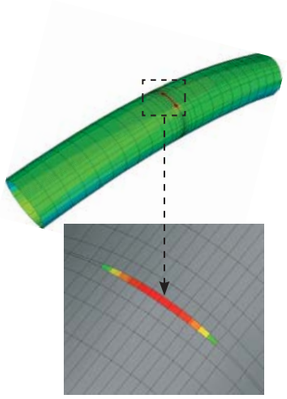
LINKpipe application areas

Early stage concept studies and design analyses
where welds (inhomogeneous material) and cracks (imperfections) need to be considered:

- In fitness-for-purpose calculations with respect to defect tolerances
- In the planning of inspection programs, and in analysis of inspection data.
- In optimisation of safety and costs through sensitivity analysis
- In calibration of safety factors
- In examination of possible mutual effects of several potentially "weak" zones on structural redundancy
- In materials selection
- In local geometry optimization



LINKpipe can be used for:

Pipeline installation
- S-lay, J-lay and Reeling
- J-tube pull-in

Subsea pipeline operations
- Lateral buckling, upheaval buckling, free spans
- Shut-ins/shut-downs (pressure and temperature cycling)
- Operation outside of design envelope

Arctic pipeline design
- Frost heave and thaw settlement
- Ice gouging/subgouge deformation

Pipelines subjected to large ground displacements
- Seismic loading
- Lateral spreading (loss of stability/slides)

Fracture and/or bulking of pipelines subjected to corrosion
- Effects on integrity from loss of wall thickness

Fatigue assessment to crack-like defects

Early pipeline design
- Sensitivity studies
- Specification of required material resistance

Tendons, umbilicals, general tubular structures

Accidental loading scenarios
- Anchor hooking
- Trawl impact

LINKpipe benefits

1. Accuracy proven through comparisons with 3D FE simulations and full-scale tests and significant improvement over analytical approaches.
   This ensures better utilization of materials and design solutions.

2. Rapid generation of new models and high speed of calculation enables an efficient 3D approach.
   Working with numerical FE models that include defects becomes applicable for routine engineering calculations.
   Scatter can be treated realistically and cost and safety can be optimized.

3. Captures "competition" between tension and compression side.
   Allows for checking local buckling while performing fracture calculations.

4. Captures the physics of effects such as reduced capacity due to internal pressure (biaxial loading).

5. Automation of sensitivity analyses and ECA calculations.
   Rapid investigation of the effect of varying material and geometry parameters.
   Automatic development of defect acceptance criteria for pipeline installation.

6. Data from monitoring systems can directly be transformed to consequences.
   Reduced need to store and transmit data.
   Reduced need for monitoring, inspection and control.

LINKftr AS, The Norwegian University of Science & Technology (NTNU) and SINTEF

The company LINKftr AS has a qualified and experienced staff with a background from fracture mechanics, materials science, design analysis and computational mechanics, as well as from commercial operations in the oil and gas industry. LINKftr AS has offices at the campus of both SINTEF and NTNU, and has access to resources, professors and research associates at both institutions, providing a high level of expertise, reflected in the high quality of the innovative software and services offered by the company.

LINKftr AS NTNU SINTEF

For technical queries and questions about pricing or terms of the software, or to obtain a trial version of the software, please contact:

Erlend Olsø, General Manager
Address: LINKftr AS, Richard Birkelandsvei 2B
7465 Trondheim, Norway
Phone: +47 48 16 45 73
Fax: +47 73 59 70 43
e-mail: erlend.olso@sintef.no
web site: www.linkftr.com

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LINKpipe

Takes you from rule-based design to direct calculations

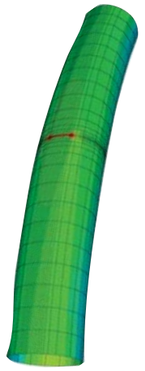
A state-of-the-art software tool for analysis of the criticality of cracks and defects in pipelines and piping systems

The LINKpipe software program offers rapid fracture mechanics calculations with an accuracy proven by fullscale tests at a speed suitable for design application

Your link between
Local failure and Structural response
www.linkftr.com

LINKftr AS

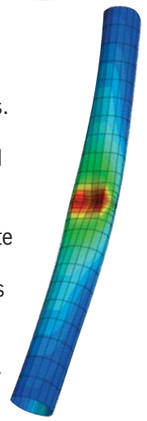
The challenge



Structural materials will inherently have cracks and defects. Steel structures like pipelines are subject to extreme loading conditions, thus defects may grow during installation and operation.

Erosion, corrosion, fatigue and other degradation mechanisms may also introduce new defects over years of operation.

During the design phase allowable defect sizes that ensure safe installation and operation over the lifetime of the pipeline is determined.



Design rules based on analytical relationships, although representing the extraction of experience and theoretical knowledge collected over generations, may be lacking in accuracy and lead to non-conservative or inefficient designs.

More accurate design tools are important to help safeguard human, environmental and economic resources.

Advanced computer models, normally in the form of 3D finite element (FE) analyses, are utilized to improve the design – safe designs, with optimized margins within the design rules are the result. However, these advanced computer models, until today, have been tedious, complicated and time consuming in use and thus impractical for design purposes.

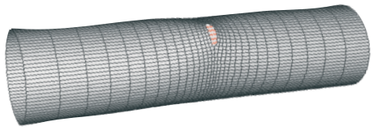
The solution: LINKpipe – a new tool for integrity assessment

LINKpipe is a non-linear, special-purpose finite element tool for performing fatigue and fracture mechanics calculations in pipelines and piping structures.

The LINKpipe tool offers a strong improvement in pipeline design technology. Fracture mechanics theory and practice has, through the LINKpipe software been merged with the finite element models of the design engineers – effectively merging the expertise of the pipeline design engineer with that of the materials and fracture mechanics experts.

LINKpipe implements the most advanced technology in the field, including the most recent state-of-the-art advances within strain-based fracture assessment, developed by a group of experts at the Norwegian University of Science and Technology (NTNU) and SINTEF.

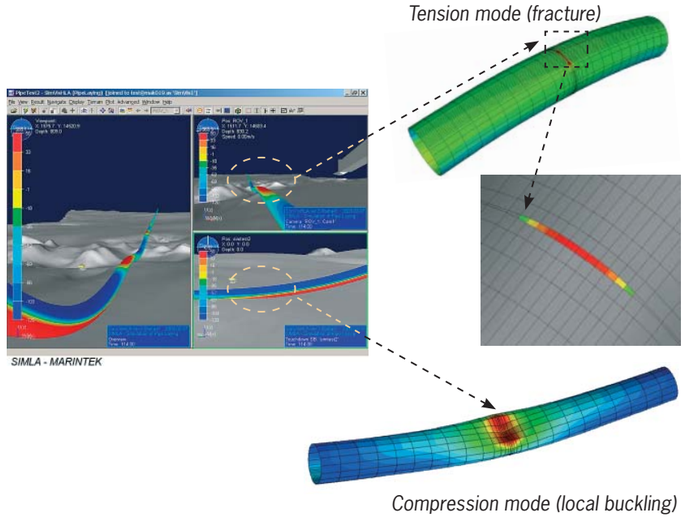
LINKpipe is a commercially available software program offered by the company LINKftr AS.



A Shell element model plus the improved line-spring element =LINKpipe

Direct link between local imperfections/ defects and structural response

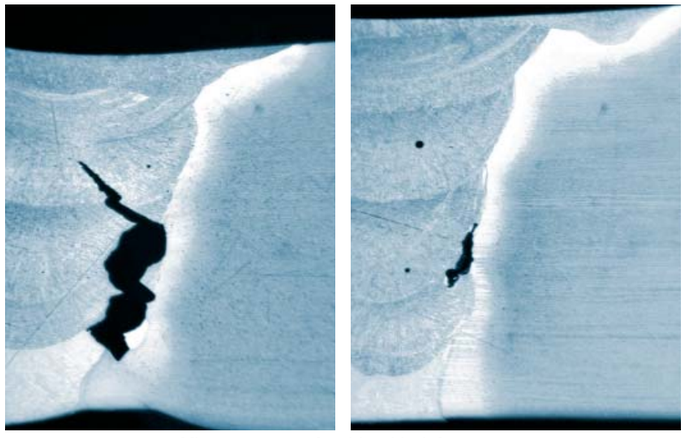
The LINKpipe software combines finite shell elements with an improved line-spring element to simulate cracks or crack-like defects. The key technology lies in the advanced modified line-spring element and is the result of many years of research at the Norwegian University of Science and Technology and SINTEF, reflecting both a thorough understanding of materials behaviour and efficient modelling strategies.



LINKpipe tells you which cracks are critical

Monitoring and inspection data offer information on the location and size of defects. LINKpipe provides you with a conclusion:

- As to whether you may safely continue the operation, or
- If a repair/replacement is required.



Microstructure of welds with defects

LINKpipe features

Linkpipe can assess fatigue and fracture to crack-like defects.

LINKpipe combines structural analysis (plastic collapse, buckling) and local defect analysis (brittle and ductile fracture).

A user-friendly graphical user interface and graphical post-processor allows for performing calculations directly on the structure with realistic:

- Size and location of surface breaking defects/weld defects with misalignment
- Internal/external pressure – the detrimental effect of biaxial loading is captured in LINKpipe
- Ductile crack growth in depth and circumference
- Large displacement tensile/bending loading

Calculation speed is very high and defect size and dimensions of the structure can be changed within seconds.

LINKpipe opens up for statistical evaluations through a built-in function for automated sensitivity analyses:

- No analytical equations are required
- Scatter in material data, loads, dimensions etc. can be examined
- Can be used to obtain partial safety factors for a given system or project

LINKpipe has a built-in function for automated ECA analyses to establish welding defect acceptance criteria for pipeline installation.

LINKpipe has the capability to analyze embedded defects and pipelines with locally reduced wall thickness due to corrosion.

Potential for coupling with global analysis (e.g. SIMLA, ANSYS and ANAQUS) through global load history.