Comments and reply from the hearing on the

December 1998 draft of

DNV RP-F101 Corroded Pipelines

Review of DNV Recommended Practice for Corroded Pipelines, No. RP-F101, Draft December 1998

R. G. Bea, University of California at Berkeley

	Observation	Recommendation	Reply from DNV
1	RP addresses only instrumented pipelines. The vast majority of pipelines are not instrumented or can not be instrumented.	Develop recommendations for non-instrumented pipelines	The RP is applicable for a metal loss in a pipeline, where a defect size is given, and the uncertainty of the sizing is accounted for. The defect could be measured or estimated (instrumented or not instrumented), with the assigned appropriate sizing uncertainty.
2	RP cites 138 full scale tests used to validate RP analytical models. Test data not referenced. Comparative analyses of agreement between test data and analytical models not provided.	Reference sources of test data. Provide access to test data. Provide analyses of test data to provide information on 'Bias' (measured / predicted) characteristics of proposed analytical models.	BG Technology and DNV made a unified guideline based on their respective R&D projects. The results from each R&D project are the property of the respective projects, but made available in the development of the unified guideline and a technical background report. The background report, which is available to the sponsors, include this information. RP-F101 is close to identical to the unified project guideline. Publication of more detailed background information will be considered and discussed with BG Technology.
3	RP provides annual Target Reliability Levels (TRL) for three pipeline Safety Classes (SC). The types of uncertainties (e.g. aleatory, epistemic) included in demonstrating that proposed analytical models and partial safety factors (PSF) meet the TRL are not provided (given use of calibration approach).	Specify types and magnitudes of uncertainties and biases that are included in the derivation of the PSF.	The uncertainties in pressure, material properties etc. are derived from the SUPERB project and the development of the DNV Submarine Pipeline Standard. The SUPERP reports are public available for a reasonable cost. The uncertainty in the depth is an input parameter.
4	RP provides PSF that account for uncertainties in pressure, material properties, quality and tolerances in pipe manufacture, sizing accuracy of the corrosion defect, etc. While the uncertainties in defect depth characterization are provided, the other uncertainties are not provided.	Provide a summary of the uncertainties utilized in development of the PSF including those of pressure, burst pressure capacity, and longitudinal stress effects.	Distributions used in the calibration will be published at ISOPE and OMAE 1999.
5	RP provides Inspection Sizing Accuracy (ISA) guidelines in terms of Standard Deviation and Confidence Level. No information is given on the central tendency characteristics of the relative sizing accuracy – tendency for instruments to under-call defect depths.	Provide information on central tendency characteristics of instrument results included in derivation of PSF. Current information provided infers a central tendency bias of unity.	This is information that should be given by the inspection tool provider. We hope RP-F101 will put focus on this matter and "force" the inspection companies to better specify the accuracy and qualify their tools and analyses procedures.
6	RP provides TRL and PSF that do no explicitly account for the effects of hydrotesting and pressure control equipment in the pipeline.	Provide guidance on effects of hydrotesting and pressure control equipment on PSF.	A hydrotest in order to confirm the integrity of a corroded pipeline is not explicitly considered.
7	Sizing accuracies are provided in terms of the accuracies of relative depth measurements. The analytical formulations are based on 3-	Provide guidance on uncertainties associated with plan dimensional characteristics as well as relative depth characteristics. This will have important	The accuracy of the length is of great importance, especially when the length is fairly short. The uncertainty in the length was included in the calibration.

	dimensional characterizations of the corrosion defects. The plan dimensional characteristics (l, c) are not known with the same accuracies.	influences in qualifying instrumentation for in-pipe measurements of corrosion defects.	
8	RP provides guidance on System Effects (SE). This guidance suggests that adding failure probabilities of each defect will lead to conservative assessments of the SE consistent with the definition of the TRL. Given a large number of significant defects and significant correlations in pipeline segment capacity characteristics and failure mode characteristics, this guideline will lead to unreasonable and unrealistic assessments of the SE.	Provide guidance on SE that will make proper recognition of effects of element-to-element strength correlations, failure mode correlations (dependent on relative magnitudes of pressure – stress and capacity uncertainties), and large component probabilities of failure.	This is described in a comment to this paragraph in the RP. The uncertainty in the corrosion sizing and the material and geometrical properties contributes most to the estimated failure probability. These are usually not highly correlated.
9	RP provides significant guidance to assess the effects of single defects (longitudinal, circumferential), interacting defects, and complex shaped defects on pipeline capacities. RP does not provide guidance on how the characteristics of these defects are to be determined from instrumentation. Given present instrumentation and instrumentation data analysis processes, large uncertainties and variabilities can be expected from different types of instrumentation and data processing.	Provide guidance on characterization of defect characteristics from instrumentation data.	Agree, this is of importance, but is not covered by the RP.
10	RP provides significant guidance to assess single defects (longitudinal, circumferential), interacting defects, and complex shaped defects on pipeline burst pressure capacity. RP does not provide information on the bias and uncertainties that have been determined from test data. Such information is critical to understanding the validity of the calibration process that has been used to derive the PSF.	Provide information on the bias and uncertainty associated with the proposed analytical models for burst pressure and combined longitudinal stresses.	We think that it can be difficult to obtain wide industry acceptance of the approach in RP-F101 without providing the data requested. However, many major oil companies and national authorities have participated in the project and have this information. We assume that these companies will accept and use RP-F101. However, some background information will be presented at conferences in 1999.
11	RP is a significant step forward in providing definitive guidance for the assessment of corroded pipelines. This reviewers primary concerns are that the information required to perform the specified analyses is rarely available in the detail required to perform the analyses.	Keep up the good work. Provide much more information on performing the measurements and analysis of the measurement data to assure practicality and efficiency of application of the RP. Provide much more information on the biases and uncertainties associated with the pipeline pressures, stresses, capacities, hydrotesting, pressure controls, and system considerations so that users can understand the limitations and range of validity of the analytical models and processes.	Fully agree. Most of the test results are the property of BG Technology, and they do not intend to publish the results at this time. Some information will be give in a planned presentation at ISOPE and OMAE this year.

Response to Request for Comment onDNV RP-F101, Corroded Pipelines from Battelle, Denny R. Stephens and Brian N. Leis

The response from Battelle was given in a letter, and is divided and copied into the table below by DNV

	Comment	DNV Response
12	Thank you for the opportunity to review and comment on your recommended practice for the assessment of corrosion in pipelines. Battelle has been active for more than 30 years in investigations of the remaining strength of corrosion defects in pipelines. We are keenly interested in research and industry practice on this topic and welcome the opportunity to review your draft recommended practice.	
13	The first section of the recommended practice, Part A, is a new development for the pipeline industry, which uses probabilistic equations to address uncertainties associated with sizing the depth of a defect and the material properties of line pipe. While we concur that defect depth and material properties are primary variables controlling the remaining strength of corrosion defects, all accepted industry criteria for predicting remaining strength include defect length as a primary variable. Length is difficult to measure, particularly with inline inspection tools, and inaccuracies in its measurement significantly influence any estimate of the probability of failure.	Agree, see comment no. 7 above . The uncertainty in the length is included in the calibration.
14	The probabilistic methodology in Part A of RP-F101 is based upon a new deterministic model for predicting the remaining strength of isolated defects defined in Part B, Section 7.2. Part B also introduces a new methodology for the assessment of corrosion defects under internal pressure and combined compressive loading, assessment of interacting defects, and assessment of complex-shaped defects. We are aware of the work conducted by BG Technology and DNV to develop this model. We are also currently collaborating with BG Technology and Shell Research on evaluation of new models for predicting the remaining strength of corrosion defects. Despite our involvement in ongoing research, we are not aware of the any publicly available documentation of the validation of this new deterministic model or the assessments of interacting defects and complex-shaped defects. We understand that the deterministic model is based upon finite-element analysis and full-scale testing, but to the best of our knowledge these data are not publicly available for review by others. If such information is available, we would greatly appreciate receipt of this documentation to provide us with an adequate basis for our review and comment. If the validation of these models is not publicly available, then their validity cannot be adequately confirmed to recommend their application.	Agree, it is important to publish background material.
15	To establish a basis for evaluation we compared the deterministic single-defect equation to publicly available data summarized and documented in References 1, 2, and 3. To be consistent with the RP-F101 range of validation noted in 1.12, we limited our comparisons to results from actual corrosion defects in pipe ranging from Grade B through X65. Figure 1 compares the failure pressure, Pf , predicted by Step 1 in Section 7.2 against the actual failure pressure of corrosion defects for which data are publicly available. Figure 2 compares the safe working pressure, Psw ,defined in Step 2, in Section 7.2, to the actual failure pressure for these defects. Here we used a design factor of F2 = 0.72, as is commonly applied in the United States.	We are aware of the large scatter when compared to the published test data. The test data developed in the BG project (and a few from DNV) was used for this project. We observed a much less scatter using the new data. Only a few published test data were used in the comparison due to insufficient information, as UTS etc.. Please also note that the burst capacity equation is different from the acceptance equation.

16	The results in Figure 1 indicate that the criterion as given has significant scatter across the database and is not universally conservative in its prediction of failure pressure. The standard deviation for the ratio of predicted to actual failure pressure is 0.225. The standard deviations for ASME B31G and RSTRENG for the same data set are 0.188 and 0.163, respectively. The results in Figure 2 indicate that although the safe working pressure is always conservative, the factor of safety against failure ranges from 1.01 to 17.3. Hence, when evaluated against publicly available data on pipe ranging from Grade B to X65, the failure criterion has significant scatter and does not appear to represent a clear improvement over existing criteria.	As mentioned above, the scatter compared to the new data is much less and is used in the calibration. Detailed information was not enclosed with the plots and DNV has not been able to compare the data. Note that the acceptance equation (given in RP-F101) is not identical with the capacity equation (not given in RP-F101).
17	In seeking a reason for this observed scatter, we note that you specify that your assessment procedures are only applicable to linepipe steels that are expected to fail through plastic collapse. Recent research summarized in References 4 and 5 indicates that a notable proportion of corrosion defects in linepipe may not fail by plastic collapse. Instead, some defects in low toughness pipe, regardless of the pipe grade, may fail by another, likely fracture based, mechanism. Your criterion does not provide guidance on how to determine, apriori, if a defect will fail by plastic collapse, and hence, cannot be universally applied.	There may be several sources for the large scatter, and one could be the plastic collapse. RP-F101 requires good toughness material.
18	Based upon the above assessment using the publicly available data within the stated range of validation, the assessment criterion outlined in Draft RP-101 does not significantly improve the analysis of corrosion defects in pipelines in the United States, which are commonly of low to moderate toughness. It is our understanding that Europe has similar pipelines in service. The comparison above also indicates that the standard deviation of the existing and proposed deterministic models for remaining strength is so large that it likely negates any benefit of probability-based approaches.	Many operators have high toughness materials, and RP-F101 utilizes this. If a brittle fracture is expected RP-F101 is not applicable.

Comments from Jeremy Janelle, BP Oil.

The response was sent to David Ritchie (Shell) who forwarded the message to DNV

	Comment	DNV Response
19	Printing error in Step 9 and 12 in the procedure for complex shape defects. t should be t_e	Will be corrected. The worked examples in the appendices have used the correct t_e

References:

1. Kiefner, J.F., and Vieth, P.H., "A Modified Criterion for Evaluating the Remaining Strength of Corroded Pipe," Final Report on Project PR 3-805 to the Pipeline Research Committee of the American Gas Association, December 22, 1989.

2. Vieth, P.H., and Kiefner, J.F., "Database of Corroded Pipe Tests," Pipeline Research Supervisory Committee, PRC International, A.G.A. Catalog Number L51689, April 4, 1994.

3. Kiefner, J.F., Vieth, P.H., and Roytman, I, "Continuing Validation of RSTRENG," Pipeline Research Supervisory Committee, PRC International, A.G.A. Catalog Number L51749, December 20, 1996.

4. Leis, B.N., and Stephens, D.R., "An Alternative Approach to Assess the Integrity of Corroded Line Pipe -- Part I: Current Status," and "Part II: Alternative Criterion," approved for publication in the Proceedings of the 7th International Offshore and Polar Engineering Conference, Honolulu, May 1997.

5. Stephens, D.R., Leis, B.N., Kurre, M. D., and Rudland, D. L., "Development of an Alternative Failure Criterion for Residual Strength of Corrosion Defects in Moderate- to High-Toughness Pipe," Pipeline Research Supervisory Committee, PRC International, A.G.A. Catalog Number L51794, Available Mid 1999.

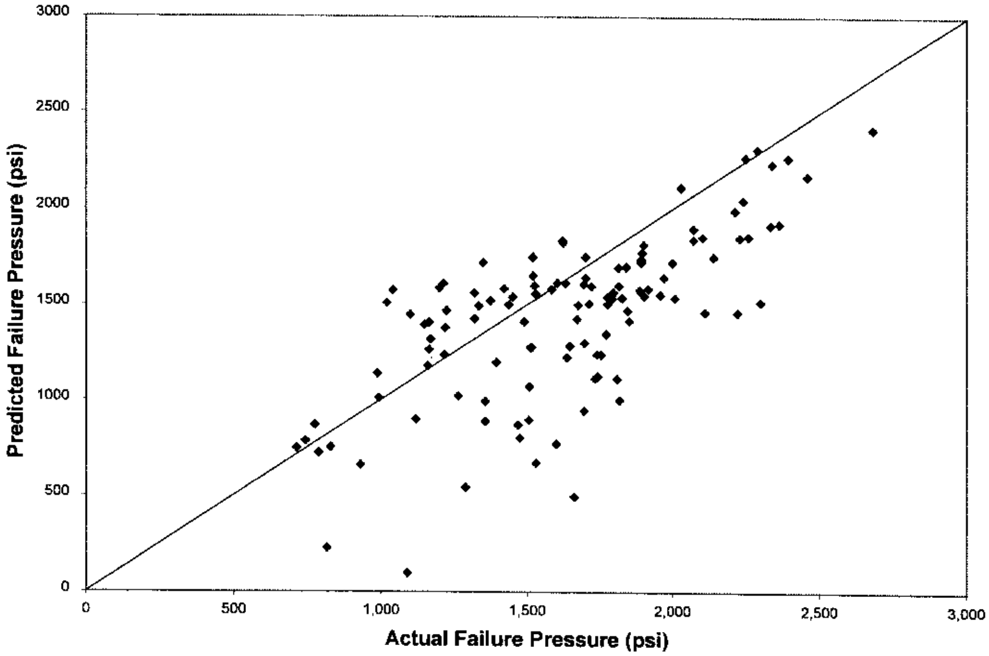

Figure 1. Comparison of failure pressure P_f from Step 1 in Section 7.2 against actual failure pressures in Grade B through X65 pipe in References 1, 2, and 3.

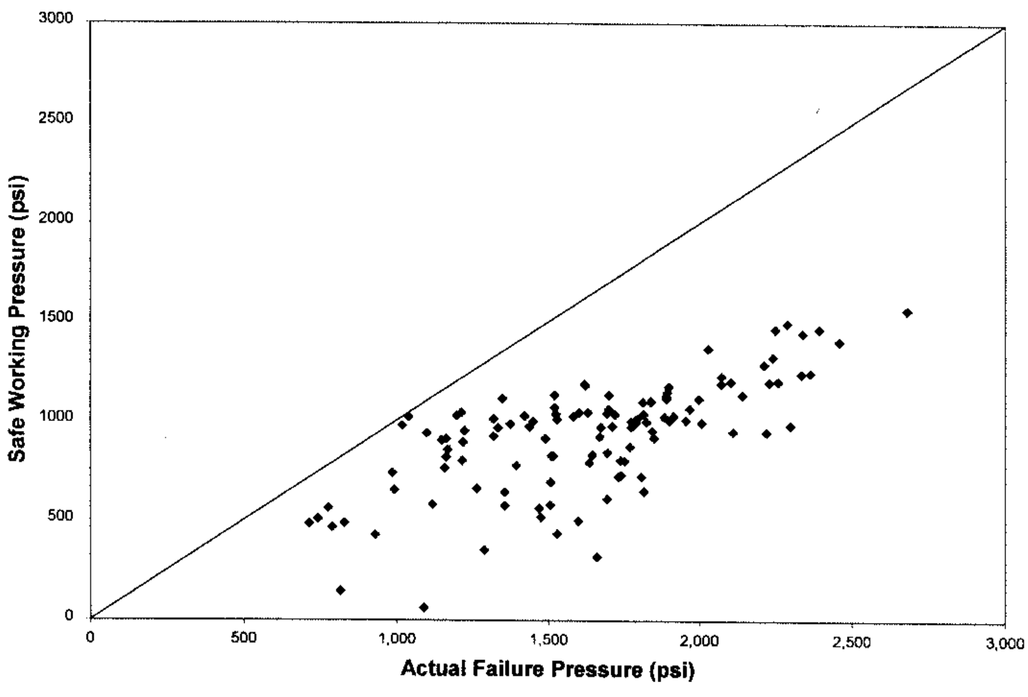

Figure 2. Comparison of safe working pressure P_{sw} from Section 7.2 against actual failure pressures in Grade B through X65 pipe in References 1, 2, and 3.

Comments from Pipetronix

The comments have been edited by DNV to suit the table format below.

	Comment	DNV Response
20	A simple question is how to apply the code on seamless pipes (you need a wall thickness t). Attached are some PTX definitions for wall thickness measurements to clarify my question.	The nominal wall thickness could be used. For UT measurements where the nominal (uncorroded) wall thickness can be measured this value should be used. The γ_m factor is higher for absolute measurements where the nominal wall thickness is measured.
21	Geometrical parameters and interaction of metal-loss features <u>For ultrasonic inspection tools:</u> Start and end of the metal-loss feature are determined by the measurement threshold (see Fig. 1) which in most cases coincides with the detection threshold of the inspection tool. The detection threshold is the minimum absolute depth for a wall thickness reduction to be recognized by the inspection tool. Generally, it is a multiple of the wall thickness measurement resolution of the inspection tool and is defined by the contractual partners prior to the inspection run. The measurement threshold can differ from the detection threshold if the related pipe joint has no constant reference wall thickness (like in seamless pipes) or if the MAOP calculation is performed on the basis of a lower wall thickness level than the actually measured reference wall thickness for the pipe joint. A measurement threshold different from the detection threshold is preferably defined as a "remaining wall thickness level" instead of a "depth level". For practical reasons the "remaining wall thickness" value of the deepest point within a metal-loss area can be recorded in the features list instead of or additionally to the "depth" value. The reference wall thickness of a metal-loss feature is determined as the wall thickness of a representative plateau in the vicinity (approx. 100 mm radius) of the feature and in the same pipe joint. The reference wall thickness of a pipe joint is determined as the most frequently measured wall thickness value in the related pipe joint.	

Pipetronix

Location and Dimensions of Metal Loss Features