Journal of Applied Sciences

ISSN 1812-5654

ANSInet
an open access publisher
http://ansinet.com

Journal of Applied Sciences 10 (21): 2693-2696, 2010
ISSN 1812-5654

Verification Properties of O-rings made from Viton Extreme with Advanced Polymer Architecture used in Pipeline Valves Containing very Sour Gas

J. Heidarian and H.H. Khanli
Department of Polymer Science and Technology, Research Institute of Petroleum Industry,
West Wing of Azadi Sport Complex, End of Hakim Blvd., Tehran, Iran

Abstract: The properties of a copolymer of ethylene-tetrafluoroethylene-perfluoro methyl vinyl with Advanced Polymer Architecture used in very sour gas conditions were verified. The sour gas contains 23% H_2S, 11% CO_2, hydrocarbons, amine corrosion inhibitors, methanol and water at 32°C and 1200 psi. The aim is verifying properties and application of this fluoroelastomer for o-ring. The results show that in sour gas phenomenons like explosive decompression, extrusion, hardening and softening were not occurred in this fluoroelastomer. Its hardness, compression set, heat aging and mechanical properties for o-ring application were appropriate. Totally it can do the sealing very well in sour gas application.

Key words: Viton extreme ETP-600S, sour gas, o-ring, explosive decompression, mechanical properties

INTRODUCTION

Viton is a synthetic rubber and a fluoroelastomer which is used in manufacturing o-rings and other molded and extruded articles from Dupont Co. USA. Viton Extreme is the latest development in Viton family. This elastomer is a terpolymer of ethylene, tetrafluoroethylene and perfluoro methyl vinyl ether. Viton Extreme is a bridge between fluoroelastomers (Viton) and perfluroelastomers. This elastomer has the best chemical resistance among all fluoroelastomers. This type of Viton designed by Dupont Co. for using in oilfield and contacting with amines and sour oils. Other properties of this Viton are: flexibility at low temperatures, optimum compression set, optimum physical properties for using in seals and also having low volume swell in hydrocarbons.

Viton Extreme ETP-600S is a Viton with advanced polymer architecture (APA) technology and it is the new generation of Viton Extremes that have improved processability (Fuller, 2006).

Natural gas fields are usually with high pressure and hot and have high percentage of Hydrogen Sulfide (H_2S) and carbon dioxide (CO_2) (Hertz, 2007a). The conditions in sour gas production contain high pressure and temperature which resulted to a very difficult environment for sealing elastomers.

High pressure increases the density of gas and cause the gas to have a nonordinary solubility power. Completely different properties of the three gases (H_2S, CO_2 and CH_4) chemically and molecularly produce a mixed solventary system which the sealing of it is very difficult (Hertz, 2007a). CO_2 and H_2S in the presence of water produce an acidic environment, so, for preventing corrosion, high amount of corrosion inhibitors are needed. Amine corrosion inhibitors which form a film at the surface of the pipe cause permanent swelling of all type of elastomers used for sealing (Hertz, 2007a). Low molecular weight of alcohols also may be injected for preventing clathrates and they can swell the seal. These environments can fail the seal physically or chemically (time dependent).

Solubility parameter conception is used for any discussion about affects between gas and elastomer. Amount of seal and fluid interaction is dependent on fluid diffusion amount in the seal. Diffusion is controlled by molecular structure, solubility and glass transition temperature of seal materials (Hertz, 2007a). CH_4 is an octopole with uniform charge distribution create a non polar molecule. CO_2 is a quadrupole with strong negative charge at both ends, categorized as a Lewis acid or electron pair acceptor (EPA agent), or an electrophil. H_2S is a dipole-created by the 90°C bond angle, categorized as a Lewis base or electron pair donor (EPD agent), or a nucleophil (Hertz, 2007b). H_2S can attack chemically the elastomers.

Explosive decompression phenomenon: Elastomers in contacting with high pressure gases finally will be super

Corresponding Author: Javad Heidarian, Department of Polymer Science and Technology, Research Institute of Petroleum Industry, West Wing of Azadi Sport Complex, End of Hakim Blvd., Tehran, Iran

saturated (Hertz, 2007a). Penetrated gas in elastomers at high pressure during discharge when sudden pressure drop occurs, expand and want to leave the elastomer. Gas may be entered to the atmosphere without any damage or may produce some blisters on the surface. The controlling variables are: gas pressure, temperature and rubber compound. Slowly pressure dropping and using rubbers with high hardness and density can increase the resistance to this phenomenon.

In this research, properties of Viton Extreme APA (Advanced Polymer Architecture) from Dupont Co. of USA for using in very sour gas conditions will be verified. The conditions are gas with following compositions: H_2S 23%, CO_2 11% and the rest was CH_4 and low molecular weight hydrocarbons. The pipeline pressure is 1200 psi and the temperature is 29°C. The gas also contains amine corrosion inhibitors, methanol and water. Till now this Viton extreme which is an APA polymer for using in gas with high percentage of H_2S has not been used and explosive decompression resistance of this elastomer in these gas conditions has not been verified. The main aim is using this fluoroelastomer as o-ring for valves in the pipelines.

MATERIALS AND METHODS

Compounded and uncured Viton extreme ETP-600S from Dupont Co. of USA were prepared. This Viton after curing and postcuring had 85 shores A hardness.

Sour gas pipeline: Pipeline containing sour gas between Masjed Suleiman and Razi petrochemical Co. in Mahshahr at the South of Iran was used.

Rheometry: At constant temperature of 165°C and in Monstanto Rheometer for 30 min the samples cured and Torque-time curve obtained.

Curing: First, the molds (O-ring, tensile and compression set molds) were prepared and then, curing of Viton extreme APA was done in the heated press at 165°C for 12 min. First the molds preheated for 2 min.

Post cure: The post curing was done in air Aven at 220°C for 16 h.

Hardness test: Hardness was measured (shore A) according to ASTM 224D.

Compression set test: Was measured according to ASTM D 395 method B (Disc).

Tensile test: Was done according to ASTM D412 with extension rate of 500 mm min^{-1}.

Aging: Was tested in accordance to ASTM D573.

O-ring test in the sour gas pipeline: Manufactured O-rings with dimensions of 26.3×3.3 mm directly installed on the valves in the sour gas pipelines between Masjed Suleiman wells and Mahshahr in the South of Iran for 2 weeks, with the pressure of 1200 psi, temperature of 29°C and compositions mentioned in Material section. Then the pressure discharged during several minutes and o-ring uninstalled from the valve, verified. Again after one hr installed on the valve and for another 2 weeks exposed to sour gas in order to assure that the o-rings can be reused several times. Later after 2 weeks o-rings removed from the valve and inspected.

RESULTS AND DISCUSSION

Curing time: After Rheometery test at 165°C, the cure time was 12 min.

Hardness test: After curing and before post curing hardness was 80 shore A and after post curing the medium hardness was 87 shore A. This hardness is suitable for preventing explosive decompression phenomenon. Having this hardness bubble/crack and blister in the surface of o-ring after exposure to sour gas with high pressure will not exist. Normally hardness of 80 shore A and more is suitable for omitting explosive decompression. Besides high hardness will reduce compression set that is very useful for o-ring.

Tensile test: Tensile test results for this Viton are presented in Table 1. As can be seen from Table 1, this Viton has almost high tensile strength, medium elongation at break and relatively high 100% modulus (comparing elostomers tensile properties that mentioned in references (Fuller, 2006; Hertz, 2007a, b).

All of these mechanical properties in manufacturing O-rings for using in high pressure are useful and can control explosive decompression phenomenon and extrusion. High modulus can help the o-rings to tolerate more pressure.

Table 1: Tensile test results for viton extreme ETP-600S

Tensile strength ($kgf\ cm^{-2}$)	Elongation at break (%)	100% modulus (MPa)
139	145	8.36

Table 2: The results of tensile test after heat aging for viton extreme ETP-600S

Hardness	Tensile strength (kg f cm^{-2})	Elongation (%)	Yung modulus (MPa)
90	147.97	214.55	6.43

Compression set test: Average compression set for this Viton was 25.5%. This amount is acceptable for o-ring application. This result indicate that life time of the o-ring manufactured from this Viton at application temperature (29°C) is almost long (several years) and in this lifetime it will not loss its applicability (due to compression set).

Heat aging test: Table 2 is the result of tensile test after heat aging: Table 2 shows that after heat aging and comparing to properties before aging, hardness did not change considerably and there are no extra softening or hardening. Extra softening can cause extrusion of o-ring and extra hardening can produce cracks.

According to this table changes in tensile strength is 6.45%, that is low enough and the seal will not be failed due to heat aging. The changes in elongation percent is +47% and technically with this elongation percent change the o-ring is applicable.

O-ring test in very sour gas pipeline valves: Two weeks after installation of the o-rings in Masjed Suleiman sour gas pipelines the installed o-rings were removed and they were in good conditions. Also their sizes were almost the same as before and did not have any swelling. The hardness of o-rings was not changed very much. For testing the o-rings in reapplication, they reinstalled in the pipeline valve again and after one months the o-rings were removed again and it was in good conditions as before and this show that if o-rings reapply for several times there will be no problem. Totally no cracks, bubble, blister, swelling, hardening and softening in the o-rings was observed. This test shows that this Viton against the sour gas, methanol, amine corrosion inhibitors and steam is resistant. High pressure of the system did not produce explosive decompression phenomenon in this Viton and its resistance against this phenomenon is good enough. Its compression set resistance is good because after one month o-ring can do the sealing very well and compression set resistance test that was done before confirmed this matter. Because the o-rings did the sealing well and there was no explosive decompression so the used hardness (85 shore A) was suitable. Regarding good ability of these o-rings in sealing operation and keeping these properties after tests in sour gas pipeline, it can be concluded that mechanical properties such as modulus of this Viton is proper for this application because it has enough resistant to extrusion rupture, crack and blister. This Viton is appropriate for this application temperature and in this temperature is not degraded by heat or oxidation.

In terms of resistance to H_2S, this elastomer is completely resistant and is not attacked chemically. Also in some literatures (Walter, 2005; West and Ray, 1981; Hindmarch, 1984; Kosty, 1982a, b; Ray and Ivey, 1978) the behavior of some fluoroelastomers in sour gas were verified and can be compared with this Viton.

It can be concluded that the solubility parameter, chemical resistance and mechanical properties of this Viton is suitable for this application.

CONCLUSIONS

Viton Extreme ETP-600S which is an APA (Advanced Polymer Architecture) Viton is suitable for making and application in very sour gas (23% H_2S, 11% CO_2 and the rest CH_4 and low molecular weight hydrocarbons, amine corrosion inhibitors, methanol and water) at 32°C and 1200 psi (specially for o-ring applications). It can pass all the needed tests for this application.

Regarding tensile properties, it is completely suitable for making o-rings and prevents phenomenon like explosive decompression and extrusion of o-rings. The compression set percent of it is relatively low and acceptable for o-rings application. This Viton keep its properties during the heat aging test and with this test, hardening or softening will not occur.

In the very sour gas, no crack, blister, swelling, hardening and softening observed in this Viton and it is stable in different agents exist.

The o-ring in very sour gas conditions did the sealing very well and no explosive decompression and extrusion occurred in it.

Sponsor: Razi Petrochemical Co., Mahshahr, Iran

REFERENCES

Fuller, R.E., 2006. Flouroelastomers Made with Advanced Polymer Architecture for Oil and Gas Applications. DuPont Co., USA.

Hertz, D.L., 2007a. Sealing High Pressure under Sour Conditions. Seals Eastern Co., USA.

Hertz, D.L., 2007b. Elastomers in the Hot Sour Gas Environment. Seals Eastern Co., USA.

Hindmarch, R.S., 1984. Rubber-the multipurpose offshore material. Plastics Rubber Process. Appl., 4: 121-125.

Kosty, J.W., 1982a. Hydrogen sulfide compatibility of fluorocarbons. NACE, 2.1-2.8.

Kosty, J.W., 1982b. Testing of fluorocarbon seal materials in hydrogen sulfide environments. Mater Perform, 21: 43-46.

Ray, T.W. and C.E. Ivey, 1978. Evaluation of seal materials for high temperature H_2S service. Institution of Mechanical Engineers, Conference Publications, Conference, Annual Technical Meeting of the Pet Society of CIM, 29th, Preper, Cal Gary, Alberta, Canada, Publisher, Pet Society of CIM.

Walter, W.S., 2005. Curable base-resistance fluoroelastomers. United States Patent 6924344. http://www.freepatentsonline.com/6924344.html.

West, A.C. and T.W. Ray, 1981. Fluoroelastomer polymers EMDash compounding and testing for downhole environments. Rubber Chem. Technol., 54: 146-154.