by the hard particles or the impurities that can be found in natural gas (rust from the pipeline, sediments, impurities, sludge, foreign hard particles or old hardened sealing medium) and in case of the sealability required in order to temporarily or perpetually close the valves on the pipeline section for the maintenance needs or other necessary operations.
By injecting the sealing medium under high pressure (~600-700 bar), with the lubricators placed on the body of the ball valve, through the system of the capillary grooves located within the sealing rings, the sealing and lubricating film is formed between the body of the ball and the sealing rings enabling the required sealability.

Working environment and conditions for the sealing and lubricating medium

The said valves are located at the system installations for production, gathering and transportation of natural gas. The average chemical composition of the natural gas is 95-98% of methane and 2-5% of other carbohydrates and other ingredients.

Table 1-N. Average composition of natural gas

metan C1	etan C2	propan C3	I-butan IC4	N-butan NC4	pentan C5+	nitrogen N2	carbon dioxide CO2	min. warmth value kJ/m3	gas density kg/m3
97,92	0,53	0,24	0,054	0,044	0,02	0,88	0,28	33.989	0,696
*44,6	0,98	0,134	0,072	0,1165	0,128	8,99	44,91	16,35	1,27

- The second column represents the composition of natural gas rich in N2, CO2.

Table 2-N.

Required performance of the sealing lubricant	The characteristics of lubricant directly reflecting the fulfillment of requirements
Recommended moment for valve opening and closing Sealing and lubrication	Composition of the lubricant Consistency Anti wearing diameter Dynamic viscosity
Water tightness	Composition of the lubricant water resistance
Persistence at high and low temperatures	Composition of the lubricant Affinity according to sliding Oil separation Dropping point Copper corrosion
Environmental requirements	Composition of the lubricant Oil separation
Anti wearing diameter	Composition of the lubricant Affinity according to sliding Oil separation Dynamic viscosity
Solvents resistance	Composition of the lubricant

2. PROGRAM FOR THE TESTING OF DOMESTIC LUBRICANT (BASIC POSTULATES)

Introduction

The purpose of this testing is to replace the sealing and lubricating medium from imports, used for the primary and secondary sealing and lubrication of ball and plug valves with the domestic lubricants produced by FAM Kruševac.

The objective of testing

The basic objective of testing the sealing and lubricating grease (sealing and lubricating medium) is the acquisition of data based on which the possibility of application of those lubricants would be assessed i.e. to determine possible disadvantages and give the suggestions to the manufacturer for the purpose of improvement of certain characteristics and reaching the level of quality of imported lubricants.

The following technical characteristics of the sealing and lubrication medium are tested:

- Sealability after the application in the static conditions - the first stage
- Resistance to washing out in the dynamical conditions – with the gas flowing (the second stage)

- Resistance to changes in the viscosity (polymerization)

Description of the testing procedure - the second stage

The testing have been performed in two ways – at the installation and in the laboratory conditions. In the installation conditions, the testing have been performed at locations for transportation of natural gas at main swich node Novi Sad .

Program of the testing

Testing of valves for sealability(leakage test)

The testing valves for sealability was performed in accordance with:

- The JUS M.C5.013 standard, which defines the way and the procedure for the measurement of sealabiliy of the valves.
- Recommendations given by the API 6D, API 598 standards, which also define the way and the procedure for the measurement of sealabiliy of the valves.

, as a basis for leakage at real conditions.

The testing of the resistance to washing out

At the real conditions, the resistance to washing out was tested by counting the number of openings and closings up to the point where the leakage occurred, without the additional lubrication during testing, and in accordance with the recommendations given by JUS M.C5.013 (as well as API 6D, API 598) standard.

The resistance to changes in the viscosity (polymerization)

The resistance to changes in the viscosity (polymerization) was checked by lubricating and testing the sealability after 30,60,90, and 180 days, i.e. the valve that was chosen would be submitted to the sealability test and after the testing it would be disassembled for the inspection of the possible changes in the viscosity.

Testing of the lubricants – the stage two

Experimental approach to the testing

In order to achieve the best possible interpretation and monitoring of the results of measurements of sealability and resistance to rinsing, the comparative analysis has been made of the characteristics of the valve lubricants, master meter lubricants, and the lubricant from the production program of FAM Kruševac,after extracting the best lubricant from first part of experiment.

Table 3-N. Comparative characteristics of lubricants

No.	Characteristics / Product name	Metod	ETALON LUBRICANTS	FAM X
1.	Colour	Visual	dark-brown	dark
2.	Appearance at 20°C	Visual	homogeneous	homogeneous
3.	Thickener	-	non soap fillers	non soap solids
4.	Un Worked Penetration, mm/10	ASTM D 217	85-115	175 - 205
5.	NLGI classification	ASTM D 217	6	4
6.	Dropping point, °C	ASTM D 2265	>300	>300
7.	Oil separation , 168 h /40°C, %	BS 2000 part.121	0	0
8.	Oil separation, 30h /100°C,%	FTMS 791m. 321	1.8	0
9.	Affinity according to sliding, 4h/100°C ,grade	GOST 19538-74	without shape changing and without oil separation	-
10.	Dynamic Viscosity , 10o/s, at +25 °C , kPas	DIN 53018/1	361.9	169.0
11.	Dynamic Viscosity, 100o/s, at + 25 °C, kPas		64.8	26.5
12.	Dynamic Viscosity, 1000o/s, at +25 °C, kPas		1.6	0.9
13.	Water resistance at, 15 min,/ 90°C, grade	DIN 51 807/1	0/1	0
14.	Water resistance at, 3h / 90°C, grade		1	1
15.	Copper corrosion at, 3h/100°C, grade	ASTM D 4048	1	1
16.	Copper corrosion at, 24h/100°C, grade		1	1
17.	Antiwearing diameter,mm	ASTM D 2266	1.02	0.56
18.	Solvents resistance, grade (statics conditions) (petrol,petroleum eter),	Visual	pass	pass

In order to be able to get as reliable data as possible of the relevant factor tested during the experimental measurement it self, the methodology of the single factor experiment has been used. It consists in enabling the possible non-included factors, which can influence the very phenomenon of the experiment or the measurement, to act in accordance with the following prerequisites:

- The influence of the non-included factors has to be negligibly low
- The non-included factors have to be maintained at the constant level
- In case the influence of these factors is incidental, their impact can be separated from the impact of the controlled factors in form of the experimental error, through statistical mathematics methods.

This would be the base way to separate only the main factor that is of interest for the observation and measurement. In accordance with that principle, during the performance of experiment, the external factors were maintained at the constant level, namely:

- Same location for performance of the experiment.
- Same lubricant for injection of the sealing and lubricating medium
- Same test bench
- Same operator
- Same test medium
- Same cone (plug) valves used for the testing
- Same tightening of the cone piston on the occasion of each repeated installation.

It is assumed that these factors act as incidental values with the normal distribution.

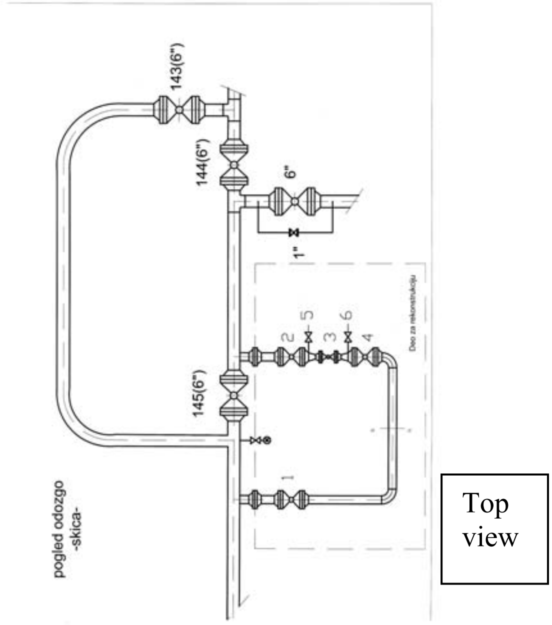
In order to reduce the influence of the error in measurement during the performance of the experiment to the minimum, for each test plug valve with the 2" bore and the ANSI 300 pressure class which have been chosen for this case and before that were in use for many years (15-20), many series of measurements have been performed with one loading of lubricant at the constant test pressure.

In that case, the result of the measurement is the average value (arithmetic mean) of the number of openings and closings of the valve at the constant pressure with one loading of lubricant until the leakage has been registered.

Before the actual performance of experiment, the visual control of the condition of external fitting surfaces of the plug and its seat has been performed.

In the course of testing, and before the injection of different sealing and lubricating medium, each valve was thoroughly cleaned and grease removed.

Picture below show (top view) constructed line (bay-pass) , for testing the valves at real conditions. Valve no. 3(at the picture) is tested one.



picture 1

Test results

The test results are shown in the following tables. In the raw entitled “Lubricant”, i.e. the master lubricant, , FAM X, are the values of the number of openings and closings of the tested valve up to the point where the leakage was registered with one loading of the valve i.e. the series. Under each column is shown the average value , Valid number of data, confidence interval (95%), variance, standard error and standard deviation for all series.

Table 1.

LUBRICANT: FAM X									
	Valid N	Mean	Confidence	Confidence	Minimum	Maximum	Variance	Std.Dev.	Std.error
28	11	3,818182	-0,176888	7,813252	0,00	17,00000	35,36364	5,946733	1,793008
29	16	2,187500	-0,424568	4,799568	0,00	16,00000	24,02917	4,901955	1,225489
27	24	1,208333	-0,194804	2,611471	0,00	14,00000	11,04167	3,322900	0,678284
28	10	1,800000	-0,354004	3,954004	0,00	8,00000	9,06667	3,011091	0,952190
28	18	1,000000	-0,287764	2,287764	0,00	8,00000	6,70588	2,589572	0,610368
27	16	2,500000	0,206008	4,793992	0,00	12,00000	18,53333	4,305036	1,076259

Table 2.

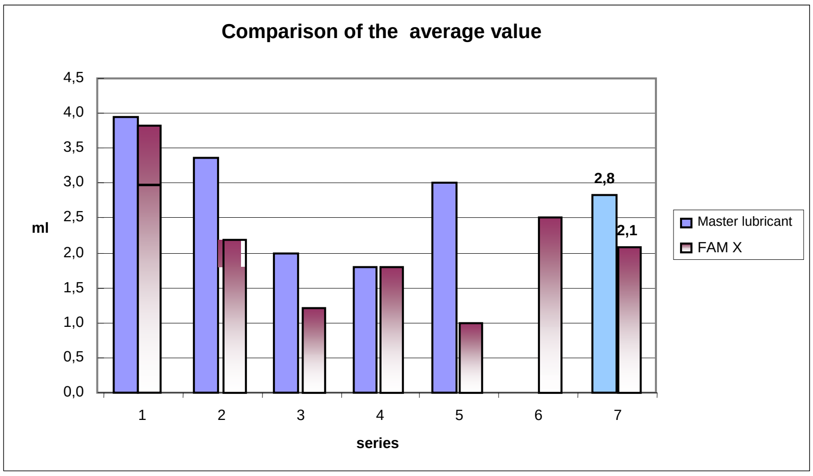
LUBRICANT:MASTER LUBRICANT									
	Valid N	Mean	Confidence	Confidence	Minimum	Maximum	Variance	Std.Dev.	Std.error
25	18	3,944444	0,34035	7,548538	0,00	30,00000	52,52614	7,247492	1,708250
25	22	3,363636	0,56769	6,159581	0,00	25,00000	39,76623	6,306047	1,344454
29	10	2,000000	-1,01621	5,016210	0,00	10,00000	17,77778	4,216370	1,333333
29	10	1,800000	-0,60352	4,203524	0,00	10,00000	11,28889	3,359894	1,062492
28	10	3,000000	-0,84493	6,844928	0,00	15,00000	28,88889	5,374838	1,699673

After arrangement of the data and elimination of the extremes values the table of average value is as shown:

Table 3.

repetitions	Master lubricant	FAM X
1	3,94	3,81
2	3,36	2,18
3	2,00	1,21
4	1,80	1,80
5	3,00	1,00
6		2,50
Average value [ml]	2,82	2,08

The best way to graphicaly illustrate all of the data from the table above is in the next graph , total average of valve leakage for each lubricant.



Graph 1

Establishing the Hypothesis

At this point, with data provided from experiments we could establish the hypothesis , assuming that tested sample i.e. , master lubricant and FAM X had equal average number of openings and closing up to the point where the leakage is detected.

We assume that :

$\bar{x}_{Master\,lubricant} = \bar{x}_{FAMX}$

Hypothesis is established about equivalent average value between samples with no diference.

After processing the results we have ,

$t_{Stat} < t_{Crit},$ i.e.

$t_{Stat}=1,25 < t_{Crit}=3,25$

with level of significance of 1% i.e. $\alpha = 0,01$.

With this data we can conclude that two sample are equal and exsisting of diference is zero.

The next table processed the statistical data,

Table 5.

t-Test: Two-Sample Assuming Equal Variances		
	Master lubricant	***FAM X***
Mean	2,821	2,085
Variance	0,826	1,042
Observations	5	6
Pooled Variance	0,946	
Hypothesized Mean Difference	**0**	
df	9	
t Stat	**1,249**	
P(T<=t) one-tail	0,121	
t Critical one-tail	2,821	
P(T<=t) two-tail	0,243	
t Critical two-tail	**3,2498**	

Next comparising is also interesting, from the data obtained from the experiment at the real conditions.Next graph ilustrate the number of openings and closing up to the point where the first leakage is detected.
Next data in the table are conected with graph above.

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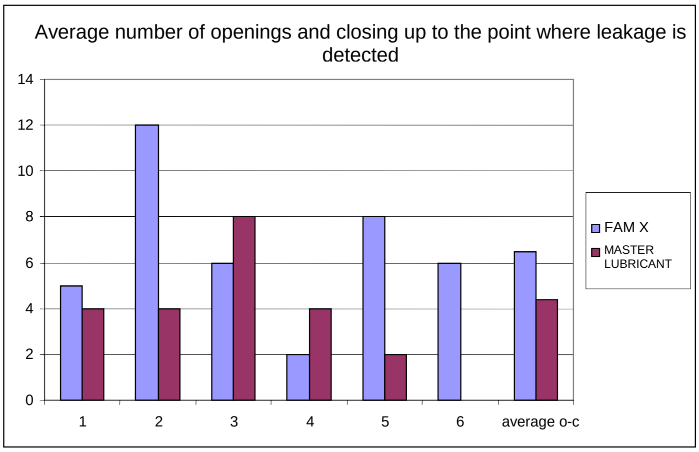

Graph 2

Table 6.

Series	FAM X	MASTER LUBRICANT
1	5	4
2	12	4
3	6	8
4	2	4
5	8	2
6	6	
average no. of o-c	6,5	4,4

Leakage registered up to the point where first leakage is detected

Results obtained for valves no. 2 and no. 3.

If we compare results from the first stage [7], and with respect of years of exploration , aproximately 20 years in service, condition of contact surfaces beetwen cone plug and body of the valves, following results had good explanation.

Valve no.2

After 16 repetitions of loading with master lubricant valve no. 2 leak after first opening and closing procedure.Loading with FAM X lubricant leak has been detected after first opening and closing procedure.Procedeure stoped after 18 loading of lubricant(repetitions).

Valve no.3

After 18 repetitions of loading with master lubricant valve no.3 leak after first opening and closing procedure.

Loading with FAM X lubricant, leak is detected after first opening and closing procedure.Procedure sopped after 17 loading of lubricant (repetitions).

Explanation:

Despite of detected leaking after first opening and closing procedure at observed valves no.2 and no.3 , loaded master lubricant and FAM X lubricant has shown good capability of sealing under the presure of 25 to 29 bar, at real conditions , compensating the scrathing surface of cone valves and other geometric imperfections of body valves.

Processing of the results

As mentioned before, the average value and the standard deviation for the tested property (factor) are considered to be the relevant data for the assessment of the lubricant quality in the given testing conditions.

3. CONCLUSION

Results obtained from the second stage has shown good corellation with data provided in the first stage of the experiment, experiments performed at the laboratory conditions (6 bar – Air), and data provided from the second stage of the experiment at the real conditions, confirmed that chosen approach of decoding master lubricant with “black box” metod and in cooperation with laboratory at FAM Kruševac, as a feed back for upgrade of necessary characteristic up to the level of projected quality and sealabillity, give a valid basis for industrial application and for further development of this strategic product and fulfiled projected goal set up at the beginning of the project.

4. LITERATURE

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