Velocity Limitation in Pipelines while Performing Welltest Operation, Quality Limitation Regarding Operational Usage of Relevant Equipment

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Abstract

Quality limitation which all equipment carries on, should be recognized and respected during the asset lifetime by any users and also those companies or individuals which expect to receive the asset`s services. This article emphasizes on Velocity Limitation in pipe lines while performing well test operation. As declared in cavitation and erosion definition in pipe lines, velocity phenomenon directly affects erosion and cavitation property of passing fluid inside pipe lines. As per American Petroleum Institute Recommended Practice 14E, two kinds of velocity are issuing inside alive pipe lines, one is erosion velocity (Ve) which indicates probable erosional property of passing fluid in term of ft. per second and one is actual velocity based on relevant passing gas rate calculation (Vg). Vg shall not exceed Ve. But these are not the only limitations. Manufacturers' comments on manufactured assets and critical criteria of each fluid that is going to pass through pipe lines are unavoidable.

This article addresses velocity limitation in pipe lines based on Mehran Engineering & Well Services Co. experience according to international standards and codes, assets manufacturer comments and Mehran standards and codes itself.

Keywords: Gas Velocity, Erosion Velocity, Erosion, Well Test Operation, Piping System.

Introduction

Quality limitation which all equipment carries on should be recognized and respected during the asset lifetime by users and those who receive services. Velocity Limitation in pipe lines while performing well test operation is one of critical aspect of different pipe brands. Cavitation is a type of metal loss, often grain by grain, and is due to high pressure shock waves, generated from the collapse of minute bubbles in high velocity fluids impinging on nearby metal surface. Erosion also is direct metal removal by cutting action of high velocity abrasive particles. Erosion failure (washout) is seen in flow lines especially at bends and joints by produced sand or debris in dependence of fluid velocity.

Velocity phenomenon directly affects erosion property of passing fluid inside pipe lines. As per American Petroleum Institute Recommended Practice 14E, two kinds of velocity are issuing inside alive pipe line, one is erosion velocity (Ve) which indicates probable erosional property of passing fluid in term of ft. per second and one is actual velocity based on relevant passing gas rate calculation (Vg). It's a general principal that Vg shall not exceed Ve. In some cases another concern or standard limits this general principal more.

Mehran Co. uses variety of piping in different well test operations base on fluid properties for issued wells/ fields. These piping could be categorized as;

a- Flexible Hoses known as Coflon type Coflexip®.
b- Rigid pipes including XXH Grayloc® or different SCH of FMC Weco Union piping connections.

General Principal which emphasizes Vg shall not exceed Ve is applicable for all of them but as stated earlier, there is some other limitation follows. In the main text all velocity limitation would be considered.

Erosion Velocity

API RP 14E defines Erosion Velocity as below;

$$V_e = \frac{C}{\sqrt{\rho_m}} \quad \ldots. (1)$$

V_e: Fluid Erosion Velocity
C: Empirical Constant
ρ_m: Gas/Liquid mixture destiny at flowing pressure and temperature

While;

$$\rho_m = \frac{12409\ S_l P + 2.7 R\ S_g P}{198.7\ P + RTZ} \quad \ldots. (2)$$

P: Operating Pressure
S_l: liquid Specific Gravity @ standard condition
R: Gas/ Liquid Ratio, @ standard condition)
T: Operating temperature
S_g: Gas Specific Gravity (air =1 @ standard condition)
Z: Gas Compressibility Factor

API RP 14E doesn't exactly specified "C". Standard declares Industry experience indicates that for solids- free fluids values of C = 100 for continuous service and C = 125 for intermittent service are conservative. For solids-free fluids where corrosion is not anticipated or when corrosion is controlled by inhibition or by employing corrosion resistant alloys, values of C = 150 to 200 may be used for continuous service; values up to 250 have been used successfully for intermittent service. If solids production is anticipated, fluid velocities should be significantly reduced, Different values of C may be used where specific application studies have shown them to be appropriate.

Where solids and/or corrosive contaminants are present or where C values higher than 100 for continuous service are used, periodic surveys to assess pipe wall thickness should be considered.

Gas Velocity Equation

Most common equation to calculate Gas Velocity inside pipe line is presented in API RP 14E as below; this equation offers realistic velocity measurement based on actual operational characteristics such as pressure, temperature, pipe ID and passing fluid quantity/ rate.

$$V_g = \frac{60\, Z\, Q_g T}{d_1^2\, p} \quad \ldots. (3)$$

While;

V_g: Gas Velocity
d_1: pipe Inside Diameter
Q_g: Gas Flow Rate, (@ 14.7 psi and 60°F)
T: operating Temperature
P: Operating Pressure
Z: Gas Compressibility Factor

Manufacturer Velocity Limitation

In Mehran Co. well testing departments three different categories of piping are in-service. These categories are listed below;

1- High Pressure Rigid Pipes which cope with pressure up to 10,000 psi. Includes flanged type and Grayloc® type connection pipes.
2- High Pressure Flexible Hose which copes with pressure up to 10,000 to 15,000 psi. Includes Technip brand Coflon type Coflexip®.
3- High Pressure Rigid Pipes which cope with pressure up to 2,000 to 5,000 psi. Including Weco Union connection by different figs and SCHs pipes.

First Category

First Category fabricated by AISI 4130 material SCH XXH or XXS. Thus no velocity limitation is applicable. Since these pipes are going to be used in upstream section of Coke Manifold which means existence of high pressure in the environment (greater than 3,000 psi) there is no concern to exceed velocity limitation at all.

Second category

Second category raises main discussion while operation is ongoing. To get familiar to the problem here it goes some preface to velocity limitation inside Technip brand Coflon type Coflexip®.

As per manufacturer, Coflon type Coflexip is made of 8 different layers which Thermoplastic inner liner makes the pipe leak-proof. This layer limits the upper service temperature of the line and the chemical compatibility to the various fluids which may be transported through the line. Various plastic materials are used to manufacture the inner liner, depending upon the service application of the liner. Mehran Co. well testing department uses Coflon as thermoplastic inner liner to be compatible with wide range of hydrocarbon, acid and chemicals and cover higher range of temperature up to 250 °F. but regarding velocity limitation inside this Coflon layer and according to manufacturer recommended practice maximum flow rate for all smooth bore thermoplastic inner sheathed lines shall not exceed 15 meter per second (49 ft. per second).

This obligation confines exceeding velocity over 49 ft. per second even if erosion velocity is much higher than gas velocity which might exceed 49 ft. per second.

Third Category

Third Category includes high Pressure Rigid Pipe by different SCHs. Mehran Co. hired a variety range of different pipe SCHs including pipe SCH 40, SCH 80 and SCH 160, all ASTM A 105 material and end connections are Weco unions in specified three figs, 206 for 6" pipes, 602 for 4" & 3" pipes even 1502 for 4" & 3" pipes. Since Mehran Co. well testing department experts in high rate offshore operation, sufficient "Flow Restrictors" are already provided to minimize erosion effects on downstream piping. Main concern in these pipes is to not exceed erosion velocity while flaring. Erosion velocity and actual velocity measurement are based on API RP 14E standard expressed above. Even if in some cases erosional velocity has been exceeded due to some unavoidable operational difficulties, extreme cautious must be considered by involved personnel and also a thickness test shall be performed ASAP.

Canadian IRP4 Standards Recommended Limitation

According to Well Testing and Fluid Handling, an Industry Recommended Practice (IRP) for the Canadian Oil and Gas Industry Volume 4- 2012 section 4.0.13.18, Maximum gas velocity inside downstream piping on sweet gas and sour wells which contains less than 1% H_2S, must not exceed 331.4 m/s (1087 ft./s). Also gas velocity inside downstream piping on sour gas with H_2S greater than 1% should not exceed 95.4 m/s (313 ft./s) or be less than 10.6 m/s (35 ft./s).

As declared in IRP4 even if actual velocity is not going to exceed erosion velocity, in presence of sweet gas or sour gas with less than 1% H_2S, shall not exceed 1087 ft. /s either. For higher H_2S concentration actual velocity must not deceed 35 ft. /s and not exceeds 313 ft. /s.

This Industrial Recommended Practice doesn't specify the piping material or being in-service duration. Thus it seems to be applicable for all situations and continuous or interrupted services by considering a conservative perspective.

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