RunCom™

Perform reliable, direct comparisons of corrosion growth between inspection runs

The ability to calculate accurate corrosion growth rates will be a key determinant in the success of your corrosion management strategy and, consequently, the future integrity of your pipeline.

Increase the value of your data

RunCom™ is Baker Hughes' suite of run comparison software designed to analyze data from multiple in-line inspections. It performs a direct, quantitative comparison to provide your decision makers with actionable information.

Our highly skilled analysts use RunCom to compare data from our MagneScan™, VECTRA™ GEMINI, as well as data from other vendors' tools. Importantly, in the event that successive inspection runs utilize different technologies, our MagneScan and VECTRA GEMINI inspections can be compared.

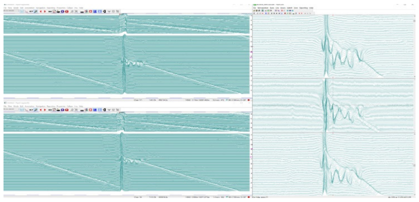
The software details the corrosion activity along an entire pipeline, confirms the effectiveness of past remedial measures, and provides the technical basis for safe and cost-effective remediation and operating plans.

Perform 'pure' comparisons

While less advanced comparison methods can indicate extreme corrosion growth between inspection runs, they cannot reliably quantify the precise extent or location of active corrosion. But this is exactly the level of detail needed to properly prioritize corrosion sites and develop successful, economical remediation strategies. In fact, it is for this reason that operators are advised to select a high-resolution inspection tool for their ILI activities.

RunCom provides a superior solution because it does not rely on previously processed data or second-hand information. One of the most common sources of error is the incorrect matching of corrosion sites. RunCom minimizes this possibility performing a direct and quantitative comparison of the raw inspection signals. This enables very high accuracy in matching corrosion sites. Through its signal scaling tools, RunCom adjusts for tool repeatability and maintains consistent sizing methods to minimize other error sources. This approach has proven to be up to three times more accurate than feature comparisons without RunCom.

Since its introduction in 1999, RunCom has proven to customers worldwide that it determines corrosion growth rates with greater confidence and higher accuracy than other methods.



RunCom performs side-by-side matching of raw signal data from various inspection tools to deliver 100% data matching accuracy and identify corrosion growth sites.

Features and benefits

- Detection of internal and external corrosion growth
- Quantification of corrosion growth throughout the pipeline
- Identification of new corrosion sites and any other new features (e.g. dents, touching metal objects, etc.)
- Signal to signal comparisons across different inspection technologies e.g. MagneScan vs VECTRA GEMINI inspections
- Provides visibility of corrosion activity (and any other changes) along an entire pipeline
- Gives early warning of active corrosion which enables cost-effective, early intervention
- Confirms where remedial measures have been effective, thus avoiding costly future excavations and repairs
- Provides a segmentation of the pipeline based on corrosion activity
- Enables better informed integrity and remediation planning decisions

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The information provided in a RunCom analysis is invaluable in the decision-making process and prioritization of the remedial measures necessary to limit future corrosion growth.

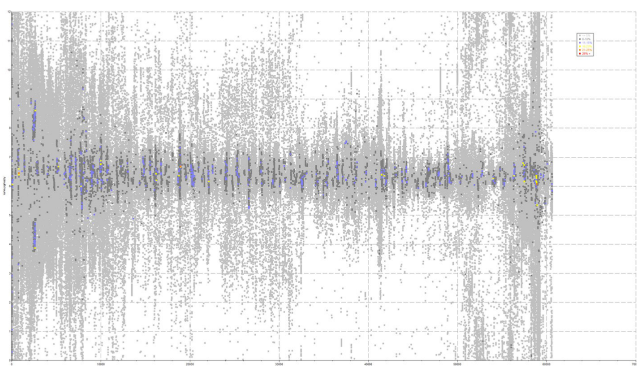
This information, together with an advanced integrity evaluation, will optimize future repair and re-inspection needs—resulting in significant cost savings—when compared with estimated rates and codified corrosion assessment methods.

RunCom Reporting Options

There is the option of a short RunCom Screening report which identifies a selection of the highest corrosion growth rates in the pipeline, recommending, if appropriate, a full RunCom assessment to be performed.

Standard RunCom reporting comprises signal matching for the full line followed by a manual assessment of a large sample of features.

An additional RunCom spool-based report can be provided following the Standard RunCom service. This includes a detailed listing of the external and internal corrosion growth rates along the entire pipeline on a spool-by-spool, feature-by-feature, and box-by-box basis, corrosion growth rate summary statistics, and charts showing the corrosion growth trends for the pipeline.



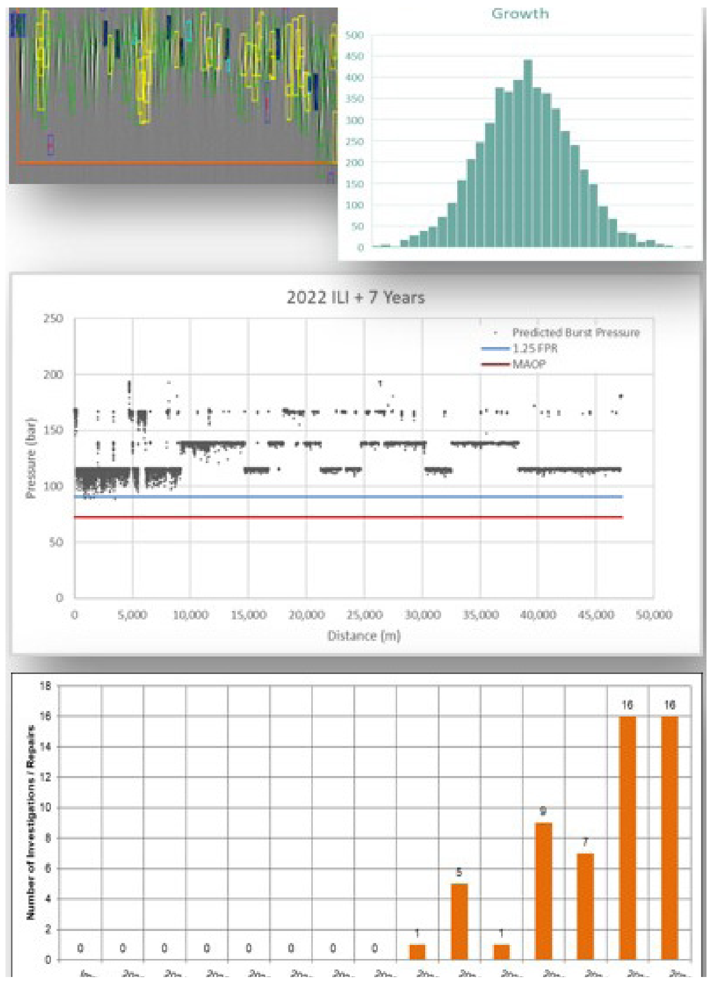
MFL RunCom typically delivers at least three times the accuracy of other box or feature comparisons methods available.

Related Integrity Assessments

A RunCom Plus assessment is available, which applies individual spool growth rates in a future integrity assessment of the metal loss in the pipeline to determine a time-based optimized repair plan.

The new RunCom Cluster Growth 3D assessment can be offered (with or after a RunCom assessment) to account for growth in all three dimensions (depth, length, and width). This most advanced assessment models the more complex interaction between nearby areas of corrosion to identify the corrosion areas that are most likely to require monitoring or intervention between inspections. This new approach:

- Uses a probabilistic simulation model to select rates from local distributions (groups) to account for variability of growth rate over time.
- Accounts for growth in depth, length and width dimensions and uses the LAPA (RSTRENG) burst pressure algorithm for assessing Cluster severity vs time.
- Models the potential for future interaction between nearby areas of corrosion via a machine learning neural net model to predict plausible sites and patterns of new defect initiation.
- Produces two growth scenarios (worst case and expected) to provide flexibility for evaluating future repair needs and optimising reinspection intervals.



A cluster severity assessment is provided (at 50th & 95th percentile scenarios), using the RSTRENG assessment method, which provides cluster dig predictions vs time.

BHCS39582 - 25001 (04/2025)

Fitness for Purpose (FFP) Assessment

Maximize the benefit of repeat ILI data

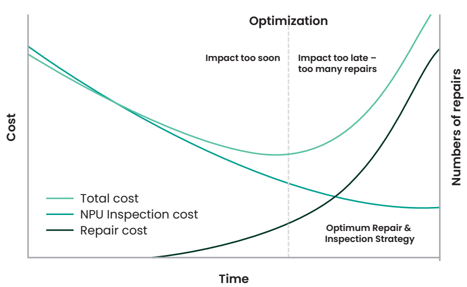
Want to use industry best practice to assess ILI reported features and anomalies?

Auto IE

The Auto IE (Integrity Evaluation) Report is an entry level pipeline integrity evaluation produced direct from the MFL ILI PipeImage data (Baker Hughes MagneScan™ and VECTRA™ GEMINI ILI data only). It delivers an automatically produced Excel based report containing a full description of the ILI findings, immediate and future integrity results in the form of a combined pipeline listing and repair plan.

Integrity Assessment

The full Integrity Assessment will evaluate the reported ILI features' expected affect on the pipeline's current and future performance. The assessment provides a future repair plan and re-inspection interval guidance, based on the pipeline's actual condition rather than on fixed intervals.



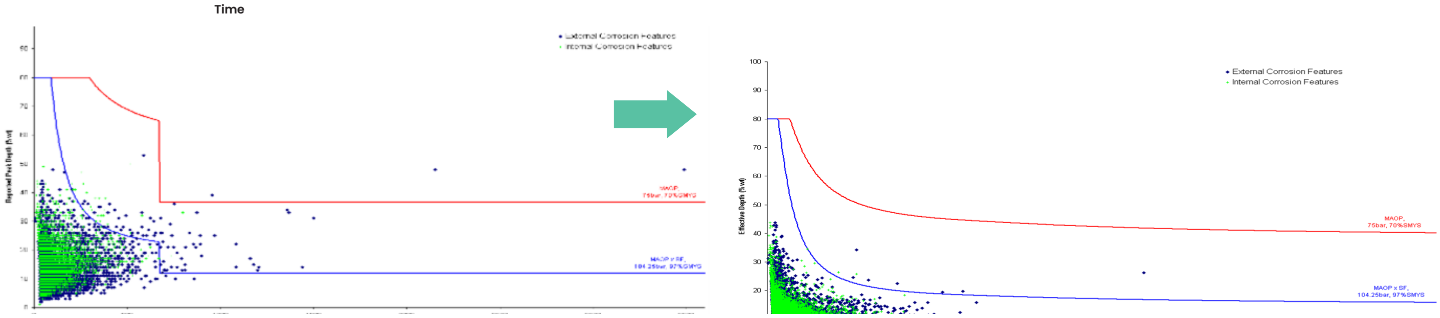
An integrity assessment can reduce your costs by eliminating unnecessary repairs, determining the future ILI interval and maintenance requirements on a demonstrable and justifiable basis.

The assessment considers the significance of metal loss features, reported dents and mill/ manufacturing defects. Pressure cycle induced fatigue, in relation to the reported dents, is also evaluated (where applicable).

Utilizing corrosion growth rate information (based on time in service, pressure history, or RunCom™), the features and their influence on the future integrity of the pipeline can be evaluated.

Features and Benefits

- Rigorous and fully documented assessment of the current and future predicted pipeline condition
- Assess the reported features and anomalies using the standard industry methodologies, tolerances and safety factors
- Avoid costly excavation and unnecessary repairs whilst maintaining safety by using more accurate assessment methods
- Determine pipeline deterioration mechanisms and provide a clear picture of future integrity issues
- Provide optimized repair and re-inspection plan based on economic and safety considerations
- Enables you to save time and resources by focusing on the excavation, repair, and remediation issues rather than data manipulation, assessment, and documentation



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Post Inspection Dent Assessment (PIDA)

Reduce risk, meet regulations and minimize costs

Is your pipeline at risk?

Mechanical damage is the single most significant integrity threat to both liquid and gas pipelines globally.

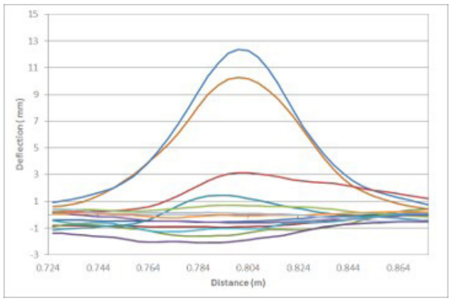
Dents can occur during pipeline construction or in-service causing a local stress and strain concentration and a local reduction in the pipe diameter. If failure as a result of a dent is not immediate, it is possible that the damage can deteriorate in service and cause failure at some time after the initial impact.

Mechanical damage events often go unreported, leaving the pipeline operator the challenge of distinguishing those defects that may threaten the pipeline's future integrity from those that are dormant and require no further action

Dent strain assessment

In recent years, there has been a shift from simple depth-based assessment of plain dents to the use of strain-based assessment that uses the dent local radius of curvature to define severity. The strain in a dent is a more relevant criterion for judging dent severity in terms of static behavior.

PIDA Strain provides a strain-based assessment of dents reported by in-line inspection including all plain, seam or girth weld dents and provides superior information compared to depth only assessments. The multi-channel caliper inspection data is processed to firstly eliminate noise and fit a series of B-spline curves throughout the dent area



and secondly to calculate the radii of curvature associated with the smoothed dent surface.

Many industry codes and recommended practices (e.g., ASME B31.8, CSA Z662, API RP 1160 and API RP 1183) recognize this advanced strain-based engineering assessment as an alternative to standard depth-based approaches.

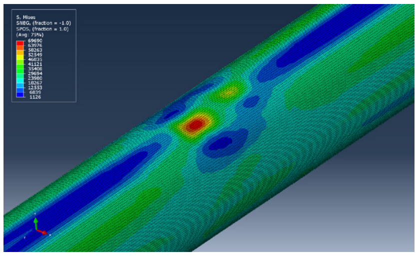
PIDA helps avoid unnecessary repairs while achieving regulatory compliance.

Dent fatigue assessment

In pipelines that are subjected to cyclic pressure loading, the presence of a dent produces a stress concentration that can initiate and grow fatigue cracks, even leading to failure in-service. It is important to assess the fatigue life of dents in such pipelines. PIDA Fatigue can offer the 3-levels of assessment as recommended by API RP 1183 for assessing dent severity in terms of fatigue damage.

Dent fatigue severity assessments using PRCI level 1 or level 2 methods involve extraction of depth, length and area attributes from the smoothed dent axial and circumferential profiles to evaluate dent restraint. The shape parameters are then used to assess the fatigue severity of all the reported dents.

For dents failing the Level 1 and 2 assessments, Level 3 can be conducted using Finite Element Analysis (FEA) to determine maximum stress amplitude and obtain allowable pressure cycles from SN design curves (for plain dents and dents associated with welds) to evaluate the remaining fatigue life.



Features and Benefits

- Accurate ranking of dents on a pipeline by severity of strain and/or fatigue life – not simply dent depth
- Application of advanced engineering techniques for assessing dent severity and meeting the requirements of an Engineering Criticality Assessment (ECA)
- Supports risk-based prioritization of remediation activities
- Minimize current and future risk of failure from latent dents
- Avoidance of unnecessary excavations and repairs

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LAPA™ Profile Integrity Assessment (LPIA)

LPIA can also be applied to the findings of the ILI survey making optimum use of a RunCom signal matching corrosion growth assessment.

LPIA makes use of every fragment of our RunCom data. We derive the depth profile through the area of corrosion that is represented by the ILI metal loss cluster and effectively grow the depth profile incrementally by applying the individual (box) growth rates direct from RunCom. At each time increment we re-calculate the corrosion profile using the LAPA methodology and check whether the profile has breached the acceptable pressure or depth limits set for the pipeline.

The outcome of the LPIA is an optimized response time for each reported metal loss cluster based on the specific set of measured corrosion growth rates which belong to that cluster.

RunCom Cluster Growth 3D Assessment (RCG3D)

A RunCom Cluster Growth 3D assessment takes into account the growth in all three dimensions (depth, length, and width) and models the more complex interaction between nearby areas of corrosion to identify the corrosion areas that are most likely to require monitoring or intervention between inspections.

By moving away from applying a fixed corrosion rate across individual clusters, or across a group, or even a whole pipeline of clusters, we are leveraging the real benefits of the RunCom data and optimizing the response timing for each of the metal loss clusters reported by the ILI survey, which in turn informs the decision regarding when to re-inspect.

PSqr Reporting

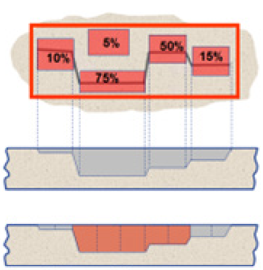
PSqr Reporting provides defect sentencing of the metal loss features reported by Baker Hughes magnetic ILI tools using a new methodology designed to provide a more accurate prediction of the burst pressure of an area of corrosion.

The PSqr model (also known as the Plausible Profiles model), developed by TC Energy in 2018/2019, removes unnecessary conservatism without compromising safety in the existing ASME B31G range of models (B31G, Modified B31G-0.85dL and Modified B31G-effective area (i.e., RSTRENG).

PSqr applies the fundamentals of RSTRENG but uses a novel approach to idealize the shape of the corrosion anomalies more accurately. RSTRENG uses a single worst-case river bottom profile to characterize the corrosion whereas PSqr uses multiple plausible profiles to characterize the corrosion profile. PSqr has been peer reviewed and validated in a 2019 PRCI project (Technical Report Plausible Profiles (PSqr) Model for Corrosion Assessment).

Applies to MagneScan and VECTRA GEMINI ILI datasets. The deliverable is calculation of burst pressure and safe operating pressure for all or selected metal loss clusters delivered in a Excel listing.

LAPA Length Adaptive Pressure Assessment



Corrosion boxes detected and clustered

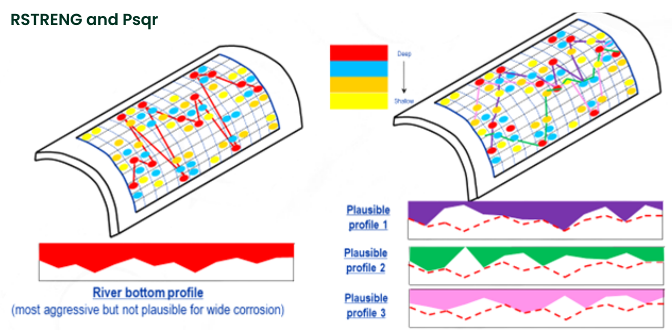
Maximum depth profile projected

RSTRENG failure pressure calculated

Minimum failure pressure

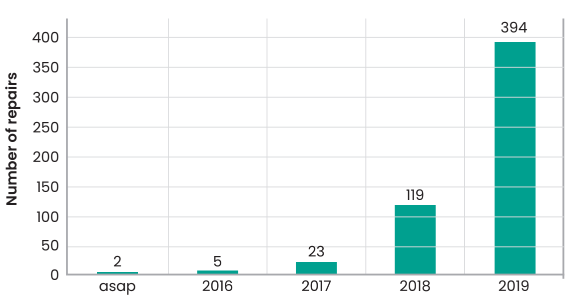
Conservatism in corrosion idealization

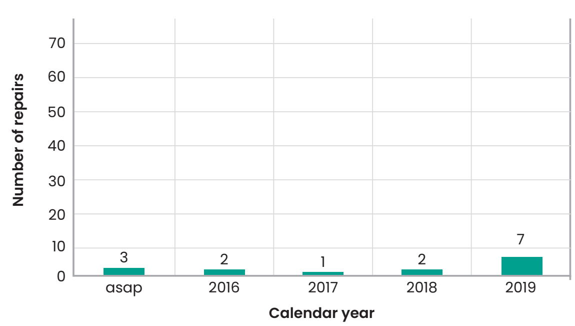
RSTRENG and Psqr



Difference between Psqr and RSTRENG – interacting corrosion in shape is more accurately characterized to avoid unnecessary repairs.

LAPA profile is grown using RunCom box rates.





Removes conservatism by applying local defect rates ➔ Less digs.

BHCS39583 - 25002 (04/2025)

Strain Assessment

Concerned about ground instability?

A bending strain assessment is conducted on the data collected by an Inertial Mapping Unit (IMU) inspection tool. The IMU provides curvature data which can be used for identification of areas of pipeline deformations and movements.

Deformations and movements can be caused by environmental and third-party interference events, such as:

- Landslips, subsidence
- Construction activities
- Thermal loadings
- Frost heave
- Scour
- Seabed movements
- Ships dragging their anchors or from trawl boards

Almost any pipeline can be affected by one or more of the above events but pipelines that are offshore, or in mountainous or geologically unstable areas are at particularly high risk. Pipeline curvature causes bending strain in the pipe wall which can lead to buckles or wrinkles, can exacerbate the significance of other defects especially cracks or even lead to global collapse in severe cases.

The bending strain assessment will assess the curvature throughout the pipeline and identify areas of pipeline movement, assess the bending strain associated with the changes in curvature and align the curvature data with ILI anomaly data to identify coincident geometric features and other anomalies.

A bending strain comparison (StrainCom™) study will compare bending strain features using two IMU data sets and identify where changes are occurring thus identifying where pipeline movement is taking place.

Standard resolution and high-resolution reporting levels are available for both the single IMU bending strain assessment and the strain comparison assessments.

Features and benefits

- Provide early warning of instability problems enabling proactive mitigation and remediation measures to be implemented.
- Apply advanced engineering techniques to locate high curvature and potentially high strain events resulting from ground instability events, e.g., landslide, earthquake, flooding, frost heave, construction damage, anchor drag, etc.
- Assess the extent of pipeline movement between IMU runs and of the resulting applied strains.
- Identify the pipeline anomalies, i.e., dents, buckles, ovalities, girth weld anomalies, corrosion, cracks etc., coincident with the strain event from available ILI data.
- Determine where strain events exceed industry guidelines.

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The following additional strain related services are also available for ONSHORE ONLY pipelines:

Total Strain Demand Report

The Total Strain Demand Report provides the total longitudinal strain (from IMU & AXISS™ combined) at:

- Each reportable bending strain and axial strain event
- All pipeline girth welds
- All reported metal loss & geometric anomalies.

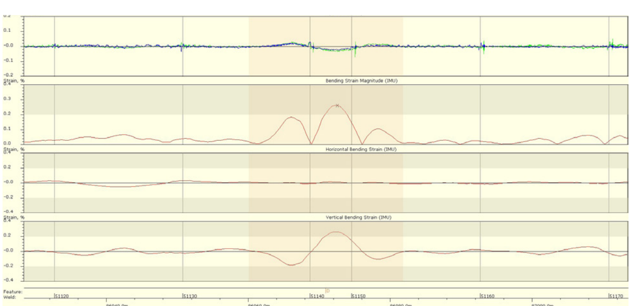
The AXISS EPS Axial Strain Inspection Technology is a non-contact electromagnetic technology, combined with the traditional magnetic flux leakage (MFL) inspection tool, which can be used to measure longitudinal strain in a pipeline.

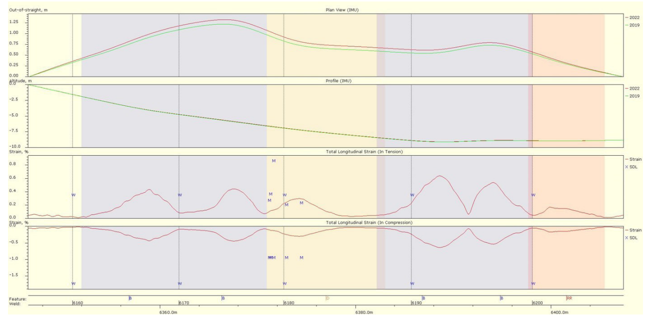
The strain demand comprises of both the longitudinal bending strain component (derived from the IMU data) and the pure axial strain component (measured using the AXISS EPS technology).

Strain demand is defined as the magnitude of strain acting on the pipeline and will vary along its length depending on the loads acting on the pipeline and the pipe geometry. The strain demand information is a required input into a strain-based integrity assessment of a pipeline section that is subject to a strain from external loads.

The Total Strain Demand Report is delivered through an Excel report and can be viewed interactively through the accompanying Strain viewer tool.

Strain viewer tool





Strain-based Integrity Assessment

The Strain-based Integrity Assessment is an engineering assessment of the severity of reported strain events. The assessment involves the calculation of the strain capacity at girth welds and at reported corrosion and geometry features that are within reported strain events and comparison against the strain demand.

Pipelines experiencing elevated longitudinal strains can potentially fail by tensile leak or rupture or by compressive buckling. The strain capacity is defined as the strain level a pipe segment can sustain without experiencing negative consequences. The negative consequences could be a leak, a rupture, or any other unacceptable change of the physical characteristics of the pipeline e.g., buckle or wrinkle. The tensile strain capacity (TSC) represents the pipe segment strain capacity under tensile loading conditions and the compressive strain capacity (CSC) under compressive loads.

- Under tensile longitudinal strain, the main integrity concern is a leak or rupture at an affected girth weld or other weakened location.
- Compressive longitudinal strain may cause the formation of wrinkles or buckles in the affected pipe segment leading to a structural integrity concern. The presence of girth weld anomalies, metal loss defects and dents can also affect capability of the pipe to sustain longitudinal loading.

The Strain-based Integrity Assessment applies industry accepted models for calculating strain capacity and the corresponding strain demand limit. The assessment can be provided following IMU+AXISS EPS surveys or just following an IMU Bending Strain Assessment and is delivered through a written engineering assessment report with accompanying Excel listings and interactive Strain viewer software tool.

Features and benefits

- Supports compliance with regulatory safety notices regarding girth weld integrity concerns.
- Comparison of strain demand (loading) vs strain demand limit (strength) is needed for making pipeline integrity decisions.
- Enables differentiation between "real" strain events and intentional construction related bending.
- Reduces spend on unnecessary geotechnical work by filtering out strain events where pipeline has enough strain capacity to withstand the deformation.

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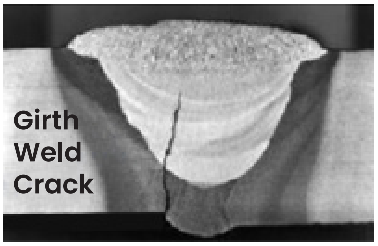
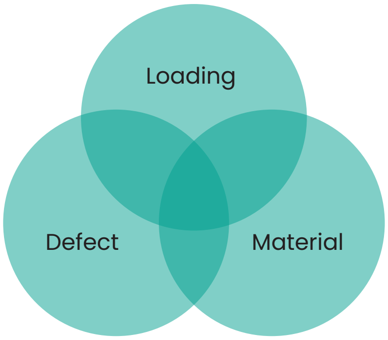
ILI Based Girth Weld Threat Assessment

Concerns regarding the integrity of girth welds in a pipeline?

Although girth weld failures are less common, there is an increasing awareness of the potential for in-service failure at girth welds.



Girth weld failures are usually a combination of interacting threats, comprising of axial loading (from ground instability or thermal loads), defects within welds (weld cracks, anomalies or corrosion attack) and material (substandard weld material properties).



Individually these threats may not present a significant threat to the integrity of the pipeline, however, where two or more of these indicators are coincident, they can be of greater concern.

An ILI based Girth Weld Threat Assessment, conducted with the results of a MagneScan™ inspection combined with other inspection technologies (e.g., caliper, IMU) can identify the presence of multiple girth weld threat indicators:

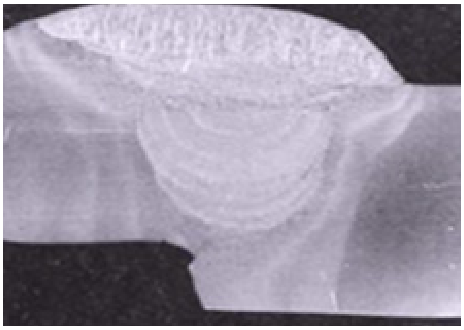
- Girth weld cracks, anomalies and discontinuities.
- Wall thickness transitions.
- Tie in welds.
- Dents/wrinkles/ovalities around weld area.
- Girth weld circumferential corrosion and rate of growth.
- Bending strain (from IMU) / Axial Strain (from AXISS™) acting at the weld.

The load bearing capacity (tensile strain capacity) of girth welds in a pipeline will be reduced by the presence of welding imperfections (weld defects, irregular weld profiles, under-matching), corrosion and other defects. Hence these affected girth welds are of concern particularly under axial loads.

The strain demand at a girth weld will be increased by the presence of geotechnical hazards that cause axial strain and/or axial bending strain. In addition, axial strain can also be introduced and during construction (e.g., due to roping) or afterwards (due to settlement).

Failure at a girth weld will occur when the strain demand exceeds the weld strain capacity. The aim of this service is to identify the girth welds at highest risk.

The deliverable, an Excel based report is provided listing the pipeline girth welds, the threat indicators and the qualitative prioritization both in isolation and accounting for coincident indicators.



Features and Benefits

- Multiple ILI data sets integrated into one consolidated girth weld listing.
- Used to identify and prioritise girth welds for investigation on the presence of multiple indicators and coincidences.
- By identifying combinations of threat indicators, girth welds are prioritized for investigation.
- Enables proactive intervention.

BHCS39586 - 25005 (03/2025)

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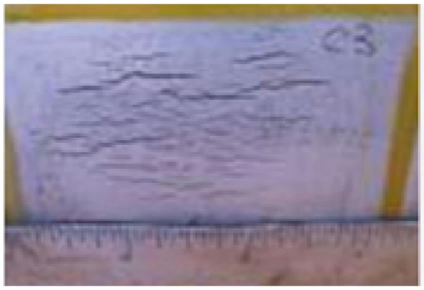
Pipeline Integrity Crack Assessment (PICA)

Need to mitigate a crack threat?

Cracking is the most severe type of defect within a pipeline and crack growth rates can be fast, with failure often resulting in a rupture.

PICA is an Engineering Critical Assessment (ECA) of cracks using fracture mechanics and fatigue crack growth methods. It is conducted with the results of an ultrasonic crack inspection (UltraScan™ CD Plus, EMATScan™) or Transverse Field Inspection (TranScan™).



A wide range of pipeline integrity crack assessment services are available from Baker Hughes from the provision of crack profile data and crack field statistics through to the comprehensive pipeline fracture and fatigue assessment using different assessment methodologies (including API 579, BS 7910, CorLas, Modified Log-Secant, and PRCI MAT-8 methods).

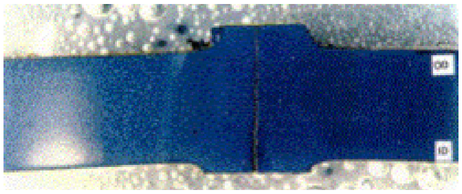
Where required, a pipeline integrity crack assessment will also include fatigue assessment of pressure cycle loading on the remaining subcritical features or effect of SCC growth on sub-critical crack colony features in a remaining life assessment.

Detailed crack profiles and advanced crack field parameters can be used in this assessment (on UltraScan CD Plus data) to reduce unnecessary conservatism and to provide absolute predictions of the crack burst and safe operating pressures.

Appropriate investigation/repair schedules can be provided, and the optimum re-inspection interval can be determined.

Found ERW Seam Weld anomalies and need to mitigate the threat?

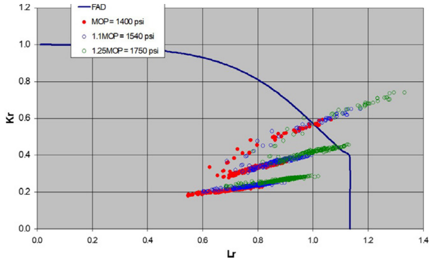
Following a TranScan (TFI) in-line inspection an ECA can be conducted on the ERW Seam Weld Cracks as reported by the TFI inspection survey in accordance with the current and future pipeline operating conditions.



An ERW Seam Weld assessment will produce a prioritized excavation/repair plan to help optimize your costs by eliminating unnecessary repairs, prioritizing the future in-line inspection (ILI) interval and maintenance requirements on a demonstrable and justifiable basis.

The assessment will provide the significance of reported seam weld cracks, metal loss features and anomalies in relation to the immediate and future integrity of the pipeline.

The deliverable will be a prioritized excavation/repair plan aimed at eliminating unnecessary repairs whilst maintaining safety and an optimization of the future in-line inspection (ILI) interval and maintenance requirements on a demonstrable and justifiable basis.



Features and Benefits

- Provide rigorous and fully documented ECA of the reported crack / ERW features in relation to the current and future pipeline operating conditions.
- Assess the reported features and anomalies using the best industry practice methodologies, tolerances, and safety factors (Level II FAD approaches in API 579 and BS7910 (for ERW features), and CorLas assessment methodology, Modified Log-Secant method or PRCI MAT-8 (for cracks)).
- Utilize higher accuracy crack profiles and field parameters to determine the significance of features reported to avoid unnecessary and costly excavations and repairs.
- Mitigate known crack / ERW seam weld threats (either from SCC, pressure-cycle induced fatigue and/ or ERW seam problems or selective corrosion).

BHCS39587 - 25006 (04/2025)

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Depth of Cover

Protection against external interference, weather & outside force threats

Pipeline depth of cover can change over time due to natural erosion, shrinkage of soils, human activity, or failure of anti-buoyancy systems.

Third-party interference is a major cause of damage to buried pipelines. In addition to routine surveillance, maintaining a minimum depth of cover is recognized as a key means of mitigation against third-party interference and exposure related threats.

Pipeline design codes set out minimum Depth of Cover requirements depending on pipeline location which can vary between 0.4 to 1.8m (1.3 to 5.9ft) depending on the terrain/land use. Operators must monitor and remediate where cover is reduced or lost.

Baker Hughes Depth of Cover assessment combines Inertial Mapping Unit (IMU) measured vertical position (collected with the in-line inspection) with ground elevation data. To capture ground elevation data on a large scale LiDAR (light detection & ranging) survey data can be used to calculate the depth of cover along the pipeline route.

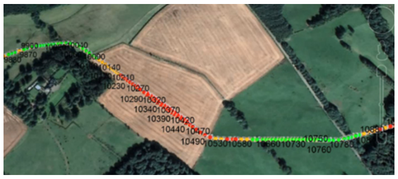
Note that the depth of cover can only be assessed in locations where both the LiDAR ground elevation and IMU centerline data is available. The LiDAR ground elevation digital model will be less accurate in locations with dense vegetation and cannot be obtained in waterways or from terrain that is covered by buildings.

LiDAR is a remote sensing method which uses laser light to measure distance to a target and is commonly used to map terrain and surface objects.

The advantage of this method is that a large amount of highly accurate data can be collected allowing the creation of a digital elevation model covering large areas such as a pipeline route. Many countries have freely available high-resolution LiDAR data collected by government agencies.

Features and Benefits

- Traditional over-line survey techniques are available for measuring depth of cover on a buried pipeline, but require significant effort, cost, and time to produce a high-resolution survey for an entire pipeline
- This service combines IMU measured vertical position with LiDAR ground elevation data to enable depth of cover evaluation along the full length of the pipeline
- The deliverable is an MS Excel report providing depth of cover measurements at every metre along the pipeline with identification of locations where cover depth is estimated to be below code requirement
- Provides charts of Depth of Cover versus distance (including tie-in points, bends) and pipeline vertical profile / ground elevation versus distance
- KMZ file is provided to explore the pipeline route and Depth of Cover results in a geo-browse



BHCS39588 - 25007 (04/2025)

ILI Based Risk

A semi-quantitative risk assessment using ILI condition data

Whilst a wholescale move to quantitative risk modelling can be daunting, a semi-quantitative risk assessment can be achieved using ILI condition data.

Pipeline risk assessment is a foundational component of effective pipeline integrity management. The industry is moving towards the use of more quantitative approaches to risk assessment. The use of risk models enables superior understanding of the risks from pipeline systems and improves the critical safety information feeding into the overall integrity and risk management processes.

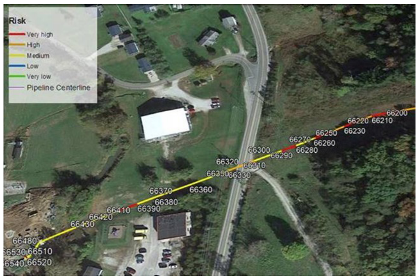
Baker Hughes have developed a risk assessment model based on pipeline data that is available following routine ILI surveys for pipelines. The risk model runs without a complex GIS or other pipeline databases and can be delivered following completion of the ILI analysis report.

The ILI based risk assessment provides a risk assessment for the pipeline threats detectable by ILI. It enables an evaluation of risk preventive and mitigative measures using quantitative ILI data to support risk management decisions.

Risk model

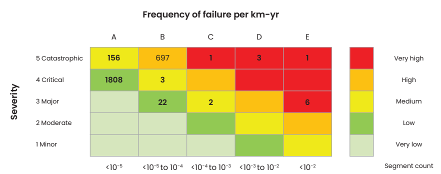
- Semi-quantitative risk model
- Outputs risk, threat probabilities and consequences of pipeline failure (loss of containment)
- Integrates available ILI and integrity data, corrosion growth, dent strain, pipeline bending strain.
- Considers threat interaction.
- Supports risk-based response planning.

> ASME B31.8S "The interactive nature of threats (i.e., more than one threat occurring on a section of pipeline at the same time) shall also be considered. An example of such interaction is corrosion at a location that also has third-party damage."



Excel based report deliverable containing:

- Summary of ILI results
- Summary of risk results (risk matrix)
- Risk profile along pipeline route (by threat, consequence and risk).
- ILI metal loss listing with cluster failure probability results.
- Joint based threat failure frequency, consequence and risk results listing.
- Segment based threat failure frequency, consequence and risk results listing.



Features and Benefits

- Identify high risk locations / main contributing threats
- Evaluate the risk against an acceptance criterion
- Evaluate the changes in risk over time
- Guide risk mitigation actions and integrity management decisions
- Demonstrate regulatory compliance

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Wrinkle Bend Assessment

Why carry out a wrinkle bend assessment?

Wrinkle bends occur due to a historical construction procedure for field bending pipe that can introduce wrinkles into the inner radius of the formed bend. At that time, the resulting wrinkles (outward deformations) were thought to be relatively benign however, more recently, there has been uncertainty regarding their impact on pipeline integrity, particularly when combined with corrosion or cracking or if subjected to external loads (e.g., from ground instability). It is important for an operator to know the location and extent of these anomalies if they are present in their pipeline systems.

The primary detection and assessment of the wrinkle bends is typically done using high-resolution caliper tool data. When combined with an Inertial Mapping Unit (IMU) tool this gives information on the bend angle and bend radius of the underlying bend as well as knowledge of the bending strain or pipeline movement (from repeat IMU runs).

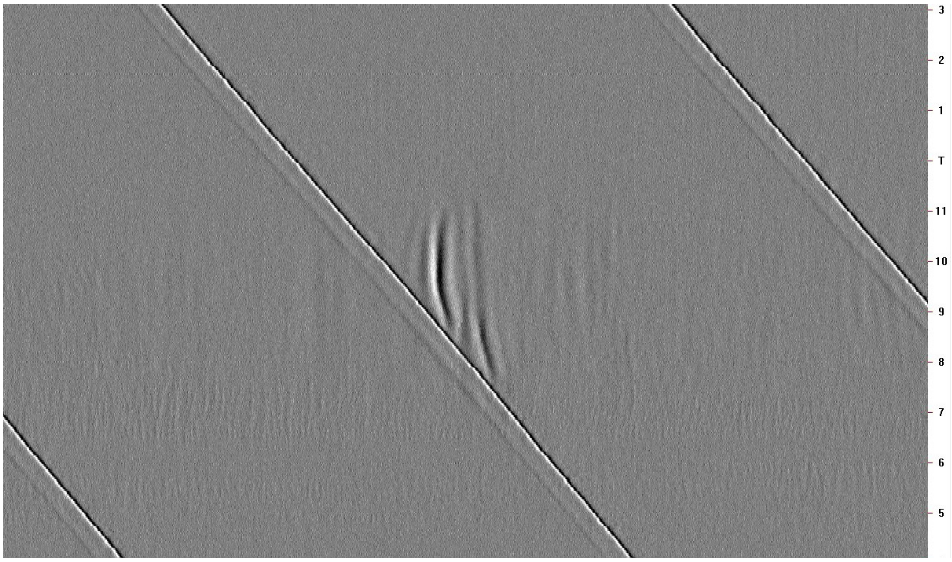
Adding MagneScan™ inspection data provides information on potential stress concentrators due to the interaction of the wrinkles with seam welds and, importantly, information on corrosion interacting with the wrinkles.

A PRCI study investigated wrinkle bend failures to identify the primary threats present. Based on these primary threats and working with several operators, Baker Hughes has developed a set of risk indicators for wrinkle bends and their interaction with stress concentrations to support the identification of potential problematic wrinkle bends. The wrinkle bend coincident attribute score (CAS) can be used to prioritise wrinkle bends based on severity and presence of the following criteria:

- Interaction with the seam weld
- Bend direction
- Distance between over bends
- Adjacency of tie-in pieces
- Presence and location of corrosion
- Proximity to bending strain (and movement) events
- Proximity to crossings

Features and Benefits

- Integration of multiple ILI data sets and an integrity risk-based evaluation
- Identification and prioritization of the wrinkle bends vs level of threat (low, medium, high) to support planning of risk mitigation
- Part of an effective integrity management strategy to assess risk in wrinkle bends
- An enabler for proactive intervention



Wrinkle bend as shown in MFL signals

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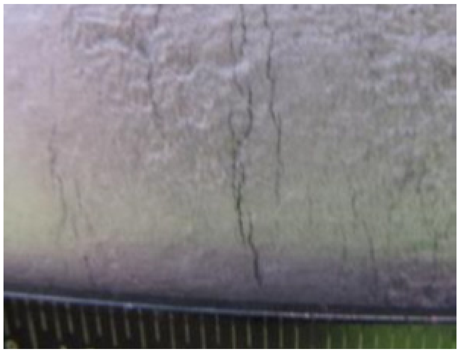
CSCC Threat Assessment

Need to mitigate a CSCC threat?

Circumferential Stress Corrosion Cracking (CSCC) is a subset of SCC, where the principal stress acting on the crack is an axial stress (acting in the longitudinal direction of the pipeline).



As with axial SCC the cracks grow perpendicular to the principle tensile stress, so for CSCC, the tensile axial stress must exceed the internal pressure induced hoop stress. In a pipeline there are multiple potential sources of axial stress... for example from internal pressure, thermal expansion or contraction, bending stresses from cold bends, pipeline crossings, tie-in points, dents or ground movement. One or more of these sources of stress could act upon the pipe and if the sum of the axial stresses exceed the hoop stress then CSCC is possible if the environment for SCC to occur is present.

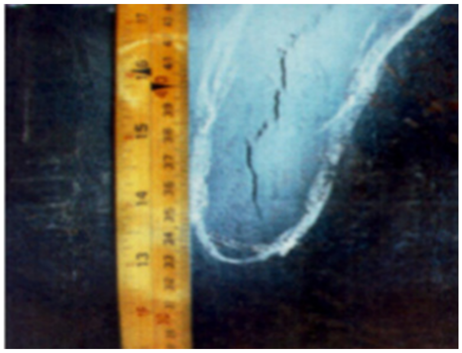
The availability and use of In-line inspection (ILI) tools to reliably detect CSCC is not as advanced, or industry accepted as it is for axial cracking. Hence, for most operators an alternative approach for assessing the susceptibility of a pipeline to this threat and prioritizing pipeline segments for evaluation is required.

CSCC susceptibility assessment

Baker Hughes has used industry research and operator feedback to identify a set of ILI detectable conditions augmented by other known parameters that together indicate potential susceptibility to CSCC.

The assessment protocol identifies the pipeline segments with susceptibility to CSCC based on the number of threat indicators that occur in the same location. The threat indicators, taken in isolation, may not all present a susceptibility to CSCC, however, where a certain combination of these indicators occur coincidently the susceptibility of CSCC will be greater.

The presence of multiple indicators is used to assign a threat score. Based on the combination of certain CSCC threat indicators the pipeline segments are prioritized for further review or field investigation.



The assessment is delivered in a report that provides a listing of all pipe spools, detailing the CSCC threat scores assigned and supplemented with the gathered information on the pipeline.

KMZ files can be provided to display the CSCC threat scores in a Geobrowser.

Features and benefits

- An alternative approach for assessing CSCC susceptibility and prioritizing pipeline locations for further evaluation
- Uses MFL ILI in combination with other technologies and pipeline data to identify threat indicators closely associated with CSCC occurrence
- Every joint is evaluated for CSCC threat indicators and scoring is assigned
- Presence of multiple indicators is used to prioritize the segments with the highest CSCC threats
- The assessment approach can be tailored to cater for the operator and ILI data available

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Ovality Assessment

Determination of Potential Local Pipeline Collapse / Buckling

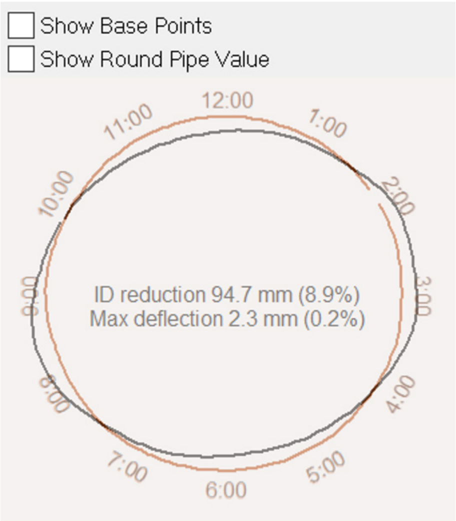
What are ovalities?

An ovality (out-of-roundness of the pipe) is a deviation from circular cross-section and is a common result of external pressure, bending and / or compressive axial stress.

Ovalities are identifiable and measurable using high resolution caliper data. Ovalities are measured in terms of their maximum and minimum internal pipe diameters (D_{max} and D_{min}).

Why assess ovalities?

Ovalities cause a variation in the hoop stress around the circumference of the pipe as well as local stress concentrations. Ovalities can also reduce the collapse pressure of the pipe under external pressure loading and can also reduce the static and fatigue strength of the pipe.



Our assessment approach

The assessment is performed using data from high-resolution caliper in-line inspection tools.

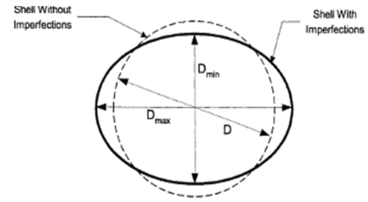
The local strain associated with the geometry of the ovalities are determined and assessed against allowable codified strain limits.

The imposed hoop stress at the ovalities is calculated to determine those which exceed design and/or global yield limits.

Where previous measurement data of ovalities is available (i.e. from a caliper inspection tool), any changes, i.e. increase in, or extent of ovalisation is determined.

Alignment of the ovality locations with pipeline bending strain / pipe strain change (pipeline movement) data resulting from analysis of any available inertial mapping unit (IMU) data. This allows identification of possible cause, additional external loading, and possible ongoing instability issues.

Further qualitative consideration of any pipeline cyclic pressure loading, coincident pipeline features, e.g. dents, metal loss etc. as well as geographical terrain and proximity to local infrastructure e.g. major roads.



Features and benefits

- Identification of unacceptable levels of localised strain due to the ovalities, calculation of the imposed hoop stress and determination of maximum depths of cover to limit further ovalisation which could lead to potential collapse / buckling
- Determination of any change in ovalisation
- Identification of possible cause, and threats to the future stability of the ovalities
- Qualitative consideration of cyclic pressure, coincident features, geographical terrain and proximity to local infrastructure
- An integrity consultancy report detailing the assessment and identifying potential problematic ovalities with appropriate measures given for their mitigation

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