

TechTalk

Assessing the suitability of Flexpipe's products for customer-specific cyclic applications



Outline

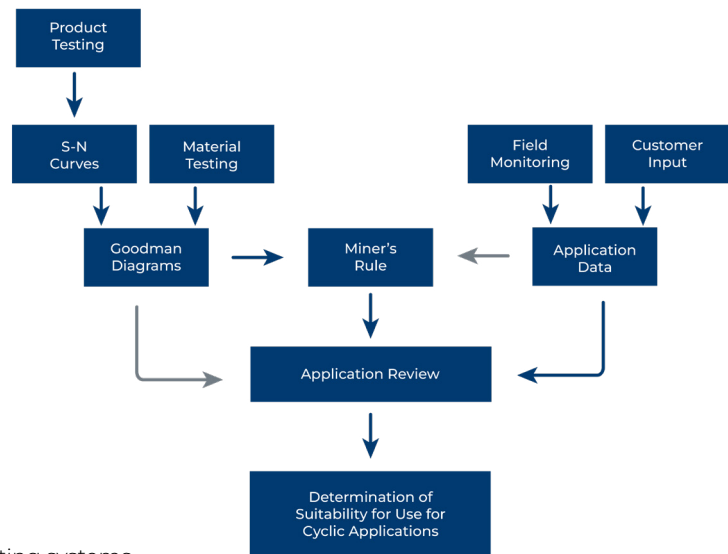
- Introduction
- Product Testing
- Material Testing
- Goodman Diagram
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- Summary

Please visit flexpipesystems.com for additional information.

This bulletin addresses Flexpipe's knowledge of cyclic applications and its expertise in assessing applications and recommending product suitability for specific applications.

With more than 82 million feet installed worldwide, Flexpipe is a leader in the spoolable composite pipeline industry.

The below flowchart shows a number of tools that Flexpipe uses to determine the suitability of a particular product for use in applications with pressure cycling or pulsations and for making a final recommendation to the customer.



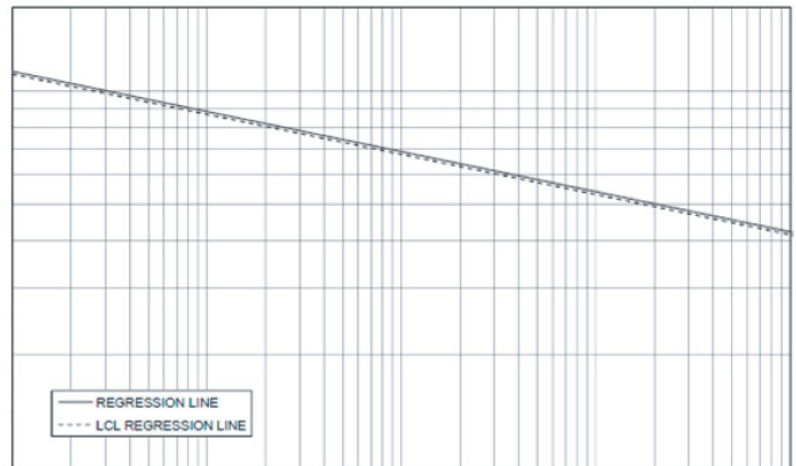
*For existing systems

Discussion

Flexpipe conducts a number of internal and external tests to validate the suitability of its products for different kinds of applications. Some of these tests that are relevant to applications with pressure cycling or pulsations include:

Product Testing

Full-scale linepipe testing: The pipe and fittings together are subjected to large-amplitude pressure cycles at the maximum allowable operating temperature of the product. The numbers of cycles to failure for each peak pressure are plotted in accordance with ASTM-D 2992 (Procedure A). The 95% lower confidence limit curve is determined from this data and used as the basis for determining the expected number of cycles to failure for full on/off cycles at a given pressure. Refer below to an example of S-N curve for Flexcord Linepipe 801 product:



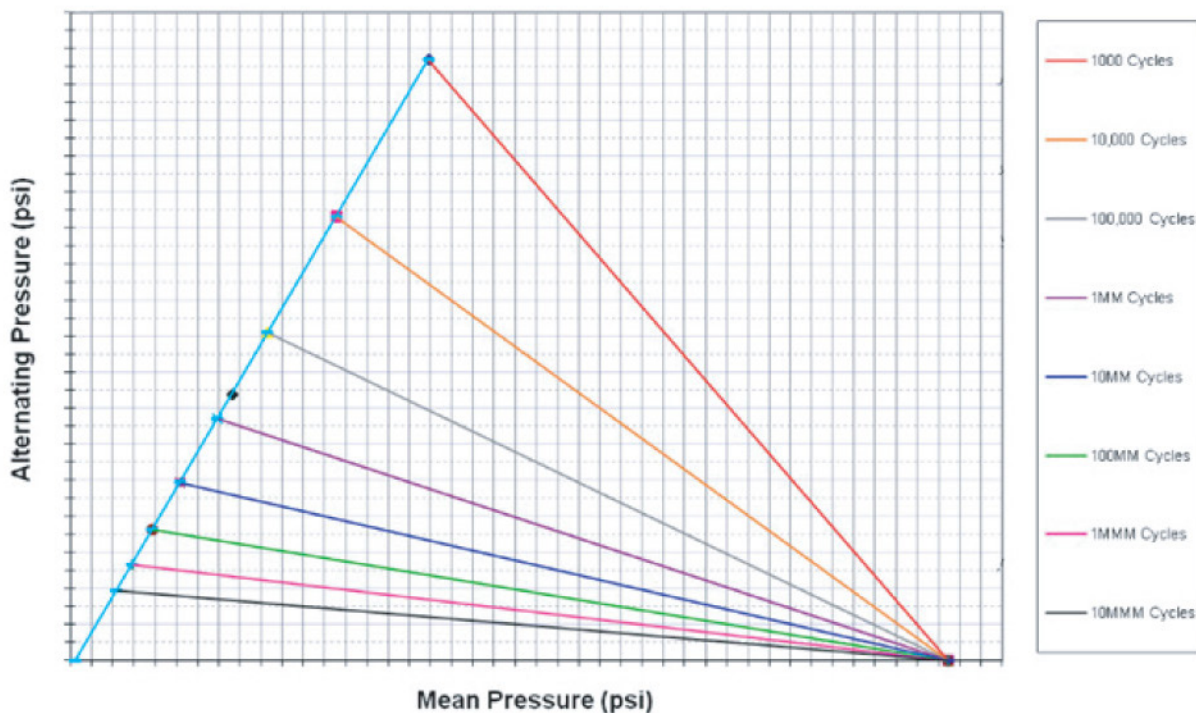
Material Testing

Fatigue testing on reinforcement materials: The fatigue testing is performed by third parties on galvanized steel cords at a variety of stress ratios of min/max stress. It has been conducted at high frequencies and includes tests up to 100 million cycles without failure.

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Goodman Diagram

Flexpipe, through its years of experience in product testing and cyclic research efforts, has collected hundreds of data points and developed Goodman Diagrams for different products to predict the cyclic life of each product. A Goodman Diagram has Mean Pressure as the X-axis, Alternating Pressure as the Y-axis and has linear profiles, which correspond to the number of cycles that a product can be subjected to at different combinations of mean and alternating pressures without failure. A Goodman Diagram is a powerful tool that allows evaluation of the life cycle, based on actual product test data, at any combination of mean pressure and alternating pressure. Flexpipe uses a Goodman Diagram in the Application Review process to determine the cycle life of a product and then applies a safety factor of at least 10 as per the API 17J requirement to calculate the number of cycles a product can be subjected to without failure over the desired service life. These calculations are then used to make a final recommendation to the customer on the suitability of a particular product for usage in a specific application. Refer below to an example of a Goodman Diagram for 3"-4" Flexcord Linepipe 801 product:



Miner's Rule

Often a system is subjected to different types of pressure cycles (e.g. high-frequency pulsations from piston pumps plus large-amplitude on/off cycles). In such cases, Flexpipe uses Miner's Rule to evaluate the combined effects of different types of loading cycles to calculate the cyclic life of a product.

Where:

n_i = number of loading cycles accumulated over lifetime

N_i = number of loading cycles to failure

Essentially, Miner's Rule states that if a system is subjected to many different types of loading cycles then the ratio n_i/N_i calculates the proportion of life consumed due to each different loading cycle. The rule predicts a safe application if the sum of all the ratios n_i/N_i is less than 1. Refer to an example below:

Miner's Rule:
$$\sum_{i=1}^k \frac{n_i}{N_i} \geq 1$$

$$\frac{\text{\# pulsations over lifetime} \times \text{S.F.}}{\text{\# pulsations to failure}} + \frac{\text{\# on/off cycles over lifetime} \times \text{S.F.}}{\text{\# on/off cycles to failure}} \geq 1$$

Application Data

Flexpipe Account Managers work closely with customers and collect inputs that directly feed into the application form. An application form is a detailed form that is used to collect information regarding the use of a pipeline system and includes information such as operating parameters, chemical exposure, pump/compressor operation, pressure fluctuations for pump jacks and for pumps/compressors.

Field Monitoring Data

Experience suggests that, at times, customers may not realize the severity of the cyclic pulsations that their pipelines are subject to. Flexpipe offers customers a service using field monitoring to gauge and assess the pressure cycles that their pipelines are subject to. A regular pressure gauge is not capable of measuring high frequency pressure pulsations. Therefore, Flexpipe uses a pulsation logging service developed in-house to record and plot pressure profiles for the customers' pipeline systems.



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The Field Monitoring System is a simple system that can be carried in a laptop bag. The pressure transducer is connected to a fitting and can be directly connected to an existing pipeline. The recorded information is then used to generate and analyze pressure profiles. The Field Monitoring System allows Flexpipe to offer the most suitable product for the customer's application.

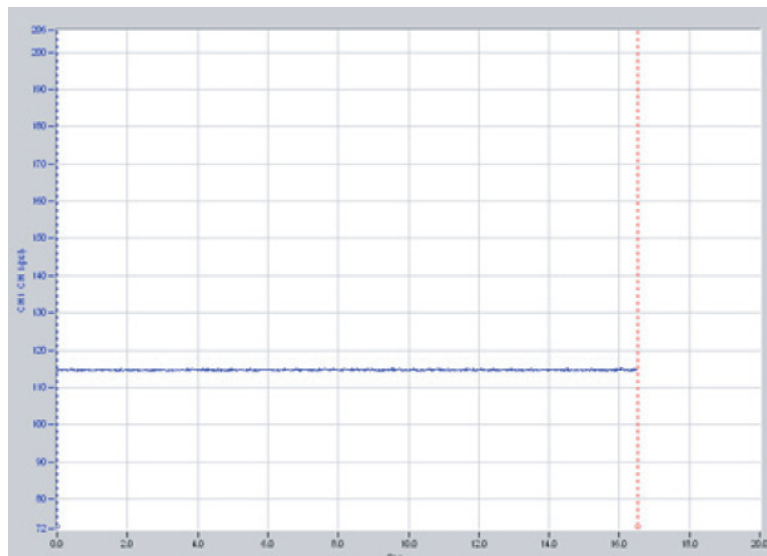
Application Review Procedure

Flexpipe's Application Review Procedure is an example of our strong commitment to reliability and customer satisfaction. The Application Review Form is reviewed by our Applications Engineering team to provide project specific recommendations regarding selection of the best product, optimal system design, and operational considerations for the intended application. The recommendations, specifically, regarding the suitability of a particular product for use in cyclic applications are based on a number of parameters such as:

Pump Types

One of the key parameters that are considered when evaluating the suitability of Flexipe Linepipe or Flexcord Linepipe for a cyclic service application is the type of pump. Different types of pumps generate different pressure cycles in a pipeline. Below is a comparison of pressure profiles for commonly used pumps:

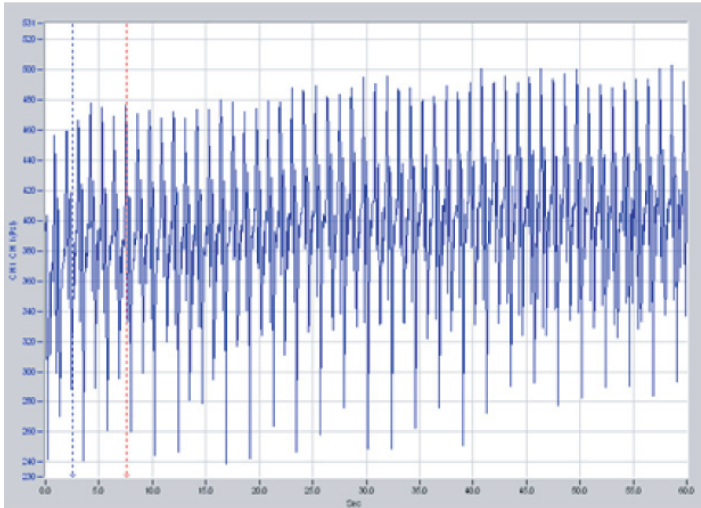
a) Centrifugal Pump



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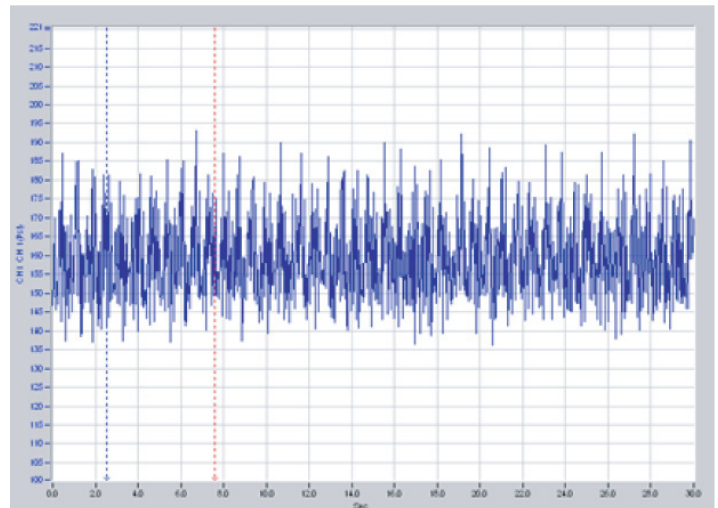
b) Positive Displacement Pumps

Duplex Pump



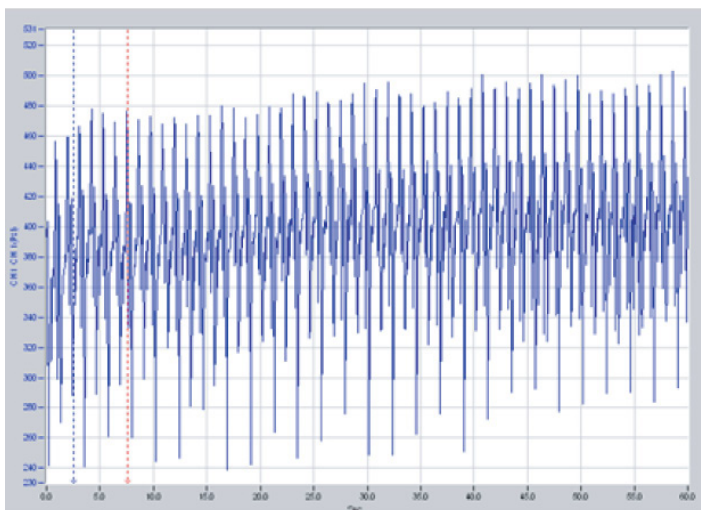
Pressure profile of a Duplex Pump that has a mean pressure of 390 psi but a peak-to-peak pulsation of 180 psi (46.2%) and a frequency of 60 cycles/min.

Triplex Pump



Pressure profile of a Triplex Pump that has a mean pressure of 160 psi but a peak-to-peak pulsation of 34 psi (21.3%) and a frequency of 120 cycles/min.

c) Diaphragm Pumps

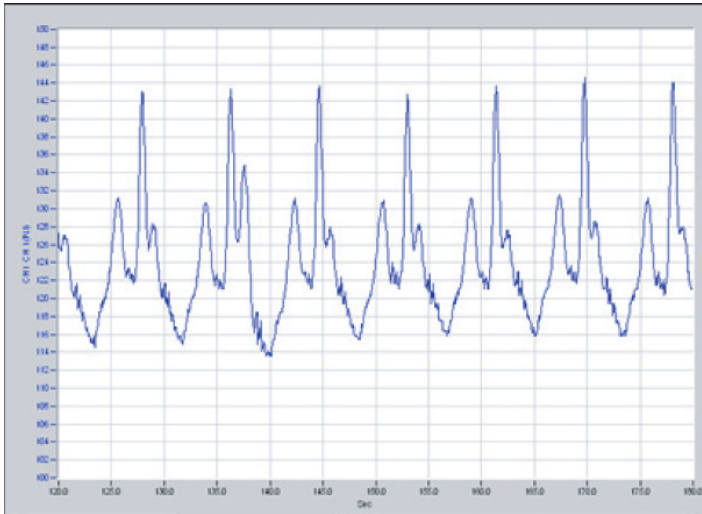


Pressure profile of a Diaphragm Pump that has a mean pressure of 130 psi but a peak to peak pulsation of 60 psi (46%) and an estimated frequency of 240 cycles/min.

The Positive Displacement pumps and Diaphragm pumps can generate substantial high frequency pressure pulsations and vibrations in a pipeline. Shawcor has specifically designed and tested Flexcord Linepipe product that is suitable to operate at full MAOP (2,000 psi), with high frequency 200 psi peak-to-peak pressure pulsations, combined with one full pressure on-off cycle/day.

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d) Pump Jacks



Pressure profile of a Pump Jack with an up-stroke pressure of 144 psi and a down-stroke pressure of 114 psi, with 7cycles/minute. The up-stroke to down-stroke differential is 30 psi.

FlexPipe Linepipe is suitable for the vast majority of pump jack applications where up-stroke to down-stroke differential is limited to 75 psig. For severe pump jack applications, where up-stroke to down-stroke differential exceeds 75 psig, Shawcor typically recommends the use of FlexCord Linepipe.

Summary

Pressure cycling is a common cause of linepipe failures. The pressure cycles can break down the structural integrity of various pipeline materials resulting in failures. Flexpipe has significant experience and knowledge of cyclic applications and combined with a robust application review process is able to recommend the most suitable product for the application.

Flexpipe provides a complete suite of products for applications ranging from steady pressure to severe pressure cycling. For applications where the system is subject to steady pressure, for example, in cases where centrifugal pumps, progressive cavity pumps, gear pumps etc. are used, Flexpipe typically recommends the use of Flexpipe Linepipe. Flexpipe Linepipe is a very good fit for the majority of applications with pump jacks, where up-stroke to down-stroke differential is limited to 75 psig.

On the other hand, Flexpipe typically recommends the use of Flexcord Linepipe for applications where the system is subject to severe cyclic pressure conditions such as applications where positive displacement pumps (Duplex, Triplex etc.) or aggressive pump jacks are used. Flexcord Linepipe is an excellent option for water transfer, Salt Water Disposal (SWD) and water injection lines.

Note: Refer to Cyclic Bulletin for further information.

Product data is subject to change without notice. Flexpipe's products are patented by US Patents 6,889,716, 6,902,205, 7,946,629 B2 and 8,042,252 B2 by Canada Patents 2,513,506, 2,513,468 and 2,562,823 and by European Patent 1592908. Additional patents are pending. ©Mattr Ltd., 2023.