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Reliability Analysis of Opukushi Seibou Oil Field Flowline Against Corrosion Failure

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ABSTRACT:

The aim of this paper was to examine the effect of corrosion on Opukushi Seibou Oil field flowline and also evaluate the reliability of the flowline. The corrosion failure is as a result of absence of corrosion inhibitor in Well 24T 6 inches flowline pipe. The first order reliability method analysis using Weibull distribution model was developed in python computer program, to analyze data of the corroded pipe. Piping dimensions from the field were obtained in imperial units for this research computer program and final results in SI units. Thickness of pipe t_2 is 7.11mm, the depth of corrosion d is 5.588mm, longitudinal length L of corrosion is 305.05mm and operating pressure of the flowline P_o is 8.49Mpa. Standard ASME code that relates extent of corrosion to the burst pressure of a corroded pipe was used to carry out a Monte Carlo Simulation for the burst pressure. Assumptions were made for corrosion longitudinal length and depth to take up the shape of a normal exponential distribution. The random value generated simulated random event that could happen at any point in the pipe. Two thousand (2000) samples were iterated using the python program to obtain results. For each sample generated the values of d and L were substituted into the equation for burst pressure as per ASME B31. The Two thousand (2000) equivalent samples for the burst pressure resolved from the Monte Carlos random sample for d and L were plotted. The shape of the distribution is in form of a Weibull distribution, which was used to calculate the probability that the pipe burst pressure is greater than the operating pressure of the pipe($P_b > 8.49MPA$). The resulting probability of 68% from a Weibull distribution of scale factor was equal to 0.0556MPA and shape parameter of 1.849(no unit), showed that the pipe was not reliable, indicating that at the present condition of the pipe it will not survive 10 more years without getting damaged.

KEYWORDS: First order reliability model, Weibull distribution, Pipe burst pressure, Pipeline reliability, Monte Carlo simulation.

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1. INTRODUCTION:

Over the past years, there has been increase demand in Hydrocarbon gas with fluctuating demand for crude oil, which has lost its price stability globally. An increased demand for Gas producing facilities to supply more products giving rise to more pipeline construction and maintenance, to transport hydrocarbons to process facilities. Opukushi Seibou oil fields Flowline reliability analysis is a case study of this work to support SPDC TUNU Gas plant process facility. Also, buried flowlines in this terrain are mostly affected by corrosion, which occurs as a result of transported hydrocarbon fluid reacting with the internal walls of the steel pipe, which leads to pipe burst, which causes spillage to the environment.

The 6 inches line was first installed to last for 30 years but due to the effect of CO_2 corrosion, leakage was observed in the pipe after 20 years. The existence of a leakage in the pipe could be a random situation due to flowline parameters like pressure, content, and temperature. This corrosion threats are to be put in check by ensuring there is a need to carryout flowline reliability analysis on Opukushi Seibou flowlines to avoid failure and estimate useful operation life. According to Nayyar (2000), piping systems are like arteries and vein used to transport hydrocarbon fluid.

Opukushi Seibou fields are SPDC Onshore Swamp facility located in Ekeremor Local government Area of Bayelsa state. The Opukushi Seibou Wellheads are in different clusters and flows in different strings. While Opukushi Well 24T is in Egbemo-Angalabiliri and Agbidiama. Communities. Opukushi Seibou Wells are Hydrocarbon Wells with Associated gas, which is part of Southern Swamp Associated Gas Gathering project to feed TUNU NODE Gas plant and Flow stations, operated by Shell Petroleum Development Company. Opukushi well 24T is a 4km Flowline, which cuts across the earlier mentioned communities, the hydrocarbon is transported via a 6'' line to Opukushi Flow station and Booster compressor station, then finally to TUNU Gas plant.

The adopted approach of solving this flowline corrosion failure is by using First Order Reliability Method (FORM), modeled in python to solve complex integrals and do sample iterations to estimate the flowline useful operational life and the use of corrosion inhibitors as control to slow the effects of internal corrosion in the pipe.

According to Richard *et al.* (2016), hydrocarbon exploration and storage has been highlighted as the most common energy source that enables the continuous use of fossil-fueled power stations through the abatement of carbon (iv) oxide. Field corrosion work experience in combination with laboratory results methodology was used to achieve a complete cycle of Carbon Capture storage, as it relates to natural dense phase CO_2 and the degradation process in anthropogenic impurities. It was concluded that as pipelines encounters CO_2 and Hydrogen induced corrosion cracking, various corrosion mitigation techniques (corrosion inhibitors, cathodic protection) are used to put control and solutions to this issue.

Weimin *et al.* (2018) asserted that based on corroded pipe sections failure analysis, laboratory exposure test method was used to carry out simulation of three likely corrosion environments inside a gas pipeline. The indicated corrosion rate by depth change was adopted in this research. Electron scanning microscopy and X-ray diffraction were used to analyze corrosion products. Results showed that the specimens completely wet in condensate water were generally corroded and the gas exposed specimens were locally corroded.

A research by Chen and Wu(2015) examined and analyzed a typical buried underground pipe in the street. An offcut pipeline sample were taken for corrosion inspection and rate of material degradation. The reliability of the pipeline was calculated, based on mechanical analysis, an established limit state function, relative variables like road traffic, internal operation pressure and corrosion considered. In addition, axial and radial stress on the pipeline were taken into account. Moreover, this was successfully calculated using the Monte Carlo model method with MATLAB. Results from the reliability analysis carried out, shows that the pipe has existed for 27 years and in a speedy rate of decline, which is a threat to the safety of the pipeline operation. According to Nayyar (2000), pipeline components are special piping accessories namely pipes, flanges, blinds, valves, gaskets, cathodic insulators, elbows and bends.

This work considered only the following peculiar factors; corrosion, condition of flowline, material toughness and type of weld/supervision, to be affecting the reliability of Opukushi Seibou flowline, particularly Well 24T.

i. CO_2 corrosion impact were noticed on the flowline from the information provided by the facility owner.

ii. Flowline condition observation showed that the pipes are of age while on storage before they were finally installed for operation.

iii. Material selection was a major quality concern, considering if it met the required specification.

iv. Type of weld/supervision used were butt weld according to clients Design and Engineering Procedure, subject to welders WPS, WQT and ITP.

In this paper, reliability analysis of a hydrocarbon production flow line was carried out. This was done by achieving the objectives of finding the causes of flowline corrosion using first Order Reliability Method (FORM) and analysing the reliability of the corroded pipe to determine if the same pipe can survive steady operational years.

Sharif and Pirali (2020) worked on reliability assessment of offshore pipeline due to pitting corrosion, which is one of the most common types of corrosion that cannot be easily detected. Pitting decreases the pipeline strength and internal wall thickness against loads during operation and environment. The first-order approximation and sampling method based on different pressure models was used to investigate the most common reliability methods for estimating the maximum depth of pitting and the effect of internal pressure on the remaining strength of corroded pipelines at different times in the pipeline service operational life. After carrying out reliability analysis on two pipeline classes and two different pipeline wall thickness, they concluded that the increase in pipeline wall thickness had more effect on decreasing the failure probability of the pipeline than using a pipeline with a higher classification.

Huo *et al.* (2019) carried out a Non-probabilistic time-varying reliability-based analysis of corroded pipeline considering the interaction of multiple uncertainty variables for integrity and safe operation of pipeline infrastructure, the mechanical properties of pipeline with corrosion failure deterioration caused by long effect of corrosion expansion. Quasi-static analysis method and non-probability theory model were used to access corroded pipelines with corrosion growth. The result of the analysis indicated that the interaction of corroded pipeline has a negligible impact on reliability. It also gave a theoretical basis for maintenance and was of great significance for risk and reliability informed decisions regarding underground hydrocarbon pipelines.

2. MATERIALS AND METHODS

2.1 Materials for Data Collection:

Materials used for this research are flowline offcut and hydrostatic testing accessories.

2.2 Sources of Data:

Primary and secondary sources were utilized.

Primary Data

Primary data were obtained through site visit, log sheets, interview with the facility owners and people from the host community.

Secondary Data

Review of existing literatures on pipeline reliability analysis was useful and used as a guide. Sources of data include client internal publications, relevant internet engineering sources, journals, magazines and periodicals.

2.3 Methods:

The following methods were used to achieve the research objectives.

(i) Mobilized leak search and pipeline repair materials and equipment on site.

(i) A reliability analysis was carried out on the flow line pipe to determine if it can be in service for 10 more years.

(ii) First Order Reliability Method was used to accurately calculate the reliability of the pipe.
(iii)A computer program written in python was used to perform iteration involving complex integrals.

2.3.1Reliability Analysis:

The reliability analysis was done by considering the given the geometric condition of the CO□ corrosion noticed as the pipe has corroded for about 20 years. Equation to model the statistical distributions includes those found in ASME B31G which explains that operating pressure is greater than burst pressure and this is given as

$$P_b = 1.1P_m \left[\frac{1-\frac{2}{3}\left(\frac{d}{t}\right)}{1-\frac{2}{3}\left(\frac{d}{t\sqrt{A^2+1}}\right)} \right] \quad (1)$$

$$P_m = \frac{2\sigma t}{D_o} \times FET \quad (2)$$

$$0.1t < d < 0.8t \quad (3)$$

$$A = 0.893\left(\frac{L}{\sqrt{D_o t}}\right) \quad (4)$$

Where:
P_b = Burst pressure of corrode pipe
P_m = Max allowable operating pressure
d = Corrosion depth
t = Thickness of pipe
A = Corroded area
σ = Yield strength of material
D_o = Outer diameter
L = Longitudinal length of corrosion
F = Design factor based on ASME B31.8
T = Temp derating factor as per ASME code
E = Longitudinal joint factor as per ASME B31.8

2.3.2 Normal distribution

The normal distribution is a type of distribution in which the mean on the x-axis is the highest point on the y-axis. It is a symmetrical bell shape curve, it deviates outwardly from both sides of mean in the middle (mean is at 50%) following the normal 65%, 95% and 99.7% rule.
The Probability Density Function (PDF) is given as

$$F(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}} \quad (5)$$

Where
F (x) = Probability density function
x = arbitrary value in a sample data
μ = mean of the sample data
σ = variance of sample data

The integral of Equation (5) from zero to infinity gives the Cumulative Distribution Function (CDF) which equates to 1, representing the probability that P(x<∞) =1 (100%).
This is proven as follows:

$$P_f = P(X < \infty) = \int_0^\infty F(x)\, dx \quad (6)$$

Where:
P_f = Probability of failure
∞ = infinity

$$P_f = \frac{1}{\sqrt{2\pi\sigma^2}} \int_0^\infty e^{-\frac{(x-\mu)^2}{2\sigma^2}}\, dx \quad (7)$$

Let,

$$u = \frac{x-\mu}{\sqrt{2}\sigma}$$

Equation (7) becomes

$$= \frac{1}{\sqrt{2\pi\sigma^2}} \int_0^\infty e^{-u^2}\, dx \quad (8)$$

Integrating the Gaussian integral above gives:

$$P(X < \infty) = \frac{1}{\sqrt{2\pi\sigma^2}} \times \sqrt{2\pi\sigma^2} = 1 \quad (9)$$

$$\therefore P(X < \infty) = 1 \quad (10)$$

Equation (10) shows the overall probability of X to be lesser than ∞ is 1.

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However, the general function for the CDF of *[x]* less any value *[a]* is given as:

$$P(x < a) = \frac{1}{2} erf\left(\frac{\sqrt{2}(-\mu+x)}{2\sigma}\right) + 0.5 \quad (11)$$

Error function (erf) is obtained when integrating the Gaussian integral in equation. This kind of integration is best done with the aid of a computer software. In this research python is used to perform complex mathematical operations using python software library.

2.3.3 Generation of Normal distribution sample data

The table for the normal distribution is formed with the following parameters

s_i = Sample start value in

d_i = Density of sample, the lesser the value the more accurate the analysis becomes

$\bar{x}$ = Mean value in

σ = Standard deviation in

Steps for generating the sample in any program can follow the algorithm below,

If σ (Standard deviation) is not known then σ can be derive using:

$$\sigma = \frac{0.68}{2} \times \bar{x} \quad (12)$$

The number of samples to be generated is derived as follows

$$\text{no of samples} = \frac{s_i}{d_i} \times 2 \quad (13)$$

Generate density values that starts from s_i to $-s_i$.

The density values follow an arithmetic progression with a difference equal to di as expressed in Equation (14)

$$\{s_i, s_i - d_i, s_i - 2d_i, \cdots, s_i - (n-1)d, \cdots, -s_i\} \quad (14)$$

Generate x-values for the normal distribution function Equation (6) and Equation (11) as follows:

The term $x_1$is defined as:

$$x_1 = \bar{x} - (\sigma \times s_i) \quad (15)$$

The below terms are derived in this sequence

$$\{x_1, x_1 + (\sigma \times s_i), \cdots, x_{n-1} + (\sigma \times s_i)\} (16)$$

Generate the normal distribution values, F(x) and the cumulative distribution P (x < a) with Equation (5) and Equation (11).

2.3.4 Weibull Distribution.

The Weibull distribution is an exponential distribution depending on its parameters.

$$P(x{:}\,\eta,\beta) = 1 - e^{-\left(\frac{x}{\eta}\right)^{\beta}} \quad (17)$$

When γ=0, the three parameter Weibull distribution becomes a two parameter Weibull distribution, the shape parameter (β) of a Weibull distribution determines the shape of the Weibull distribution, varying the value of η and β can also change the skewness of the Weibull. The Probability Density Function (PDF) of a Weibull distribution is obtained by differentiating the CDF function P(x) as follows

$$F(x;\eta,\beta) = \frac{dP(x{:}\,\eta,\beta)}{dx} = \frac{\beta}{\eta}\left(\frac{x}{\eta}\right)^{\beta-1} e^{-\left(\frac{x}{\beta}\right)^{\beta}} (18)$$

with the aid of the research computer software the inverse of an error function can be obtained in Equation (19) as follows

$$\beta_i = -1.4142135623731\sigma \times erfinv(1.0 - 2.0P_f) + \mu \quad (19)$$

2.3.5 Weibull Matching Data of Samples

In deriving the table of values, data samples can be handled in groups, since Weibull is easier to manipulate when the number increases from zero and exact values are matched to new number series.

$$5677 - 5676 = 1.$$

Based on the arithmetic progression,
a = First term of progression
d = difference
Weibull distribution formula used is.

$$w_x = \frac{(x-a)}{d} \qquad (20)$$

Example, to find Weibull match for 5690 in the example using above the equation (19) is as follows

$$x = 5690, a = 5676, d = 1$$

$$w_x = \frac{(5690 - 5676)}{1} = 14$$

2.4 Reliability of pipe:

The reliability of the pipe is related to Equation (1) in the sense that for the pipe to be considered reliable or safe Pb must be greater than the operating pressure Po. Therefore, the probability factor (Pf) is given as:

$$P_f = P(g(x) < 0) = \int_0^{g(x)} F(x; \eta, \beta) dx \qquad (21)$$

$$P_f = P(g(x) < 0) = P(x: \eta, \beta) \qquad (22)$$

$$g(x) = P_b - P_o \qquad (23)$$

Substituting equation 1 and 2 into equation 23

$$g(x) = \frac{2.2\sigma Ft}{D}\left[\frac{1-\frac{2}{3}\left(\frac{d}{t}\right)}{1-\frac{2}{3}\left(\frac{d}{t\sqrt{A^2+1}}\right)}\right] - P_o \qquad (24)$$

2.4.1 Monte Carlo Simulation

Monte Carlo principle consists of solving various complex mathematical problems via the construction of some random procedure for each problem, with the parameters of the system equal to the required quantity of the problem.
Based on Equation (24), a Monte Carlo simulation can be used to generate random values for d and L based on the mean and predicted deviation σ of the data obtained from site, the generated sample can be used to plot a Normal distribution for every value of L and d generated. To simulate real life random application the random values of P_f can be used to derive first and second term:

i. Since σ is not given then; $\sigma = \frac{0.68}{2} \times 12.008 = 4.09in$ as stated in equation (12)
ii. no of samples $= \frac{4}{0.1} \times 2 = 80$ samples
iii. 80 samples of the density values are generated using Equation (14), also the list below was generated from the python algorithm written to perform the operation.
iv. {4.0, 3.9, 3.8, 3.7, 3.6, 3.5, 3.4, 3.3, 3.2, 3.1, 3.0, 2.9, 2.8, 2.7, 2.6, 2.5, 2.4, 2.3, 2.2, 2.1, 2.0, 1.9,
v. The x-values for L are generated using Equation (15) to get the first term and equation (16) for the second term: The first term x_1 is derived as: $x_1 = 12.008 - (4.09 \times 4) = -4.352$see Equation (15). The remaining terms are obtained using Equation (16) {-4.323, -3.915, -3.507, -3.099, -2.691, -2.283, -

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1.875, -1.467, -1.059, -0.651, -0.243, 0.165, 0.573,

vi. The normal distribution values are generated using Equation (5) F(x) ={3.28e-06, 4.86e-06, 7.15e-06, 1.04e-05, 1.5e-05, 2.14e-05, 3.01e-05, 4.21e-05, 5.83e-05, 0.000692, 0.000867, 0.00107, 0.00132, 0.0016,
The cumulative distribution values P (x < a) are generated using Equation (11). {0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.001, 0.001, 0.998, 0.999, 0.999, 0.999, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0}

3. RESULTS AND DISCUSSION

Results for all calculations are then tabulated as an output of the python algorithm following the table format in Table1. However, x, F(x) and P (x < a) becomes L, F (L) and P (L < a).

Field Data
Flowline operating pressure,
P_o = 1231.13lbf/in^2
Pipe thickness, t = 0.28in
Outer diameter, D_o = 6.625in
Depth of corroded pipe, d = 0.217in
Longitudinal length of corrosion,
L = 12.008in
Max operating temperature, T_m = 45^{o}C
Using Equation 2, to obtain Max operating pressure
σ = 3500 lbf/in^2
F = 0.80
D_o = 6.625in
t = 0.28in
T = 1
E = 1

$$P_m = \frac{2 \times 35000 \times 0.80 \times 0.28 \times 1 \times 1}{6.625}$$

P_m = 2366.791lbf/in^2 (16.32Mpa)

Also use Equation 4, to obtain Area of corroded pipe.

$$A = 0.893\left(\frac{12.008(in)}{\sqrt{6.625 \times 0.28(in^2)}}\right)$$

A = 7.873in^2 (0.1999m^2)

Table 1 Normal Distribution Data Sample for Lm

S/N	Sample(si)	Length(L) (in)	Nominal Distribution F(L)	Cumulative distribution P(L<a)
1	3.9	-3.915	0.000004864	0
2	3.8	-3.507	0.000007146	0
3	3.7	-3.099	0.0000104	0

Table 1 is the table that gives a summary of the entire steps carried out using the normal distribution function and cumulative distribution function. Two plots are made for F(x) vs x and P (x < a) vs x to show the distribution

Table 2 Normal Distribution for

S/N	Sample (Si)	Depth(d) (in)	Norm. Dist Function F(d)	Cumulative Function P(d<a)
1	3.9	-0.071	0.000266	0
2	3.8	-0.064	0.000383	0
3	3.7	-0.057	0.000547	0

The data in Table 2 is used to plot the graphs in Figure 3 and Figure 4 for normal distribution versus corrosion depth and cumulative distribution versus corrosion depth respectively

3.1 Matching plot to a Weibull distribution.

The process in Table 2 is done with a loop that keeps running and randomly changing the value for β and η until T_2 matches T_3 to some degree. The best match for the generated sample is obtained at η = [8.077] and β = [1.849].

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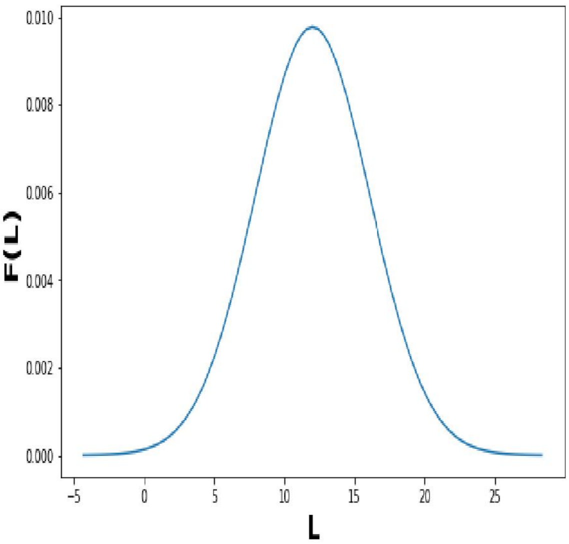
Table 2 Table of Values for Burst Pressure Weibull distribution

	x	bins	m	freq	m× f	%freq	F (x: η:β)	F(x: η:β) ×bins	P (x: η:β)
1	0	1177	1172	0	0	0	0	0	0
2	1	1187	1182	4	4728	0.002	0.0274	33	0.0141
Total				1804	2E+06		1253		
Compare				T_2=	1265	T_3=	1252		

Normal distribution F (L)



Length (L)

Figure 1 Normal Distribution Plot for Longitudinal Length

3.2Depth of corrosion

distribution The Depth of corrosion also follows a

$$\sigma = \frac{0.68}{2} \times 0.217 = 0.074in$$

normal distribution just like that of the Longitudinal Length Distribution. However, some parameter values change to the data relating to the depth of corrosion.

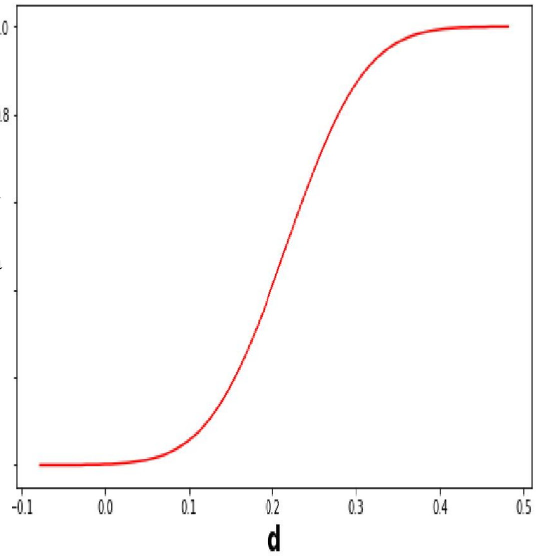
$s_i = 4$ (chosen value to generate sample)

$d_i = 0.1$ (chosen value to generate sample)

$\bar{x} = L = 0.217$in.

Follow all the mathematical steps in equation (12), beginning from sections (ii) to (iv) and Table 2 to generate graph of P (d<a) against depth of corrosion

Cumulative distribution P (d



Corrosion depth (d)

Figure 2 Cumulative Distribution Plot for corrosion depth (d)

Weibull Distribution of Pipe reliability.

To know the kind of distribution the values of P_b can take when plotted, Equation (23) is used to find theprobability index of a randomly generated probability value, this is called a Monte Carlo simulation and the probability index can be derived with Equation (19)

3.4 Burst Pressure Probability Distribution

Monte Carlos simulation is used to generate the random values for *[d]* and *[L]* using Equation 12 Consider Table 1, if any value like the 36th number under column L is selected to find the probability of having a longitudinal length of corrosion equal to or less than 10.365 inches, the probability for P(L < 10.365) = 0.344 (34.4%) as shown in the table.

However, Probability index *[β_i]*, is obtained when Equation (23) is used in substituting the probability value in place of P_f shown as follows: σ = 4.09in, μ = 12.008in, P_f = 0.50,

$$\beta_i = -1.4142135623731 \times 4.09 \times erfinv(1.0 - 2.0 \times 0.50) + 12.008 = 12.008$$

$$\beta_i = 12.008in\ (305.00mm)$$

As expected β_i = 12.008in because the mean is always at 50% for a standard normal distribution. This can be confirmed by using Table 1 and interpolating between 0.499 and 0.539 of column P(L<a). However, to reduce the time spent in calculating β_i a python program is used to perform the calculation many times for the Monte Carlo simulation by generating β_i for the Longitudinal length of corrosion and the depth of corrosion the randomly generated values are then plugged into an equation to solve for the burst pressure P_b in Figure 3. Using a python program, the sample data for the burst pressure distribution for different corrosion depths and longitudinal length are selected randomly. The data is the distribution obtained from the Monte Carlo simulation.

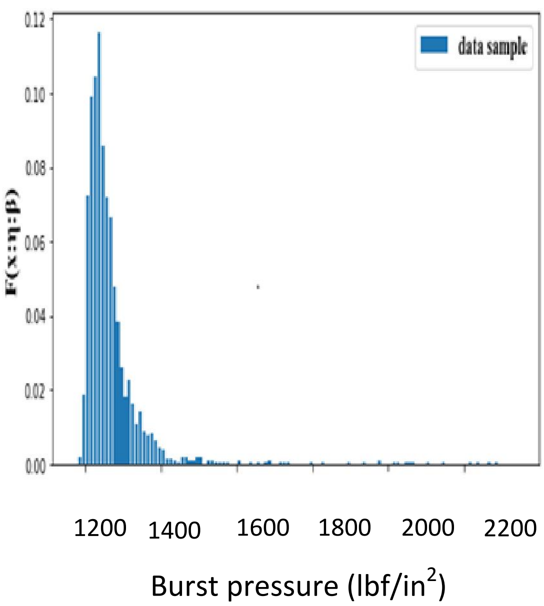


Figure 3 Monte Carlo Simulation of PDF vs Burst Pressure

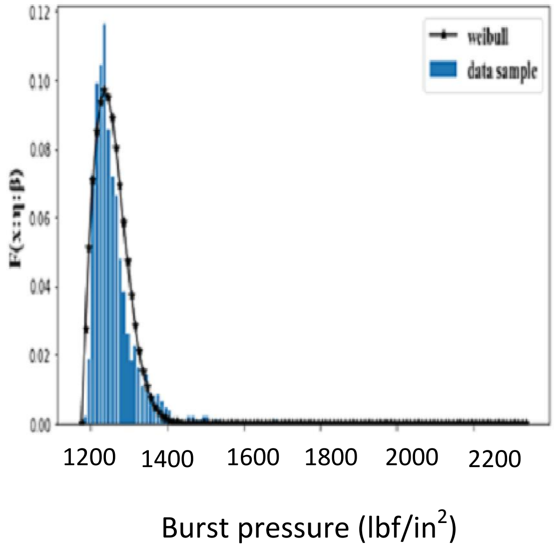


Figure 4 Burst pressure

In the graph figure 4 the Weibull plot is matched to the sample data bar plot. In order to get similar shape, the python program iterates until the best match is found.

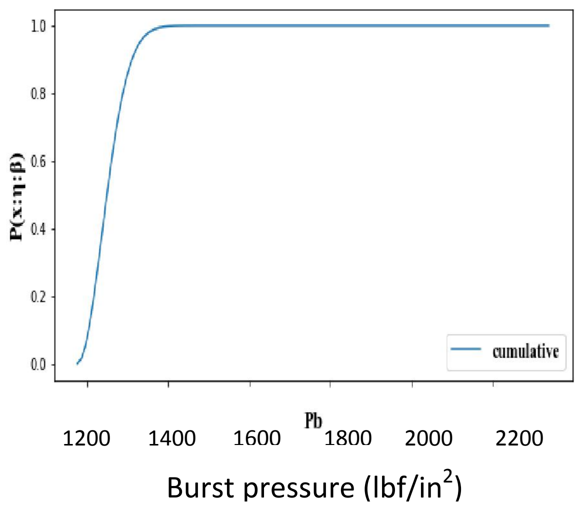


Figure 5 Weibull Cumulative vs Burst Pressure

To match the data to the Weibull distribution, Table 2 is used as template for matching. Based on the last row of Table 3, the best match is found when T_2 = 1259 and T3 = 1239. Table 3 also contains the values used to plot the cumulative frequency distribution (P (x: η: β) vs P_b), The variable P_b is represented by the bins in Table 3.

3.6 Reliability of corroded pipe at operating pressure.

The probability of any corroded pipe is derived using Equation (23). It represents the probability that g(x) is less than zero. Where, $g(x) = P_b - P_o$, and P_b is represented by the bins column. The probability that $g(x) < 0$ is the same as the probability $P_b < P_o$, meaning that the probability of the burst pressure is less than the operating pressure is the failure region. While $P_b = P_o$ is the surface region of the probability plot, $P_b > P_o$ is considered as the safe region.
In reference to section, the bins data in Table 3 are grouped with a difference [d] in Equation 10. The first term [a] of the bins is the first number in the bins column which is 1177 lbf/in^2 the match pair for the Weibull distribution is 0 on the x column. Follow equation (19), to find the probability that the burst pressure is less than $x = 1231.13 lbf/in^2$

,

$$a = 1177 lbf/in^2$$

,

$$d = 10\text{units}$$

$$w_x = \frac{(1231.13 - 1177)}{10} = 5.413$$

Therefore, to find the probability x in equation (17) is equal to w_x for the Weibull distribution.
Where:
$\eta = 8.753$,
$\beta = 1.9626$,
$x = w_x = 5.413$

$$P(P_b < P_o) = P(P_b < 1231.13) = 1 - e^{-\left(\frac{5.413}{8.753}\right)^{1.9626}}$$

$$P(P_b < P_o) = P(P_b < 1231.13) = 0.32252 = 32\%$$

Thus, the probability that the pipe will not fail is

$$P(P_b > 1231.13) = 100 - P(P_b < 1231.13)$$

$$P(P_b > 1231.13) = 100 - (P_b < 1231.13) = (100 - 32)\%$$

$$P(P_b > 1231.13) = 100 - (P_b < 1231.13) = 68\%$$

Based on the result the probability that the pipe will last up 30 years after getting corroded for 20 years is 68%. This could mean that this same flowline could break down multiple times within the next 10 years.

4. CONCLUSION

From the study, the aim of the research which is to examine the effect of corrosion on Opukushi Seibou oil field flow line and the reliability of the pipe were achieved. The cause of flowline corrosion on Opukushi Seibou oil field particularly well 24T flowline were found to be CO_2 corrosion, which reduces the longevity of pipes and also affects flowline from operating at a high or set pressure. This was done based on the First Order reliability analysis and inspections performed.

The objective to determine if the pipe can survive steady operational years was also achieved. Here, we were able to predict that if the pipe can survive 10 more years based on its design, with a First Order Reliability Method carried out using Monte Carlo simulation to generate random data sample of the depth of corrosion and longitudinal length of corrosion. The distribution of depth of corrosion and longitudinal length of corrosion is a Normal distribution that affects the Burst pressure which takes the form of a Weibull distribution. Based on the analysis carried out, the probability of the 6 inches pipe to survive more operation is about 68%. This is very poor and would require future maintenance to be carried out. First Order Reliability Analysis was used to forecast pipe life expectancy. The input of this work recommendation should be to carryout flowline maintenance campaign for old pipes, to boost hydrocarbon production and support electricity generation for Tunu AGG plant.

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