THE DOWNHOLE VISUAL ANALYTICS COMPANY

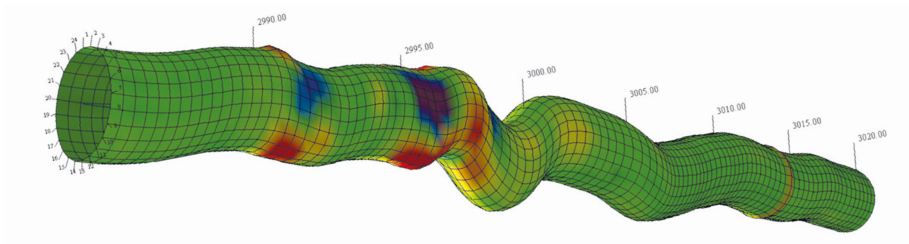
Powered by EV Epidote

PIPE DEFORMATION ANALYSIS

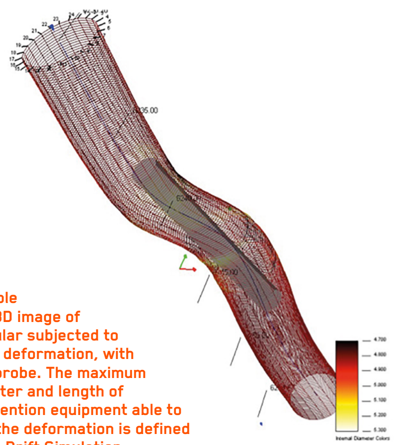
Pipe Deformation Analysis is EV Epidote's proprietary, in-house developed method of analysing caliper data to better define the 3D geometry of tubulars that are sheared, buckled or deformed by other mechanisms

Pipe Deformation Analysis (PDA) quantifies the 3D geometry of buckled tubing or casing, predicts well access limitations and provides insight to the cause and effects of deformation.

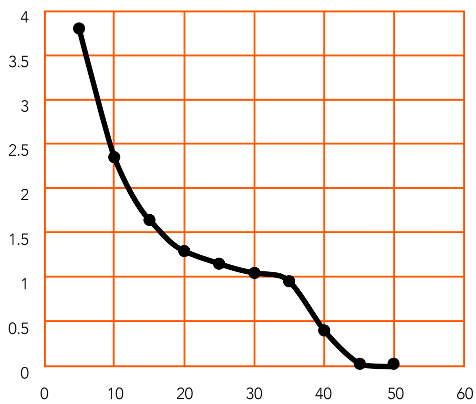
Tubular deformation is identified, measured and understood using the response of standard Multi Finger Caliper data. The method uses a proprietary inversion scheme based on caliper eccentricity and tool geometry, using software based on EV Epidote's MIPSPro analysis package.



The complex 3D geometry of a well subjected to steam induced deformation is defined using PDA. Well access was severely restricted, but interventions could be planned following PDA Drift analysis.



Example MIPS3D image of a tubular subjected to shear deformation, with drift probe. The maximum diameter and length of intervention equipment able to pass the deformation is defined by the Drift Simulation chart to the right.



Well Access Drift Simulation
Maximum Drift Diameter (ins) vs Probe Length (ft)

Casing, liner or tubing can be deformed and damaged in various ways. These include shear deformation caused by fault re-activation; bending caused by uneven lateral loading; and 'helical buckling' of tubing due to unexpected mechanical issues, or temperature and pressure changes. All these examples are of concern to the operator due to restricted well access and potentially compromised pipe integrity.

PDA analysis of deformed tubulars provides the operator with an accurate 3D geometric description of the damaged pipe including the length, direction and magnitude of the deformation offset from the original pipe centre line. The geometry of the deformation can provide insight to its cause, or confirmation of existing predictions. Results may also be of value to well or field scale Geomechanical models.

OVERVIEW

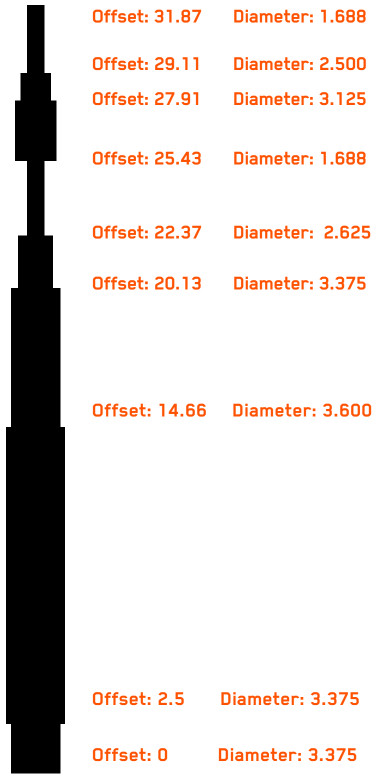
DRIFT ANALYSIS

Having defined the 3D shape of a deformation, drift calculations are made providing limitations for the length and diameter of intervention equipment that can descend past the deformation. The ability to access the well with a wide range of intervention equipment is determined.

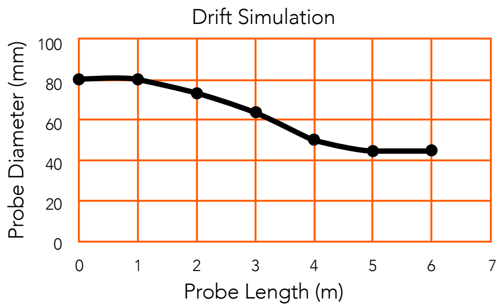
- Interventions can be planned accounting for access limitations, and operational savings made by eliminating drift runs and unsuccessful attempts to access the well with incorrectly sized intervention equipment.
- Up to four modes of drift analysis are calculated, with a chart of maximum drift probe diameter versus length being a primary output.
- Specific interventions equipment or toolstrings can be readily modelled to confirm ability to descend / ascend past the deformation:

- Slickline toolstrings	- Expandable tubulars
- Wireline instruments	- Patches, straddles
- Coiled Tubing BHA	- Plugs, Packers
- Drilling BHA	- Perforating guns

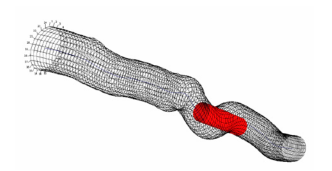
- Drift analysis results include maximum clearance when access is possible, or hold up depth when restriction prevents access for a specific toolstring.
- Method has been applied to well abandonment to predict tubular retrieval through deformation.
- Fast turnaround product available when immediate operational decisions are required.



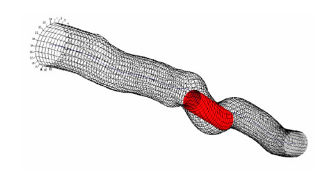
Example toolstring or other item of intervention equipment that can be modelled to predict potential well access issues. Recommendations can be provided on the suitability of the planned intervention equipment, and suggestions made for alternative configurations when access limitations are predicted.



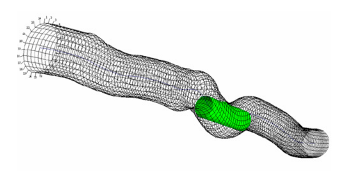
Example drift diameter against length chart for uniform cylinders predicting intervention equipment access through a deformation. Chart shows for example that a 51mm (2.0") OD item of equipment will pass this deformation only if its length is less than 4.0m (13.1ft).



3.5m x 60mm diameter drift unable to descend below deformation



3m x 65mm diameter drift unable to descend below deformation

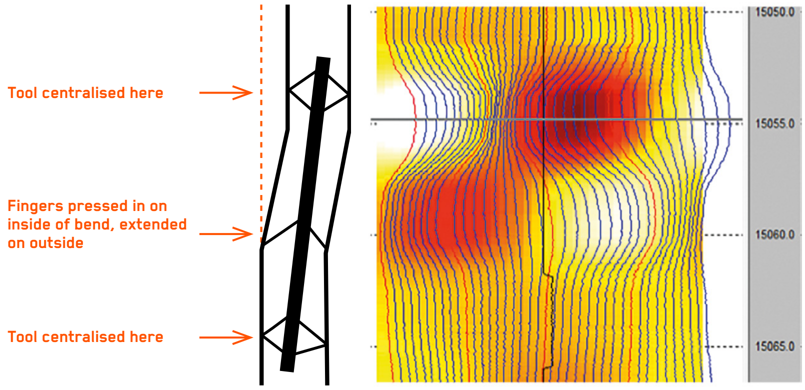


3m x 60mm diameter drift able to descend below deformation

3D images and interactive MIPSView simulations or videos of deformation and selected drift probes are provided to help visualise and quickly communicate results. Examples demonstrate well access is possible for a 3m length x 60mm OD item, but not possible for a slightly larger OD (3m length x 65mm) or slightly longer (3.5m length x 60mm) items of equipment.

METHOD

PDA uses an inversion technique to calculate the geometry of the deformed tubular using eccentricity information from multi-finger caliper (MFC) data. As an MFC instrument traverses a short radius bend a characteristic signature is produced in the data as the measuring fingers on the inner side of the deformation are pressed in, and those on the outer side are extended.



Observed 'signature' in multi-finger caliper data due to decentralisation over a deformation

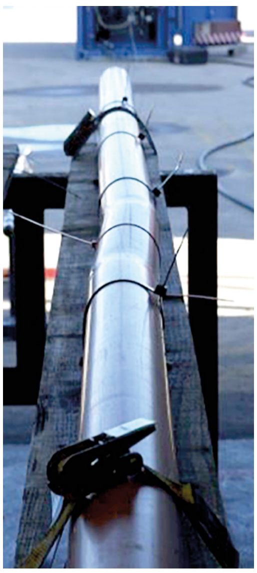
MIPSPro software calculates the caliper eccentricity, and with knowledge of the toolstring geometry an inversion method is used to calculate the centre line geometry of the deformation. 'Natural' eccentricity due to gravity is accounted for in the analysis, along with any doglegs in the original wellbore path. Boundary conditions are applied during the inversion to constrain results. A closely spaced gyroscope survey dataset (sometimes referred to as a 'continuous' or 'high resolution' gyro) can equally be used define the wellbore centerline through the deformation.

With the centre line of the deformation defined the centralised caliper data is 'wrapped around' it preserving any ovality, localised 'kinks' or metal loss over the deformation zone. These features are thus accounted for and enhance accuracy of the subsequent drift analysis.

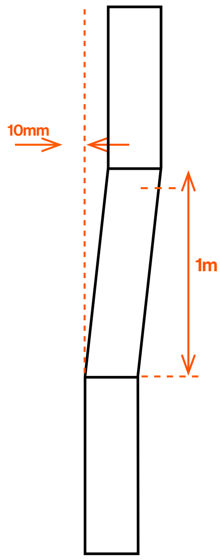
VERIFICATION AND OPERATIONAL CONSIDERATIONS

Pipe yard tests were satisfactorily performed to confirm methodology and computations. A tubular with known deformation was logged with a multi-finger caliper toolstring, Pipe Deformation Analysis performed and results compared with the original known deformation. These tests also provided straightforward recommendations for optimal tool-string configurations for future surveys.

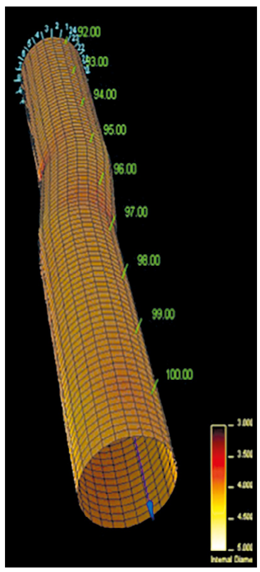
Pipe Yard test (courtesy of Altus Intervention) demonstrating close agreement between PDA results and actual deformed pipe



Pipe Yard Tests



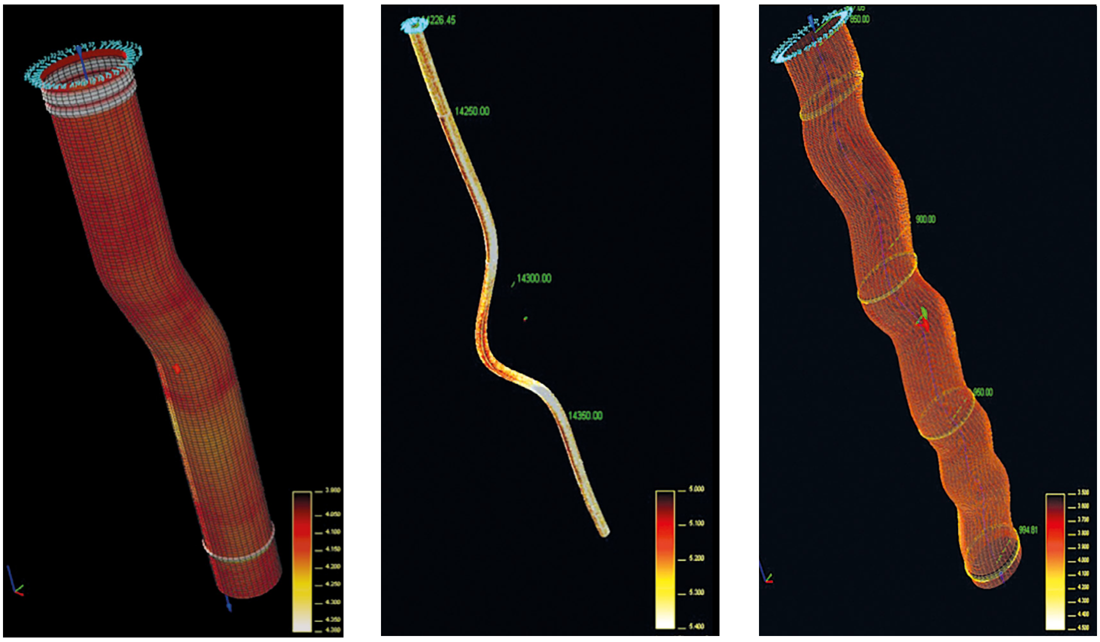
Test Geometry



Model Results

APPLICATIONS

EV Epidote have completed analysis for a number of major North Sea, US and Canadian operators of helical, shear and 'Euler' deformations ranging from a few feet in length to those extending to many hundreds of feet. Mechanisms have included formation subsidence, fault reactivation, or mechanical issues with completions. Time lapse analysis to monitor deformation changes over time has been undertaken, along with fast turnaround analysis where operational decisions and selection of intervention equipment was made on the basis of promptly delivered drift analysis. Pre-job modelling to optimise equipment selection prior to an intervention is another primary service.



Example MIPS3D views of Shear deformation, 'Euler' bending and Helical buckling

DELIVERABLES AND RESULTS

PDA results are presented in a detailed written report and as part of a license free MIPSView project. The written report provides numerical values and images of the deformation size, direction and depth, along with charts and text of the drift analysis predictions. The MIPSView package helps the user quickly visualise and understand the deformation geometry and the drift analysis results. Results can be viewed as 2D cross-sections or in 3D views over the complete deformation or 'zoomed-in' to the resolution of the original caliper data (typically every 0.24" or 5 mm). Interactive 3D representations allows complete inspection of the deformation and well access drift results.