Practical Challenges of Using the RP 1183 Shape Parameter Methods

Rhett Dotson[1], Brian Leis[2],
[1]D2 Integrity, [2]BNL Consulting

PPIM 2025
PIPELINE PIGGING & INTEGRITY MANAGEMENT
JANUARY 27-31 • HOUSTON

Organized by
CLARION
TECHNICAL CONFERENCES

https://doi.org/10.52202/078572-0027

Proceedings of the 2025 **Pipeline Pigging and Integrity Management Conference.**
Copyright © 2025 by Clarion Technical Conferences and the author(s).
All rights reserved. This document may not be reproduced in any form without permission from the copyright owners.

https://doi.org/10.52202/078572-0027

Abstract

The shape parameter equations developed as part of research efforts within PRCI have been the subject of significant debate within the pipeline industry. Publications as early as 2019 began identifying challenges in applying the equations. Since that time, the shape parameter equations have been updated and incorporated into the first edition of API Recommended Practice 1183, published in 2020. Following their inclusion in RP 1183, several publications identified technical questions surrounding the equations and example problems included within the RP. Additionally, some operators have begun incorporating the equations into their integrity management plans. In response, ILI vendors and consultants have sought to automate the process for extracting the required information from dent profiles captured by ILI tools. This paper examines some of the key challenges in automating the process of characterizing dents and extracting the necessary information for the shape parameter equations which have not been broadly discussed within the industry to date. In particular, the paper examines the challenges in identifying complex dents, establishing depth baselines, repeatability, and employing smoothing. Additionally, the paper examines some questionable behavior in the recently released updates to the sublevel equations. The paper concludes with recommendations for operators and vendors using the equations and potential questions that remain to be addressed.

Background

The mechanical damage strategic research program (SRP) is an ongoing multi-year research initiative supported by the Pipeline Research Council International (PRCI). One of the objectives of the SRP is to provide operators with methodologies for assessing pipeline dents based on data collected from in-line inspection (ILI) caliper tools. The SRP included significant investments in numerical modelling combined with full-scale fatigue testing. The Level 1 and Level 2 approaches were formally published by PRCI as part of the MD-4-9 report in November 2018 (1). Both the Level 1 and Level 2 approaches relied upon the calculation of a dent shape parameter which was correlated to fatigue life.

A brief description of the shape parameter and associated fatigue assessment equations is included here, but readers are encouraged to review the MD-4-9 report (1) for a more thorough description. Both the Level 1 and Level 2 approaches require twenty characteristic lengths and areas to be determined from ILI caliper data which are then used to calculate the requisite restraint parameter (RP) and shape parameter (SP) for each quadrant of a dent. It is important to note that the Level 1 and Level 2 approaches require a dent's restraint condition to be determined first. Once the restraint condition is determined, the user can apply a set of equations to determine the dent fatigue life based on the shape parameter, restraint condition, mean pressure, and pressure range.

The Level 1 and Level 2 approaches were also incorporated into the first edition of API RP 1183 (2). Additional approaches were introduced at the same time, including screening based on depth, spectrum severity indicator (SSI), or stress range magnification factor (K_M). Since the first publication of RP 1183, additional sublevel equations have been proposed including the Level 0.5, 0.5+, 0.75

https://doi.org/10.52202/078572-0027

and 0.75+ equations (3). As the level of the equation increases, the required information and calculation complexity increase while the conservatism is expected to decrease. The various equations published by PRCI are based on regressions developed from a database of numerical analysis results covering a range of pipeline diameters, wall thickness, depths, and restraint conditions which has expanded slightly since the first report in 2018.

The shape parameter approaches have been the subject of debate within the pipeline industry. As early as 2018, questions were raised about the application of the shape parameter equations in their application to large numbers of dents (4). That publication raised questions regarding the required dent length for use in the first-generation derivations of the shape parameter equations and provided several examples identifying the need for more guidance on assessing asymmetric dents or identifying complex or multi-peak dents. The 2020 IPC publication (5) examined the repeatability of the Level 2 shape parameter approach across large numbers of dents and identified repeatability issues with the calculation of the restraint parameters. Similar issues with the restraint parameter were confirmed again recently in a large study of over 9000 dents by others (6). Additional concerns have been raised concerning the accuracy and repeatability of “restrained” versus “unrestrained” dent predictions from the restraint model, particularly for shallow dents (7). Multiple authors (8) (9) raised questions regarding the conservatism of the screening approaches in RP 1183 as well as inconsistencies between the various correlations (i.e., lower level approaches predicting longer lives). More recently, a series of publications (10) (11) have raised questions regarding application of the approaches to dents with sharp curvature, skewed dents, and the ability of the equations to accurately capture the response of the dent after the peak strain had migrated away from the peak of the dent.

Following these publications, PRCI published a white paper (12) responding to some of these questions. This white paper discusses the screening table that was removed from the first edition of API RP 1183 by way of an amendment. Additionally, the white paper provides comparisons of the screening approaches to a set of one thousand verified dents provided by pipeline operators. Readers of this paper are encouraged to read the previous publications to understand the nature of the concerns raised and the responses provided in the PRCI publication.

Purpose

Given the significant attention and debate generated by the first edition of API RP 1183, it is certain that the technical questions raised in the past several years will continue to be explored by industry subject matter experts (SMEs) and stakeholders. Users of the approaches as well as regulators should be aware of the issues that have been raised and educated on their implications. Nevertheless, the purpose of this paper is not to review or reinforce the technical issues raised in prior publications. Instead, the purpose of this paper is to investigate the practical challenges in applying dent fatigue screening approaches, including the shape parameter equations, to large numbers of dents. The practical considerations have received little attention in the recent debate and are often overlooked when operators seek to use the screening methods or the shape parameter approaches. In addition to these practical considerations, the paper explores the behaviour of the recently proposed sub-level 0.5, 0.5+, 0.75 and 0.75+ assessment approaches.

The objective of this publication is twofold. First, the authors desire to create awareness among operators who are using screening approaches or shape factor approaches and provide practical guidance on how to avoid improperly applying screening criteria to dent features. Second, the authors desire to share their observations on the recently proposed sub-level assessment approaches.

Challenges in Dent Selection

Before examining the challenges with the application of the shape parameter equations, it is important to recognize the importance of correctly identifying which dents are applicable for screening approaches. All the simplified screening approaches that have been developed to date are generally applicable to smooth, single-peak dents. Fundamentally, this requires that a dent first be identified as "smooth" and "single peak" prior to the application of the approach. It is noteworthy that the notions of complex, skewed, sharp, multi-peak, or interacting dents are subjective within the industry and among ILI vendors. Operators may have observed that ILI reports will sometimes describe a dent with these terms in the comments section of a pipe tally. However, these comments are often based on analyst judgement and best-effort approaches. Furthermore, the ILI reporting requirements for some operators might limit the inclusion of unstructured comments like these in the tally. Thus, operators should be wary of using only the pipe tally to identify dent features that should be excluded from the dent assessment approach.

Three examples are offered herein to illustrate the challenges in identifying applicable dents for screening processes based on a pipe tally alone. The first example is a complex deformation, shown in Figure 1. In this example, two distinctive peaks can be seen in the caliper data. It could be argued that these are two separate dents, or it could be equally argued that this is a single, multi-peak dent since a full return to nominal pipe between each peak is not completely obvious. Either scenario would result in the exclusion of the dent from screening assessment methods. In this instance, the dent feature was seen in three separate inspections and reported both ways by the ILI vendor (twice as a single dent and once as two dents). This illustrates the ambiguity that exists in identifying complex or multi-peak features. Given the orientation of the dent (top third of the pipe) and the association with metal loss, it is certainly possible this is an indication of third-party damage. Without additional review of the caliper signals, this feature could be deemed acceptable using any of the approaches that rely on reported depth (3% OD) even though the feature complexity in Figure 1 indicates that the dent falls outside of the applicability of these approaches. This includes the PRCI equations and depth-based approaches from the European Pipeline Research Group (EPRG) (13).

A second example is shown in

https://doi.org/10.52202/078572-0027

Figure 2. In this example, the dent locations and dimensions from the pipe tally are shown graphically for three separate inspections. In the 2015 and 2018 tally, only a single dent was called. However, in the 2020 pipe tally, two distinct dents with a circumferential and axial offset were identified. None of the reports identified the single features as complex or multi-peak.

A final example for identifying applicability is shown in
Figure 3. This feature presents a dent with a skewed orientation relative to the pipe axis that was not specifically identified as skewed or complex in the pipe tally. API RP 1183 notes that dents oriented at an angle greater than 30 degrees relative to the pipe longitudinal axis are not applicable to the PRCI screening or Level 2 assessment approaches. Dent skewness is not uniformly reported today in an ILI pipe tally. For this example, only a detailed review of the three-dimensional shape would have provided the necessary data to assess applicability.

The three above-noted examples illustrate the challenges and pitfalls that can exist in using the pipe tally alone to identify suitability for a screening assessment approach. Unfortunately, these examples are common in ILI reporting for complex features, because a standard process and definition does not exist in the industry that can be readily adopted by the vendors. Currently, these features can only be reliably identified by a thorough review of the caliper data and the associated dent profiles.

As an aside, applicability issues are also found even when using the interaction criteria from API RP 1183 for more straightforward features such as girth welds. The interaction criteria in Section 6 of API RP 1183 are easy to apply, as the identification criteria utilizes the distance from the peak dent depth to determine girth weld interaction. Unfortunately, the interaction criteria has been observed to miss potential interactions on longer dent features. An example of this is shown in Figure 4. The example dent is longer than 3 ft (1 meter), and the deformation clearly interacts with the girth weld near the downstream edge. This interaction was not identified by the MD-4-9 interaction criteria despite the deformation and the girth weld overlapping. The boundaries of the MD-4-9 interaction boxes are shown with dashed lines in the image, and the weld falls outside of those boxes. The interaction was identified as part of a detailed assessment for the dent; however, if the RP 1183 interaction criteria is strictly followed and fails to capture this type of interaction, it is unlikely that the interaction will be identified in a final report.

Based upon the above examples, the authors suggest the following to ensure that appropriate assessment paths are selected for each dent:

1. Work with a combination of the pipe tally and ILI signal data when identifying the suitability of a dent for a particular method. The tally can serve as an overall tabular list of all candidate dents, but the evaluation of characteristics like multi-peak, skewed, complex, or and interacting is best handled by examining the caliper data.
2. The pipeline operator should be included in the assessment selection decision for any dents where there is substantial uncertainty about the applicability of a given approach.

https://doi.org/10.52202/078572-0027

Shape Parameter Calculation

Once a dent has been deemed appropriate for an assessment, there are other important considerations if the operator elects to use the shape parameter equations. RP 1183 lists 42 recommended lengths or areas in Table 2 that can be extracted from dents with 20 of these dimensions being required to perform a PRCI Level 2 Shape parameter assessment (2). If the shape parameter approach is deemed applicable for a dent, operators should be aware that there can be substantial variability in the calculated characteristic dimensions even in the hands of qualified practitioners. While many operators perceive the extraction of these dimensions as a straightforward exercise, the reality can be quite different.

The primary cause of this variability is in the setting of the pipe's baseline shape. This step is nontrivial and can introduce substantial subjectivity into the assessment. Section 6.1 of RP 1183 recognizes this challenge when it says "*the definition of the baseline shape may require engineering judgement and may not be circular*" (2). This recommendation inherently implies that an engineer should be involved in the decision to set baselines, and not only an ILI analyst. Once the baseline shape is set, the depth of the dent can be determined, and the required measurements for the shape parameter equations are all expressed as a percentage of this dent depth as shown in
Figure 5. These measurements then determine the restraint parameter and result fatigue lives. In this description, the word "dent depth" can be misleading as inexperienced users tend to believe this is the same as a pipe tally dent depth. Unfortunately, this is not the case, and the descriptions and graphics in Figure 7 of RP 1183 attempt to differentiate the two depths (2). It is also noteworthy that the definition of dent depth in API RP 1183 is not the same as that in the Pipeline Defect Assessment Manual (13)[1].

Several issues are often encountered with setting baselines and calculating the required lengths and areas. The issues with "shallow off-takes" in asymmetric dents and challenging interpretations of multiple peaks were described in 2018 (4). A similar example is provided in this paper in Figure 6 for an 8-inch diameter pipe. In this example, the axial profile is complicated by a gradual reduction in the baseline profile. Additionally, the upstream shoulder of the dent appears more elongated than the downstream profile. One suggestion for baselines is shown in Figure 6, but the upstream baseline could arguably be set to two or even three potentially shorter locations depending on individual judgement. Depending on experience, it is possible that the user may choose substantially longer lengths approaching a full joint.

This profile was distributed to members of the author's team to demonstrate resulting impacts that might exist in this judgement. The calculations were repeated six times with four engineers and two

---

[1] It should be noted that the definition of "dent depth" is not identical in either 1183, EPRG, or in vendor reporting specifications. The challenge of variations in the definition of dent depth could serve as its own publication.

https://doi.org/10.52202/078572-0027

former ILI analysts. The results are summarized for the quadrant producing the maximum restraint parameter in Table 1. The subjectivity in setting the upstream baseline can be seen in the significant variation in the L_{15}^{AX} values. Furthermore, the influence of smoothing can be seen as Engineer 1 and Engineer 4 selected the same baseline depth, but differences in applied smoothing altered the remaining lengths and areas. This example is remarkable in that the variation results in restraint parameter values spanning from 18 to 31, potentially impacting the chosen restraint condition of the dent. In API RP 1183, values of the RP greater than 20 generally indicate restrained dents while values less than 20 generally indicate restrained dents. The RP acknowledges that values close to 20 may be evaluated both ways but does not provide a definition for "close". Follow-up guidance in (14) found overlap between RP values of 15 and 25, but this guidance has not been introduced into API RP 1183. Nevertheless, this variation in restraint parameter calculation is consistent with the conclusions in (5) and (6)[2].

The previous example illustrates the variation that might arise from human judgement that should be expected when extracting the required lengths to use the shape parameter equations. It is important to note that this variation is not the result of tool measurement error. On the contrary, the shape parameter approach has significant repeatability challenges based solely on the subjectivity in setting the baselines. In practice, the impacts of subjectivity and "engineering judgement" required in establishing the baselines might be partially mitigated through a rigorous engineering review process, whereby the baselines are independently set by two or more engineers and differences are reconciled in a review session prior to reporting. However, such a process requires time and engineering oversight. Additionally, the variation seen in Table 1 would be expected to increase if the values were calculated based on multiple caliper data sets.

The challenges related to baseline shapes and repeatability are primarily unique to the PRCI approaches. In this regards, depth-based approaches such as EPRG (13) have a significant advantage as they rely on ILI dimensions that are tied to a reporting criteria and specifications meeting the requirements of API 1163 (15). If operators wish to broadly adopt the PRCI equations, they must recognize that engineering judgement is required in establishing the baselines, and variability will exist even with a rigorous review process. Until there are better quantitative, repeatable algorithms for baseline selection that reduce the need for engineering judgement, operators should be involved in the review of dent profiles to ensure consensus that baselines are appropriately established.

Behavioral Concerns

---

[2] It may be asked what the impact is on remaining life, but the decision to show the variation in the measurements illustrates the subjectivity in the approach and what could be expected when the measurements are taken by ILI analysts who may not have the ability to assess the variability in the chosen baseline.

https://doi.org/10.52202/078572-0027

Apart from the practical challenges discussed in the previous section, the authors of this paper have also discovered some unusual trends in the more recently developed screening equations. In API RP 1183 (2), the shape parameter equation is presented as a Level 2 assessment approach. An additional screening approach (Level 0) based on the calculation of the stress range magnification factor, K_M^{Max}, is also presented in section 7.4.2. Since the publication of RP 1183, four additional screening approaches have been proposed as part of the PRCI MD-5-03 project (14). The four additional screening approaches (Level 0.5, 0.5+, 0.75, and 0.75+) all utilize the stress range magnification factor, K_M^{Max}, and are ordered by ascending complexity and decreasing conservatism. Each of these approaches was developed based on trending results contained in an updated database of finite element model results. A summary of the approaches is included below:

- Level 0: This approach utilizes K_M^{Max} which is calculated based on only the pipe geometry (diameter and wall thickness) and the spectrum severity indicator (SSI).
- Level 0.5: This approach calculates K_M^{Max} based on pipe geometry and the pressure range for the pressure cycle being evaluated.
- Level 0.5+: This approach calculates K_M^{Max}, based on pipe geometry, pressure range, and mean pressure for the pressure cycle being evaluated.
- Level 0.75: This approach incorporates dent depth into the K_M^{Max} calculation as an extension of the Level 0.5 equation.
- Level 0.75+: This approach incorporates dent depth into the K_M^{Max} calculation as an extension of the Level 0.5+ equation.

The MD-5-3 report notes that the Level 0.75 and 0.75+ equations are expected to be less conservative and more accurate than the Level 0.5 and Level 0.5+ equations (14). However, the report notes that the Level 0.75 equation may not be less conservative than the 0.5+ equation since these equations have the same number of independent variables.

Since all the screening equations rely on a calculation of K_M^{Max} based on pipe geometry (D/t), the screening relationships were first reviewed by plotting K_M^{Max} as a function of D/t for various dent depths. The results for the Level 0.75+ equation are shown for dent depths ranging from 0.5 to 7% OD for unrestrained dents in Figure 7 and for restrained dents in Figure 8. Both figures show a discontinuity in the formulations that occurs near a D/t ratio of 60. For unrestrained dents, the discontinuity appears exactly at a D/t of 60, and the discontinuity would only directly impact NPS30 x 0.5” pipe configurations. However, for restrained dents the discontinuity extends from D/t ratios from 48 to 60 and impacts a common pipe geometry for almost every NPS from 6 – 36 inches. The influence of this discontinuity is explored in the paragraphs that follow.

Using NPS 30 as an example, two common wall thicknesses are noted on the edges of the transition zone for restrained dents in

https://doi.org/10.52202/078572-0027

Figure 8. NPS 30 x 0.625" has a D/t of 48 while NPS 30 x 0.5" has a D/t of 60. First it should be noted that the guidance in (14) specifies equations for a D/t of "24 to 60" and "60 to 130" making it unclear which set of equations should be used when the D/t ratio is exactly 60 (this occurs only for NPS 30 x 0.5" pipe). For the NPS 30 x 0.625" condition, the curves indicate that dents of any depth from 0.5 – 7% OD will have a K_M^{Max} of 3.84 for a pressure range from 10 to 70% SMYS (all dent depths converge on the same point). However, if the same dents appear in a pipe with a lower wall thickness of 0.5", then the K_M^{Max} value ranges from 2.6 to 3.1 for the same pressure range depending on which set of coefficients are used. It seems unusual that a reduction in wall thickness for dents of any depth would result in lower severity.

Similar unusual trends were noted when examining the relationships for the Level 0.5+ equation as a function of pipe geometry. The results for 40% SMYS pressure ranges with mean pressures of 25 to 55% SMYS are presented for unrestrained dents in Figure 9 and for restrained dents in Figure 10. Unlike the Level 0.75+ equation, both the unrestrained and restrained conditions show a narrow range of transition that occurs for pipe geometries with a D/t at exactly 60. For the unrestrained condition, the functions indicate that the Level 0.5+ equation is relatively insensitive to pipe geometry as the functions are nearly flat across the range of pipe geometries, particularly for D/t ratios greater than 60. The unusual behaviour for the Level 0.5+ functions from D/t ratios from 24 – 60 could be an artefact created from the chosen fitting technique and the available data.

Unfortunately, the behaviour of the Level 0.5+ equation for restrained dent functions in Figure 10 is more unusual. For the Level 0.5+ restrained condition, the impact of the discontinuity at a D/t of 60 is significant. Depending on which set of coefficients are chosen by the user for a NPS 30 x 0.5" pipe, the maximum K_M^{Max} value could range from 2.1 to 3.8 for a 40% pressure range with a mean pressure of 35% SMYS (orange curve). Pipe configurations near the discontinuity are also impacted. Three points representing three different pipe configurations with matching diameters or wall thicknesses are highlighted on the same curve in Figure 10 to illustrate the impact of the discontinuity. For a 40% pressure range with a mean pressure of 35% SMYS, the results indicate that a dent of any depth in NPS 24 x 0.562" has a K_M^{Max} of 3.24 while a dent of any depth in a thinner wall thickness NPS 24 x 0.375" configuration has a K_M^{Max} of 2.46 (25% reduction). Similarly, a dent of any depth in an NPS24 x 0.375" pipe is more severe if it occurs in an NPS22 pipe with the same wall thickness as the K_M^{Max} is 3.81 (55% increase). It is unusual for a decrease in wall thickness or a reduction in diameter to correlate with an increase in severity. In fact, this behaviour is at odds with the general trend shown in the rest of the plot identified as increasing severity with increasing D/t ratio. This behaviour raises the question "what physical phenomena could exist in pipelines to cause such a sharp change in a screening function near a D/t of 60?"

It should also be noted that while the results in Figure 10 are shown for shallow restrained dents in the Level 0.5+ equation, similar behaviour is observed for deep restrained dents in the Level 0.5+ equation. Instead of plotting the results against D/t ratio, the Level 0.5+ data for deep restrained dents is shown plotting K_M^{Max} as a function of pressure range in Figure 11. In this figure, several pipe diameters with a common wall thickness of 0.375-inches are shown plotting K_M^{Max} against pressure range. The influence of the transition zone can be seen as the NPS24 (D/t of 64) and NPS30 (D/t of 80) pipe configurations both have different slopes that intersect the results for the other pipe diameters at pressure ranges from 30 to 50% of SMYS. The authors cannot identify an explanation for why a dent in an NPS24 pipe would be less severe than a dent in an NPS20 pipe of the same wall thickness only when the pressure range is greater than 30% SMYS.

The previous examples examined the behaviour of the Level 0.5+ and the Level 0.75+ equations. Other unusual trends were observed in the Level 0.75 equation. K_M^{Max} is plotted as a function of D/t for the Level 0.75 equation for various dent depths in Figure 12. The discontinuity in the functions is again evident at a D/t of 60. However, the functions appear as overlapping horizontal straight lines for D/t values greater than 60 indicating a constant K_M^{Max} that is independent of pipe geometry *and* dent depth. Stated another way, this plot indicates that any pipe geometries with a D/t greater than 60 will have a maximum stress magnification of approximately 2.7 regardless of dent depth for a pressure range of 70% SMYS. It should be noted that this behaviour is also seen in Figure 8 for the 0.75+ equation which showed only a maximum 20% increase in K_M^{Max} for D/t values above 60 regardless of dent depth. Both plots reinforce the question of "what physical phenomenon would exist to produce such a sharp change in behaviour at D/t ratios greater than 60?"

The results of this trending in the Level 0.75 equation can be seen more clearly when various configurations of NPS24 pipes are plotted against dent depth in Figure 13. The two lowest D/t ratios for the NPS24 configurations appear near the bottom of the figure and both configurations are nearly linear with dent depth (NPS24 x 0.688" and NPS24 x 0.562"). Similarly, the two largest D/t ratios for the NPS 24 appear near top of the figure with a slightly different shape showing a gradual increase in K_M^{Max} as dent depth increases (NPS24 x 0.25" and NPS24 x 0.218"). In contrast, the NPS 24 x 0.375" with a D/t ratio of 64 shows a different trend intersecting the two larger D/t combinations at dent depths greater than 4.5% OD. This plot raises the question of what physical phenomena exist in the NPS 24 x 0.375-inch combination (D/t=64) to produce such unique behaviour?

While the cause of these discontinuities in the various screening equations is beyond the scope of this paper, both the magnitude and shape of the functions as they approach the discontinuities is concerning and raises questions regarding the accuracy of the functions. It should be noted that while the results shown in each of the figures is shown for a singular pressure range, the discontinuity exists for every pressure range with variations in the magnitude.

In closing, the purpose of presenting these plots is first and foremost to raise awareness that there are some unusual trends in the recently developed screening equations. The authors recognize that screening equations could result in simplistic functions, particularly in the absence of a robust data set with enough data points to fully characterize the behaviour (i.e., a depth-based threshold might appear as a straight line when plotted against D/t). In more robust

data sets, the screening functions would be expected to follow fundamental mechanical principles. For example,

Figure 9 shows lower K_M^{Max} values at higher mean pressures for unrestrained dents. At first glance, users might question whether higher mean pressures should produce lower stress magnification (and hence longer fatigue lives). However, this behaviour might have a physical explanation in the fact that unrestrained dents will re-round at higher pressures. This re-rounding typically results in lower depths and lower stress concentration at higher pressures. This explanation is offered as an example of how the trends can be physically understood. In the context of the numerous plots shown in this paper, the authors can offer no explanation for the sharp transition zone, variation in trends near the transition zones, or the near constant K_M^{Max} at higher pressure ranges for restrained dents. It is recommended that the underlying data for these functions be reviewed to better understand this behaviour.

Recommendations

The authors recognize that many of the equations developed by PRCI and discussed in this publication are relatively new. It is expected that additional questions may arise, and issues may be identified as the equations are used by operators and explored by other researchers. In response to the challenges and behavioural issues identified in this paper, the authors offer the following recommendations:

1. Operators should not rely upon ILI final listings to determine the applicability of an engineering approach for any dent screening assessment. This recommendation includes determining applicability for PRCI screening approaches (14) and depth-based approaches from EPRG (13).
2. Operators should work with a combination of the pipe tally and ILI signal data and should be prepared to review all dent profiles when determining applicability of a given dent assessment approach.
3. Operators should be included in the assessment selection decision for any dents where there is substantial uncertainty about the application of a given approach.
4. Operators should be aware that variability exists in setting baselines required to extract the required information for the shape parameter approach. This variability is separate from the effects of tool measurement error and is inherent in the PRCI Level 2 equation. As a result, operators should be prepared to review the profiles and selected baselines when using the Level 2 shape parameter approach.
5. Operators should be aware of the following observations for the Level 0.5, Level 0.5+, Level 0.75, and Level 0.75+ screening equations:
    a. All the equations have discontinuities near a D/t ratio of 60 that do not currently have a physical explanation.

https://doi.org/10.52202/078572-0027

   b. For some of the approaches, the shape of the trends for K_M^{Max} at pipe geometries near D/t of 60 do not match the shape of the trends for D/t ratios above or below 60.
   c. Clarification is needed for which coefficients should be used when the D/t is exactly 60 for all of the sub-level approaches.
6. It is recommended that the methods and the underlying data used to develop the Level 0.5, Level 0.5+, Level 0.75, and Level 0.75+ screening equations be reviewed to better understand the behaviour in these functions.

Recognition

The authors wish to offer specific appreciation to Amin Eshraghi for his support and observations, and to others who contributed by way of reviewing and providing comment.

References

1. Tiku, Sanjay, et al. Fatigue Life Assessment of Dents with and without Interacting Features. s.l. : Pipeline Research Councile International, 2018. PR-214-114500-R01.
2. American Petroleum Institute . Assessment and Management of Pipeline Dents. 2021. Recommended Practice 1183.
3. Tiku, Sanjay, et al. Improvement in Dent Assessment and Management Tools. s.l. : Pipeline Research Council International, 2024. PR214-223810-R01.
4. An Authoritative Comparison of Remaining Life Assessments for Pipeline Dents. Dotson, Rhett, et al. Calgary : International Pipeline Conference, 2018. IPC2018-78247.
5. Judge me by my Size, Do you?: How Reliable are Dent Assessments Based on ILI Dat? . Doton, Rhett, et al. Calgary : International Pipeline Conference, 2020. IPC2020-14732.
6. Pragmatic Study of Dent Restraint Conditions for ILI-Reported Dents Based on API RP 1183. Wang, Rick and Zhang, Shenwei. Calgary : International Pipeline Conference, 2024. IPC2024-132915.
7. Detaining Dents - Determining Restraint for Dents Measured by ILI Case Study. Hardy, Jonathan and Newton, Chris. Houston : Clarion, 2023. 35th International Pipeline Pigging and Integrity Management Conference (PPIM 2023).
8. The State of Dent Screening and Shape-Based Assessments: Discrepancies to Consider. Polasik, Steven, et al. Calgary : International Pipeline Conference, 2022. IPC2022-87301.
9. A verification study of fatigue-based methods in API RP 1183 for estimating fatigue life of pipeline dents. Zhui, Xian-Kui. s.l. : International Journal of Pressure Vessels and Piping, 2023, Vol. 205.
10. Dent strain and stress analyses and implications concerning API RP1183 - Part 1: Background for dent geometry and strain analyses during contact and re-rounding. Leis, Brian, et al. 3, s.l. : Journal of Pipeline Science and Engineering, 2023, Vol. 3.

https://doi.org/10.52202/078572-0027

11. Dent strain and stress analyses and implications concerning API RP 1183 - Part II: Examples of dent geometry and strain analyses during contact and re-rounding. Leis, Brian, et al. 1, s.l. : Journal of Pipeline Science and Engineering, 2024, Vol. 4.
12. BMT Canada Ltd. The Facts about API RP 1183 (First Edition) Table 6. s.l. : Pipeline Research Council International, 2024.
13. The Pipeline Defect Assessment Manual. Cosham, Andrew and Hopkins, Phil. Calgary : International Pipeline Conference, 2002.
14. BMT Canada Ltd. Guidance for Performing Engineering Critical Assessments for Dents on Natural Gas Pipelines. s.l. : Pipeline Research Council International, 2023. PR-214-223806-R01.
15. American Petroleum Institute. In-Line Inspection Systems Qualification. s.l. : API, 2013. API Standard 1163.
16. American Society of Mechanical Engineers. Manual for Determining the Remaining Strength of Corroded Pipelines. s.l. : The American Society of Mechanical Engineers, 2023. ASME B31G-2023.
17. Improvements to B31.8 Dent Strain Estimation and Assessment of Dent Formation Induced Cracking. Tang, Huang, et al. Calgary : Internaional Pipeline Conference, 2024. IPC 2024-133905.

https://doi.org/10.52202/078572-0027

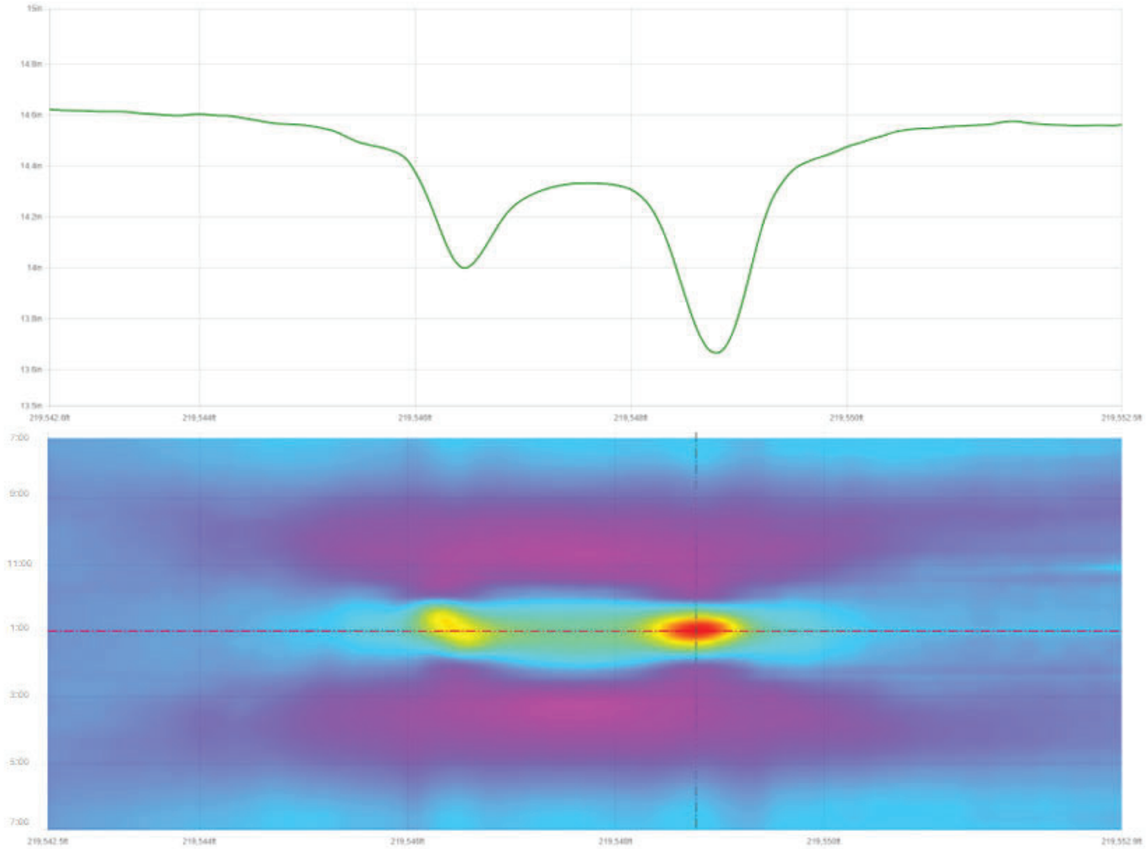

Figure 1: Example multi-peak dent

https://doi.org/10.52202/078572-0027

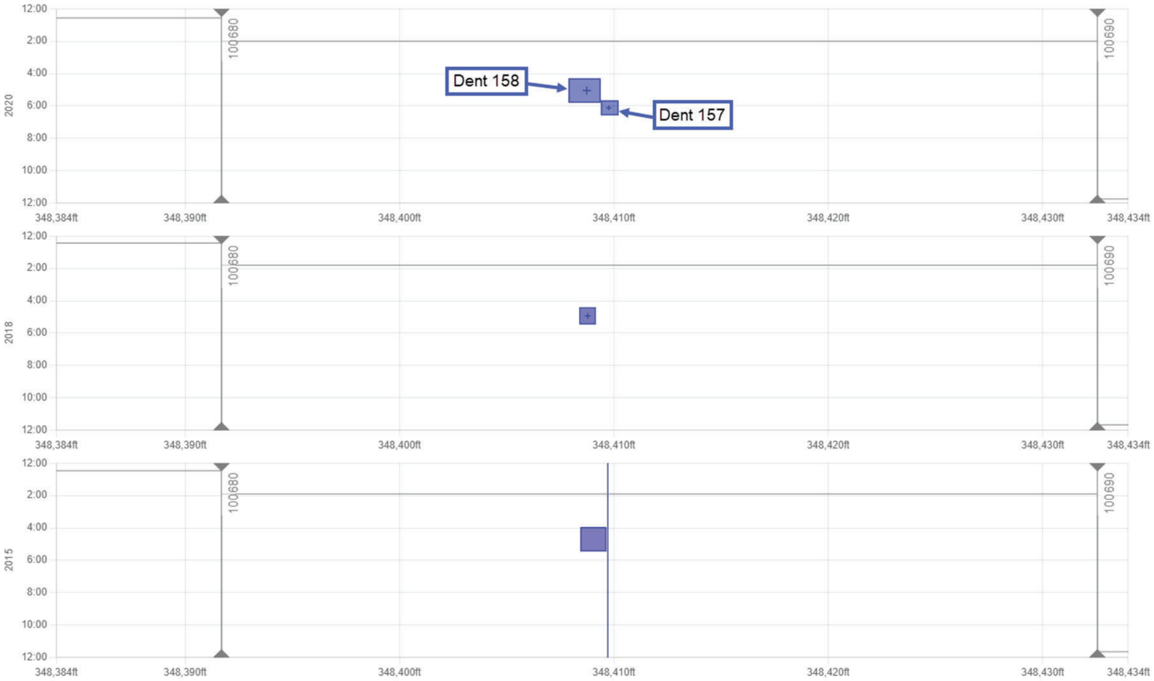

Figure 2: Variation in dent reporting

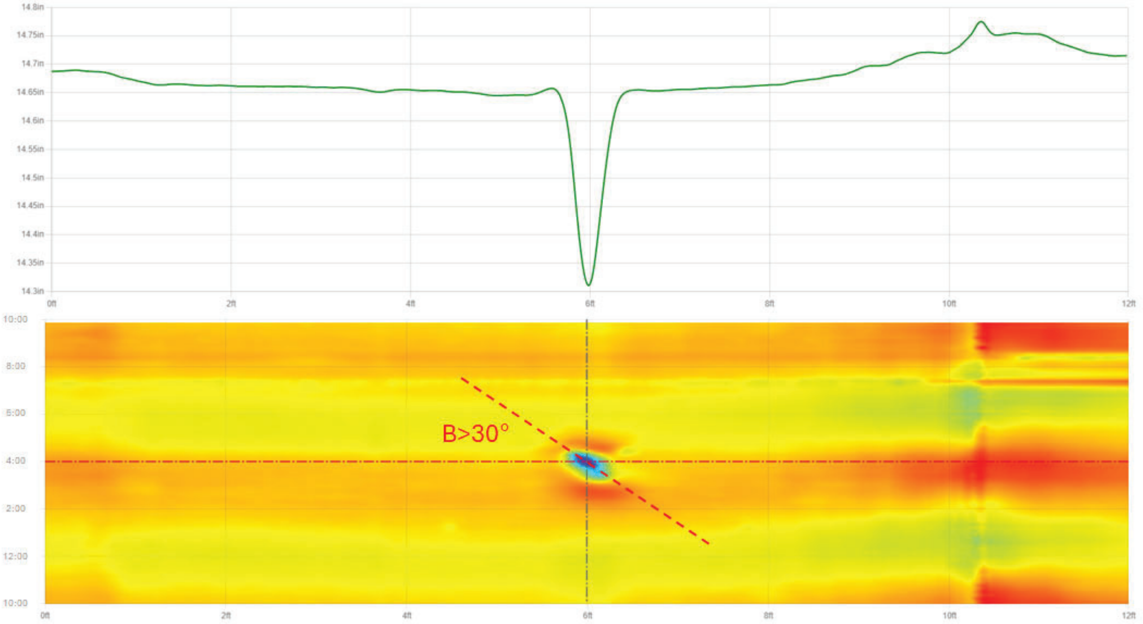

Figure 3: Skewed dent

https://doi.org/10.52202/078572-0027

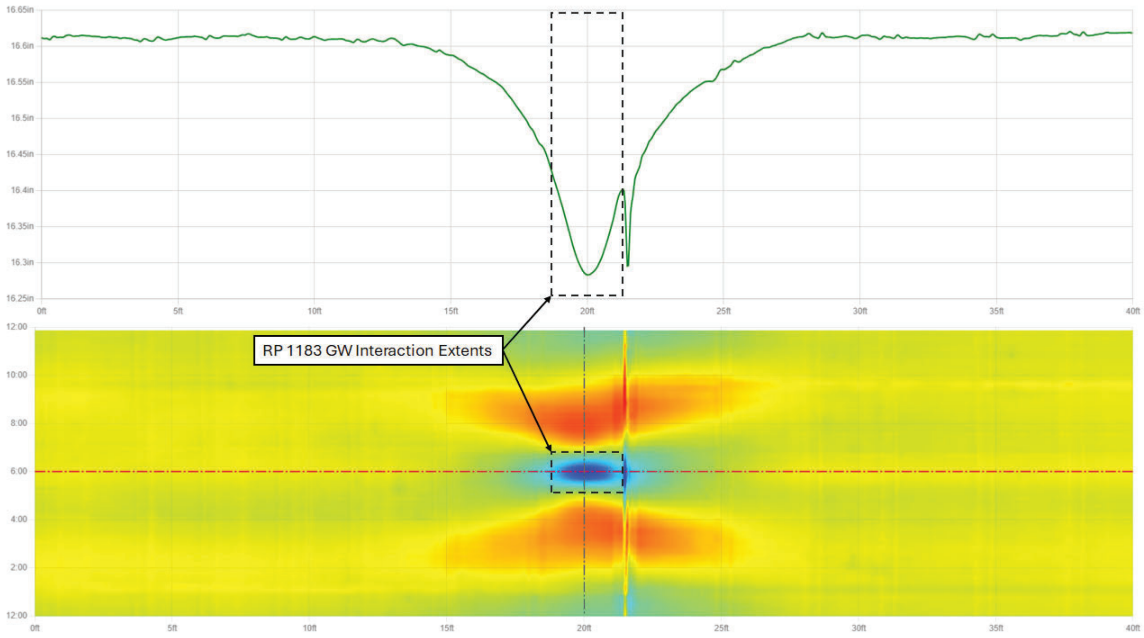

Figure 4: Comparison of API RP 1183 weld interaction boxes to deformed region of long dent

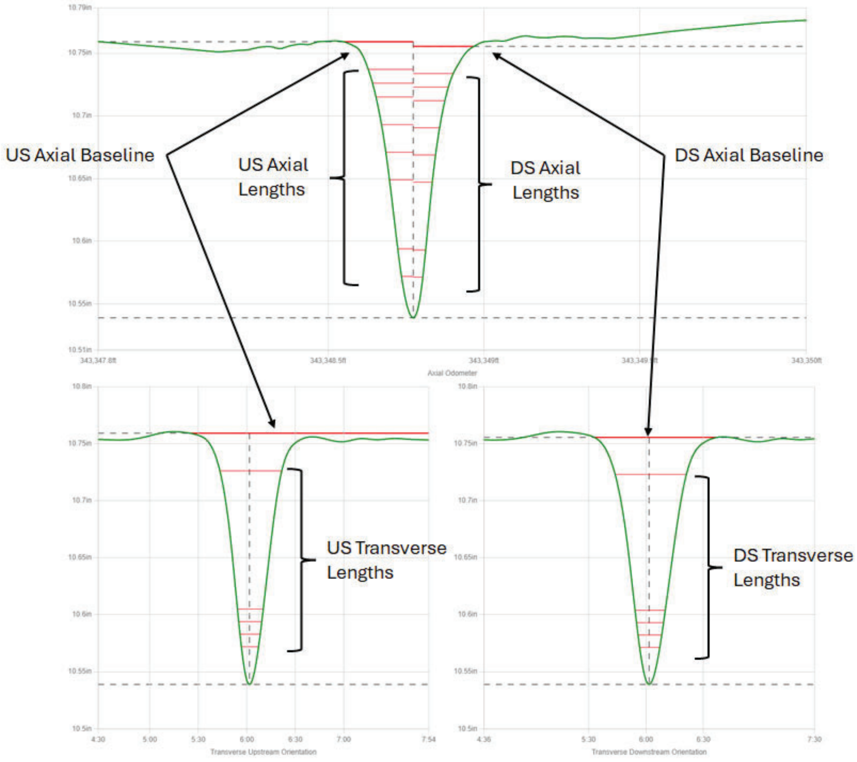

Figure 5: Required lengths for shape parameters

https://doi.org/10.52202/078572-0027

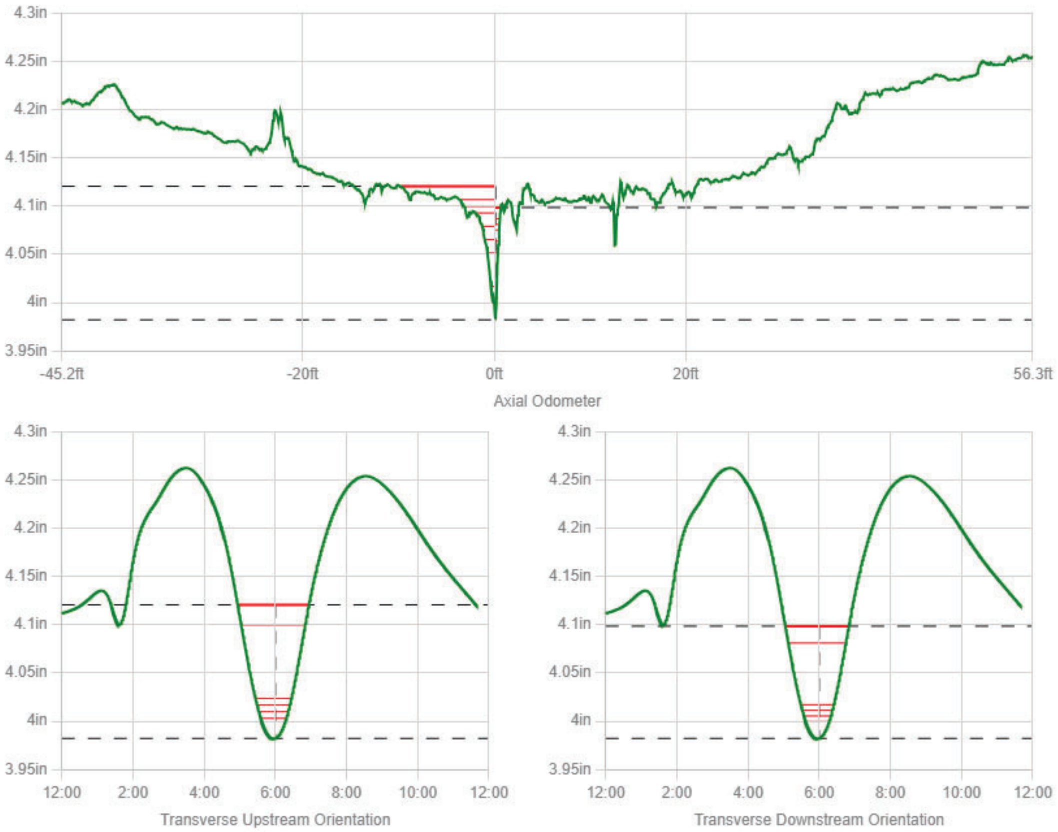

Figure 6: Challenging profiles

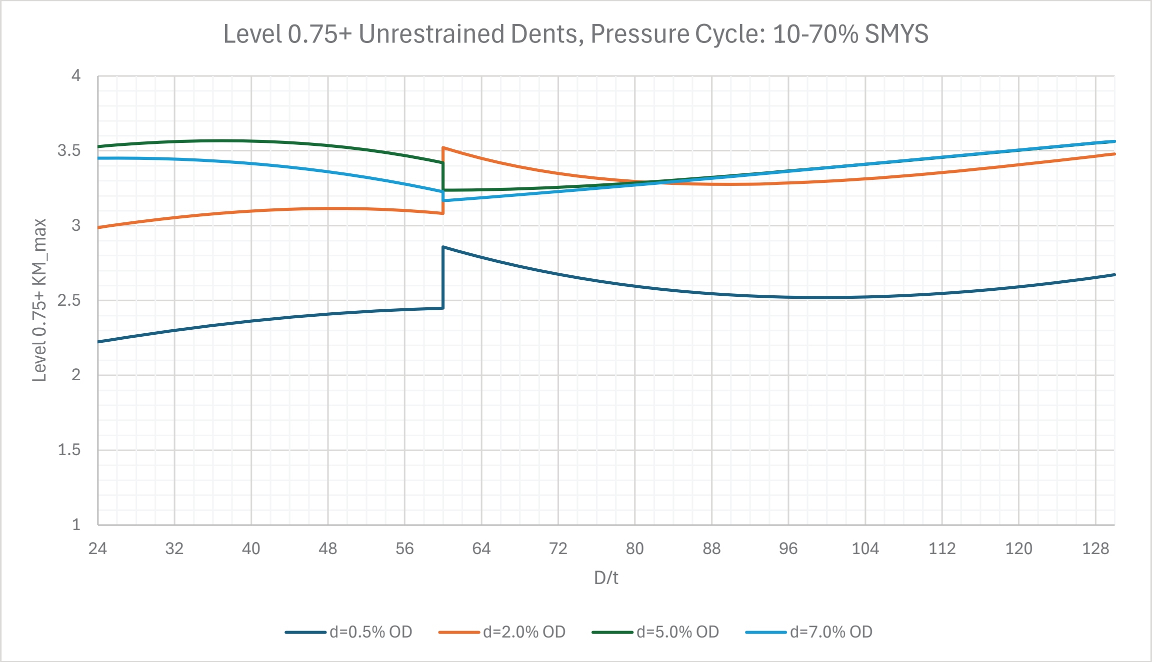

Figure 7: Level 0.75+ relationships for unrestrained dents

https://doi.org/10.52202/078572-0027

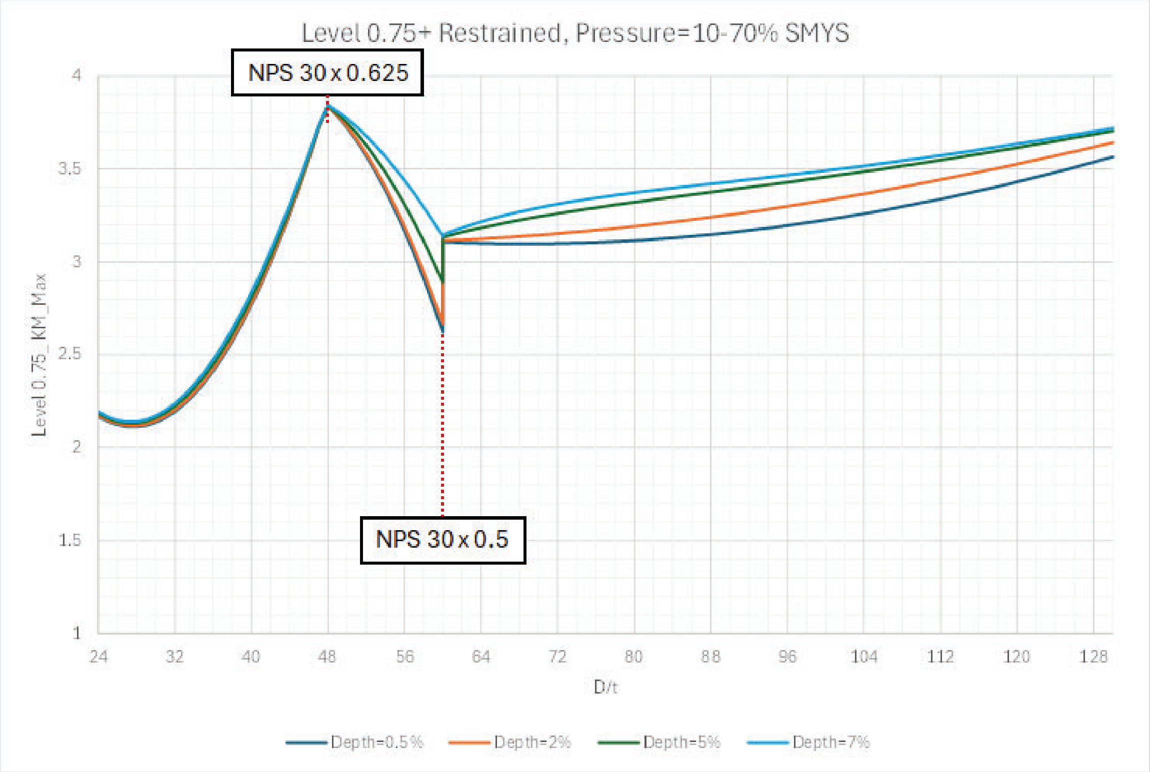

Figure 8: Level 0.75+ relationships for restrained dents

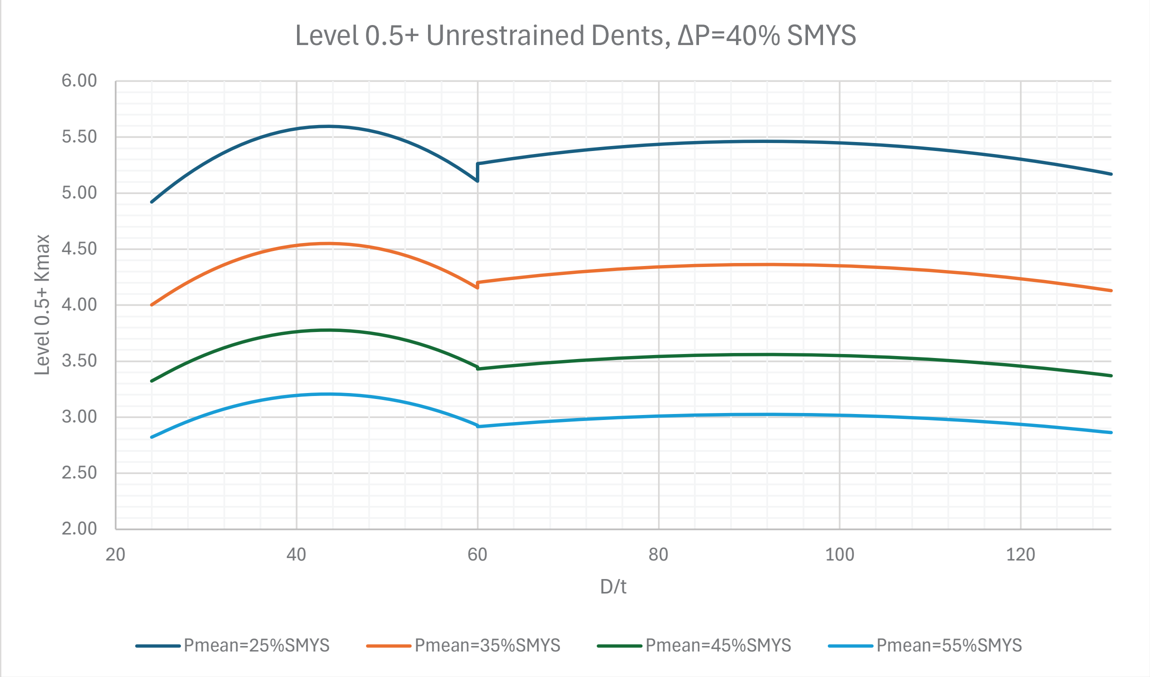

Figure 9: Level 0.5+ relationships for unrestrained Dents

https://doi.org/10.52202/078572-0027

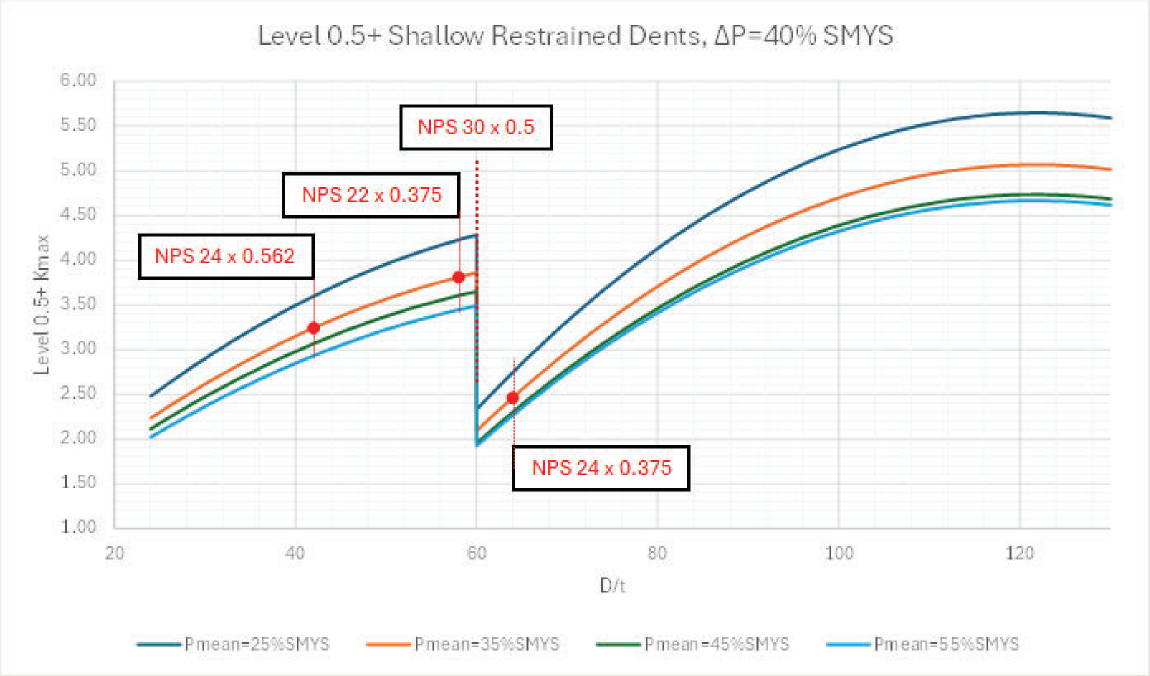

Figure 10: Level 0.5+ relationships for shallow restrained dents

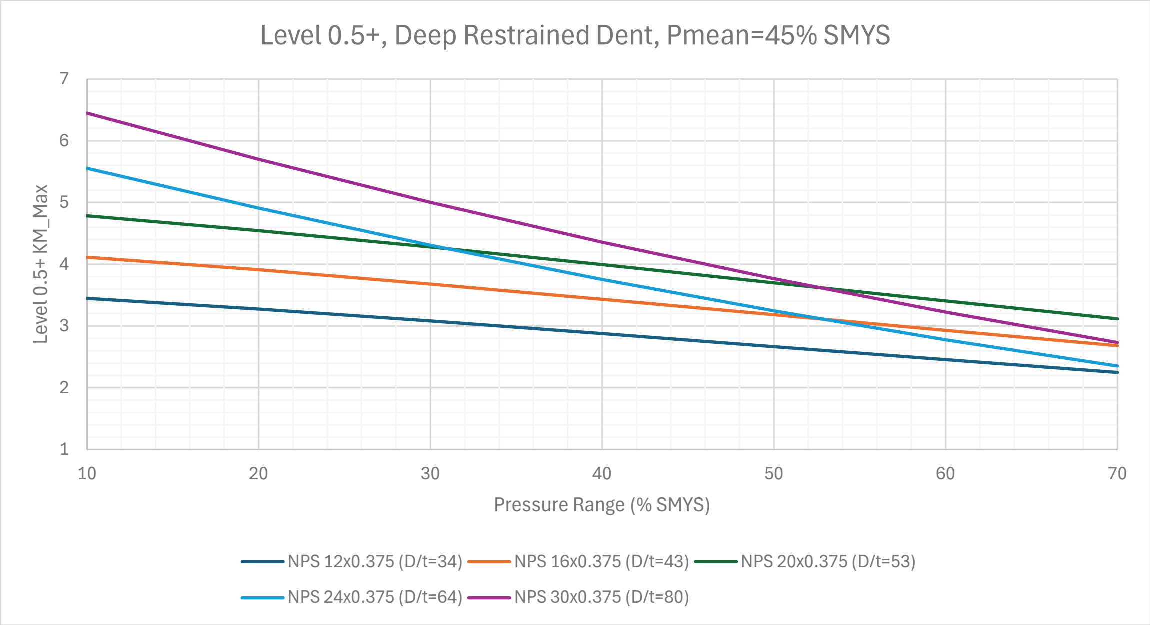

Figure 11: Level 0.5+ relationship for deep restrained dents with NWT=0.375”

https://doi.org/10.52202/078572-0027

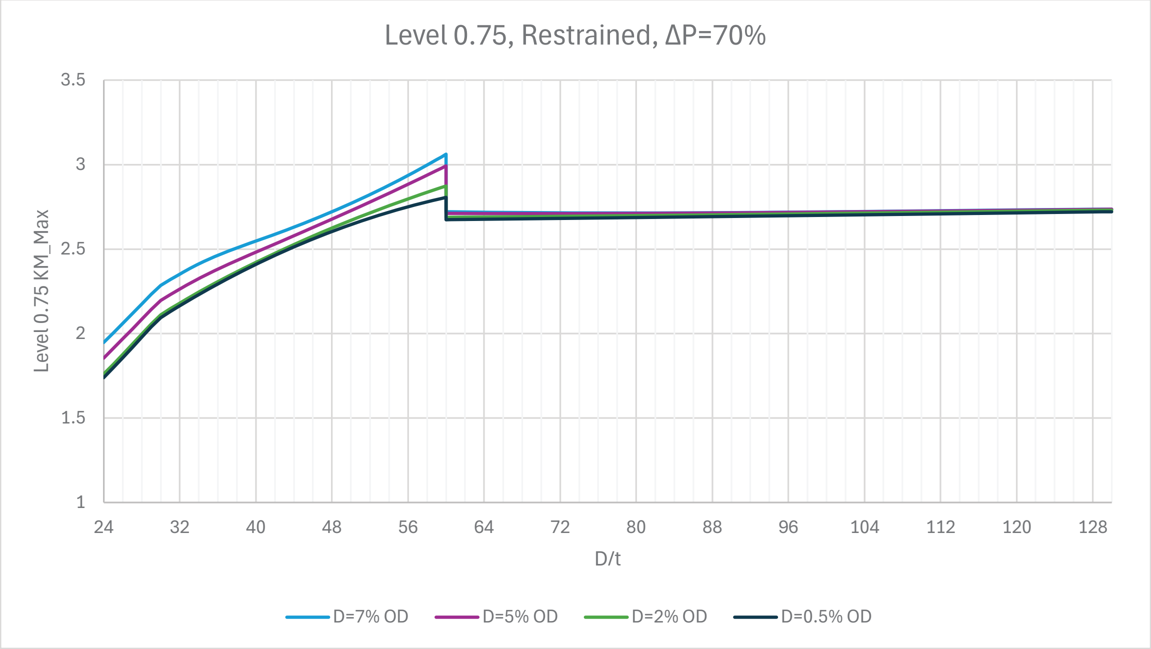

Figure 12: Level 0.75 for restrained dents, ΔP = 70% SMYS

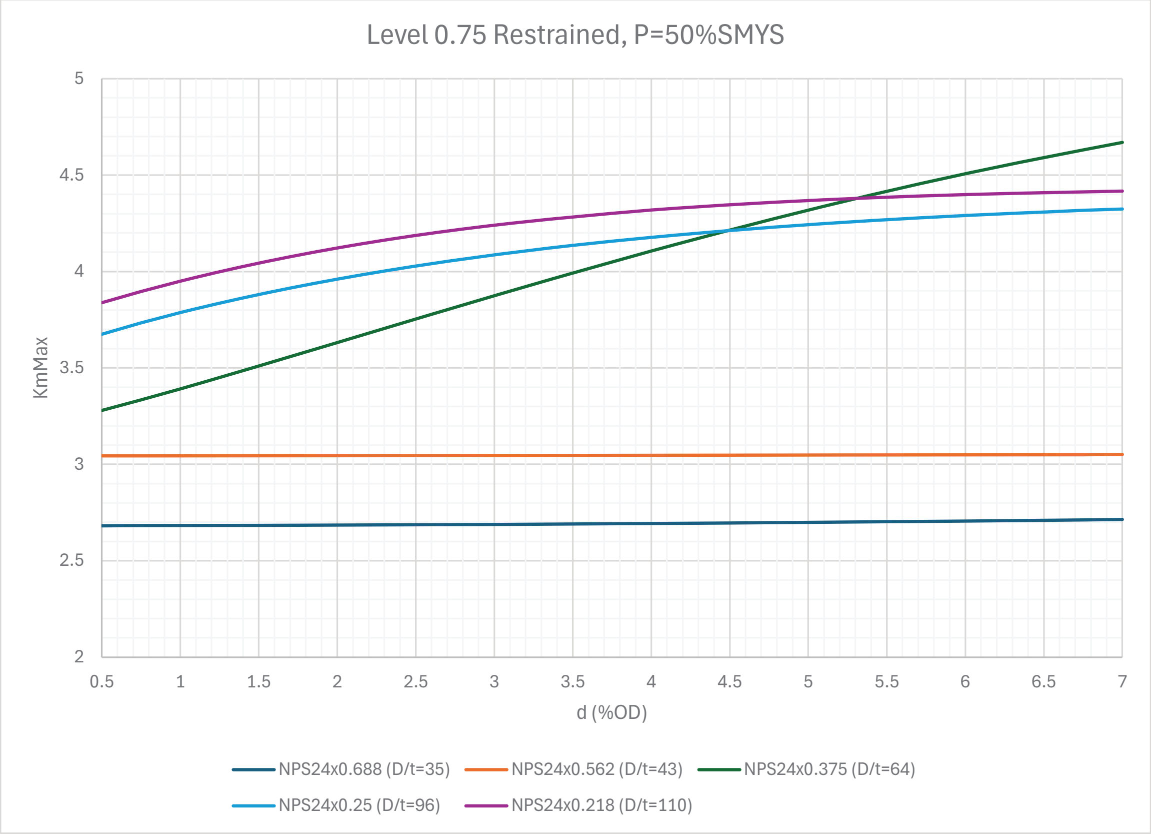

Figure 13: Level 0.75 for restrained dents, ΔP = 70% SMYS

https://doi.org/10.52202/078572-0027

Table 1. Example Variation in Shape Parameter Calculations

	Description	LAX 15 (in)	LAX 30 (in)	LAX 50 (in)	AAX 15 (in)	LTR 70 (in)	LTR 80 (in)	ATR 15 (in)	Max RP
Calc 1	**Engineer 1**	39.7	16.6	10.4	3.24	1.02	0.82	0.084	31.3
Calc 2	**Engineer 2**	22.7	14.2	9.0	1.24	0.98	0.78	0.064	23.4
Calc 3	**Engineer 3**	16.2	12.0	8.3	0.68	0.91	0.73	0.058	19.3
Calc 4	**ILI Analyst**	13.8	10.4	7.3	0.42	0.86	0.68	0.043	18.1
Calc 5	**ILI Analyst**	21.2	14.7	9.3	1.14	0.97	0.78	0.068	23.1
Calc 6	**Engineer 4**	39.7	17.3	10.3	3.4	1.1	0.9	0.1	30.1
Average		25.6	14.2	9.1	1.69	0.97	0.78	0.07	24.2
Std. Dev		11.4	2.6	1.2	1.30	0.08	0.08	0.02	5.5