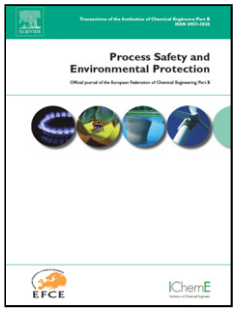

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PII: S0957-5820(18)30427-0
DOI: https://doi.org/10.1016/j.psep.2018.06.039
Reference: PSEP 1441

To appear in: *Process Safety and Environment Protection*

Received date: 13-4-2018
Revised date: 20-6-2018
Accepted date: 30-6-2018

Please cite this article as: Wang, Qianlin, Zhang, Laibin, Hu, Jinqiu, Real-time risk assessment of casing-failure incidents in a whole fracturing process.Process Safety and Environment Protection https://doi.org/10.1016/j.psep.2018.06.039

Real-time risk assessment of casing-failure incidents in a whole fracturing process

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Highlights

- Risk assessment is essential to prevent casing-failure incidents in the fracturing.
- A matrix-based and real-time risk assessment method is put forward.
- Static and dynamic failure probabilities are integrated using the design matrix.
- This method improves assessment accuracy and is more in line with on-site conditions.

Abstract: With the increasing development of hydraulic fracturing technologies, shale gas exploitation is becoming a highly industrial process. Casing-failure incidents which could cause serious leakage of the high-pressure and hazardous chemicals have triggered an intense public discussion in the fracturing industry. Quantitative risk analysis (QRA) is a common technique used to study the carrying capacity of a casing. However, this technique tends to only show static risk state after the casing has been run down to the formation, but is not sufficient to monitor its real-time failure risk during the whole fracturing process. Therefore, a matrix-based risk assessment method is proposed to improve the conventional QRA by using stress-strength interference theory and value function modelling to calculate the static and dynamic failure probabilities of casings, respectively, over a period of multi-stage sand fracturing. Further studies are developed to integrate these two probabilities with the application of a design matrix, particularly for the quantitative analysis and assessment of casing failures. The visual risk graphs are also provided to show the failure risk states and levels for the casings in real time. The assessment procedures can clearly delineate the operation characteristics of shale gas fracturing – high pressure, large displacement, and sand erosion. To illustrate the validity of the methodology, a production casing of a gas well at one fracturing stage is chosen as a test case. Results show that the real-time risk is more accurate and practical, as well as improving the assessment effectiveness of casing-failure incidents during a whole fracturing period.
Keywords: casing failure; real-time risk assessment; shale gas fracturing; risk matrix; design matrix

1. Introduction

Shale gas exploitation using hydraulic fracturing, a recently introduced technique, has spurred exponential growth of gas well drilling and significantly improved the production of natural gas by stimulating fluid flow from wells (Rahm, 2011; Vengosha et al., 2013). This has resulted in it having become increasingly a highly industrial process using hazardous chemicals, flammable materials, and heavy equipment. In particular, it has become well accepted that fracturing casings are essential for this resource-intense exploitation and its stable and safe operations (Middleton et al., 2013; Feng et al., 2016). However, recent findings have illustrated casing-failure incidents.

For example, from 1998 to 2011, casing failures occurred in 11 out of the 18 wells in the Ann Mag Field, South Texas: 61% of the wells had casing collapse, 8% experienced casing parting, and the remaining 31% had fill or sand production problems (Yuan et al., 2013). Most (62%) of the casing-failure wells were located in the shale zones. In another example, in the Pennsylvania Marcellus field, there were 97, 140, and 120 failed wells between 2010 and 2012, at failure rates of 6%, 7.1%, and 8.9%, respectively, and these casings were subjected to the loss of integrity which was noted in inspection comments (Ingraffea et al., 2014).

Generally, casings are increasingly damaged or deformed due to multiple, periodic load spectra. In shale gas