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Proof of pipeline strength based on measurements of inspection pigs

Abstract:

The report is aimed at collecting and documenting the state of the art and the extensive know how of experts and pipeline operators with regard to judging the structural integrity of pipelines.

In order to assess the actual mechanical strength of pipelines based on measurement results obtained by inspection pigs, guidance is given for future processing, which eventually can be used as a basis for an industry standard.

A literature study of the commercially available types of inspection pigs describes and synoptically lists the respective pros and cons.

In essence the report comprises besides check lists of operating data for the pipeline and the pig runs mainly the evaluation of defects and respective calculating procedures. Included are recommendations regarding maintenance planning, verification of defects as well as repetition of pig runs.

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Summary

Since modern inspection pigs are able to not only locate pipeline defects but to also define their type and size, principally the possibility exists to differentially evaluate the test results.

Subject of the analysis of mechanical strength and life expectancy is the definition of the remaining strength of defective pipeline components and the calculation of the life span expectancy with regard to safe operation.

The purpose of this report was the collection of existing knowledge how defects found with inspection pigs are used to assess the mechanical strength of a pipeline and to also define time criteria for pig run intervals.

DGMK (German Society for Petroleum and Coal Science and Technology) ordered TÜV Süd Deutschland Bau und Betrieb GmbH, München and TÜV Anlagentechnik GmbH of TÜV Rheinland/Berlin-Brandenburg e.V. to describe pigging systems for the detection of wall thickness reductions, out of roundness, and cracks as a prerequisite to prove pipeline strength and to describe state of the art methods and criteria for the determination of safety and remaining life span of individual defective parts and of total pipeline systems based on the measurements of such inspection pigs.

The report differentiates between articles of generally valid aspects about how to judge defects and articles containing special calculating methods based on regulations and validations with the help of dimensionless indices. Both calculating methods are acknowledged among experts and are being shown in the report.

The procedure regarding inspection run intervals is being described separately.

In future every expert can obtain repeatable and comparable results based on the steps described in the report. The described procedure allows tolerances for pipe specific or defect peculiarities of a pipeline.

In order to judge the impact on integrity caused by the detected deviations from the original design a checklist has been prepared which lists the required documentation of pipeline and operating data.

In order to obtain reproducible results of high quality from a pig run another checklist summarises the requirements to be specified for a pig run.

The main part of the report comprises methods of rating defects. The following types of defects were investigated:

a) by TÜV Rheinland

- cracks
- roofing
- defects of shells
- defects of girth welds
- defects of longitudinal welds

b) by TÜV Bayern

- corrosion
- buckles
- oval shape
- lamination
- reduction of wall thickness (from manufacturing)
- plastic deformation

Uniform criteria were defined for each type of defect. The various report items were carried out responsibility only by the TÜV concerned.

Calculations of pipe stress and integrity assessment were conducted following two methods:

1. Based on Federal Standards (TÜV Bayern)

The calculation of stress in compliance with German standards implies standardized components which do not exceed the maximal allowed tolerances such as material specification and dimension. The calculation procedures are defined in the Federal technical rules and standards. Attention shall be given to the so called AD-Merkblatt S2 and DIN 2413.

2. Prediction of failure based on dimensionless indices (TÜV Rheinland)

The method is being mentioned in Standard 2413 as a possibility for life expectancy calculations for steel pipes with defects. With this procedure bursting and pressure change factors can be derived out it also allows longterm forecasts regarding probable failures, which can be used to develop time intervals for recurring pig runs. The method of forecasting is very accurate and is leads with regard to bursting strength and tiring strength to conservative results.

Considering the time intervals for inspection pig runs, factors are listed which have a time dependent effect on the formation or mitigation of the respective types of defects. The weight of the factors is pipeline related and must be defined individually. The limits for the use of inspection pigs are described in the above mentioned literature study.