Ocean

Pipeline Solutions

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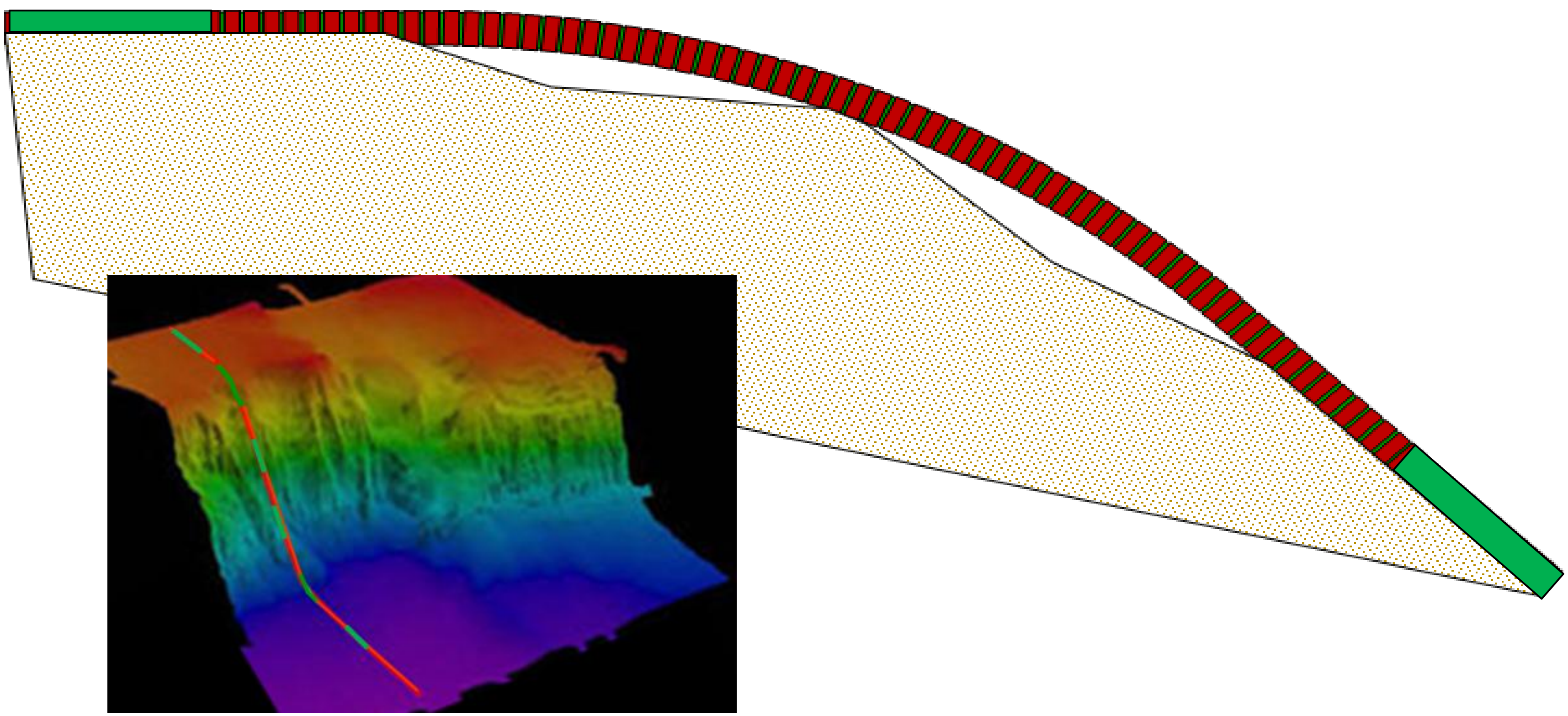
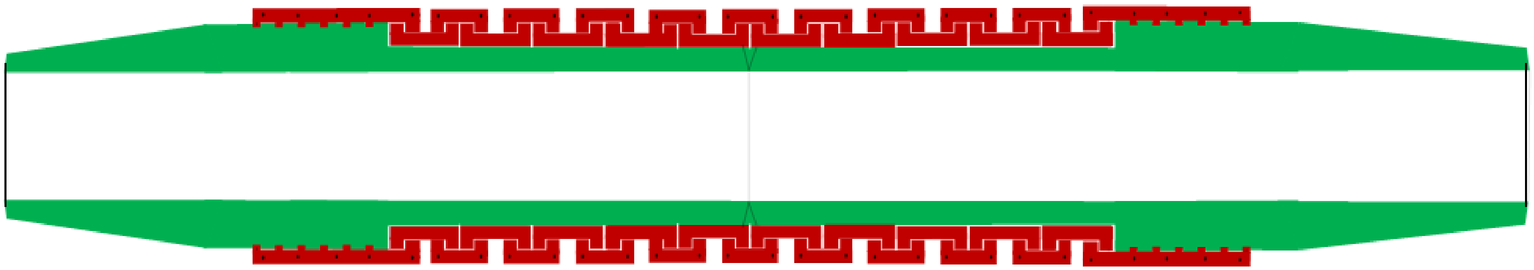
SCOPE OF SERVICE

Support and supply for Bending Restrictor Pipe Joint (BRPJ) and Bending Restrictor Sleeve (BRS). Bends created in conformance with the strain and ovality criteria regardless if soil indentation occurs, free spans and high spots are crossed. Applicable with S Curve, J Curve and reeling installations.



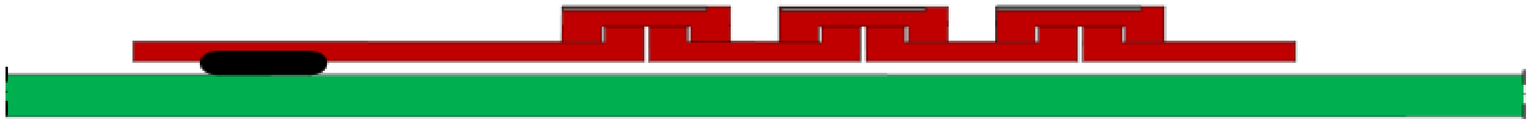
BENDING RESTRICTOR PIPE JOINT - BRPJ

The BRPJ forms an integral part of the pipeline
ensuring conformance with bending strain and ovality criterium.

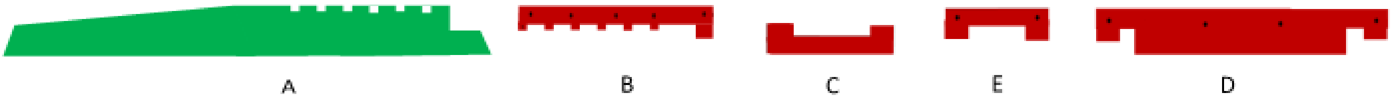


BENDING RESTRICTOR SLEEVE - BRS

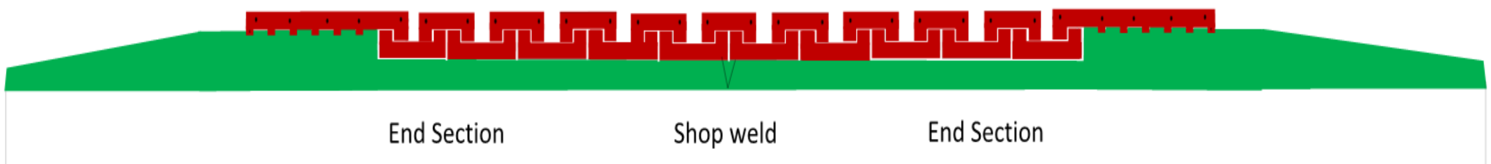
The BRS ensures conformance with bending strain criterium with an annuls
to the pipeline sufficiently large to allow passing of insulation and anodes.



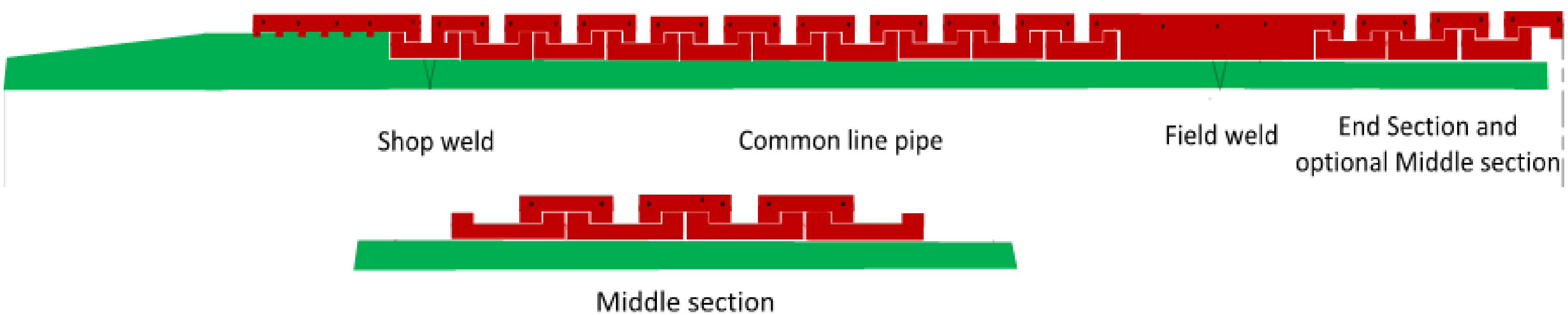
Standard component configurations



Part A connects to the pipeline
Parts B, D and E are half shells facilitating assembly
Part C is fully cylindrical

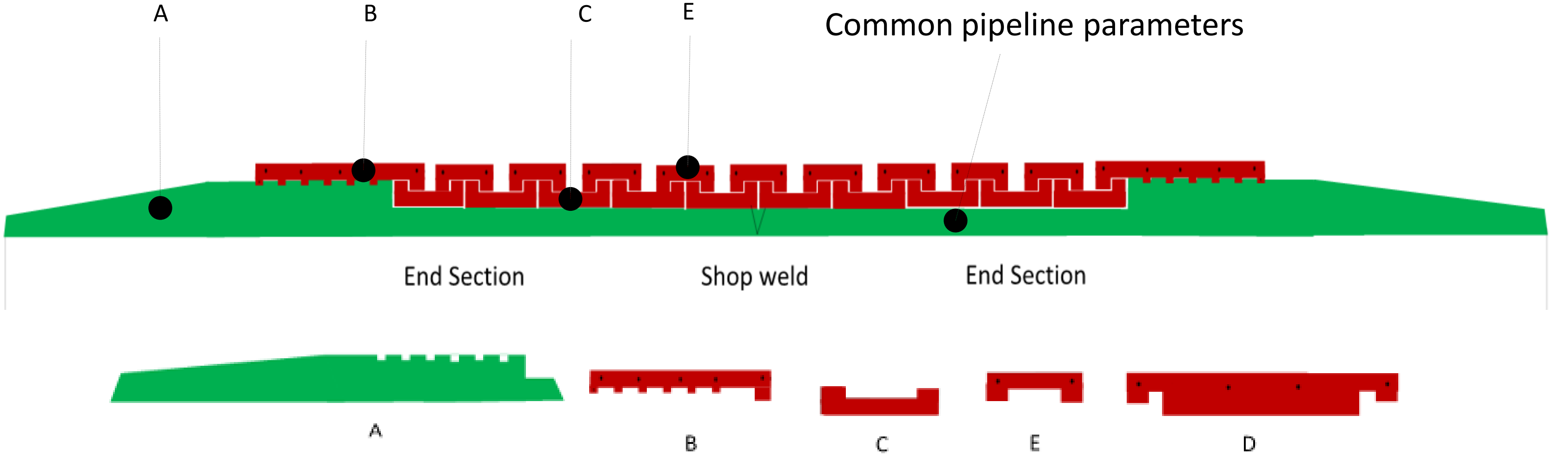


Space during shop welding is provided by closing the gaps between parts C and E



Part D closes the space required for welding during the installation phase

BENDING RESTRICTOR PIPE JOINT - FUNCTION

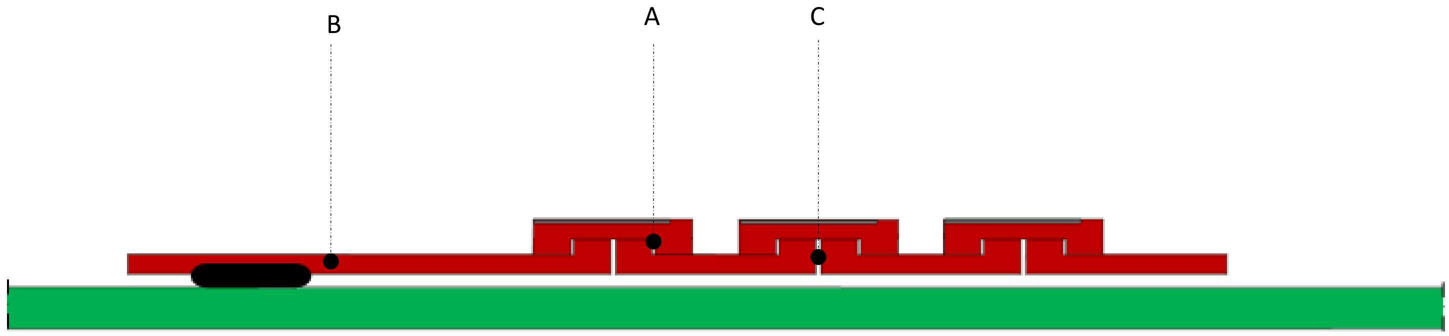


- Collars C transfer compression forces by closing adjacent gaps.
- Collars E transfer tension forces when the pipeline elongates in tension.
- Collars C transfer tension forces to collars B or alternatively compression forces to part A.
- Collars D closing the space at field welds, transfer compression forces or alternatively tension forces to collars C.
- The section modulus of the collars are added to the pipeline when the slots and gaps close resulting in discontinued yielding.
- Components shown in green are of pipeline grade and red of high strength material.

BENDING RESTRICTOR SLEEVE - FUNCTION

When crossing an obstruction by reeling the pipeline is bent one additional cycle to loading and straightening during the installing process.

Annulus is designed to accommodate passage of insulation and anodes.



- Collars transfer tension forces by closing of gaps A
- Collars transfer compression forces by closing of gaps C
- Collar B is an extensions containing an inflatable packer or spring-loaded friction connection for conveyance to the seabed
- Component shown in green represents the pipeline and red of high strength material
- All components corrosion coated with thermal spray aluminum (TSA)

EXAMPLE BEND CAPABILITIES

DNV-OS-F101 allows up to 5% strain with the additional requirement P

Nominal pipe diameter	Bend angle for listed arc lengths and strain levels: 1 meter				10 meters				Bending radius in meters			
	1%	2%	3%	4%	1%	2%	3%	4%	1%	2%	3%	4%
6	6.8	13.6	20.4	27.2	68.0	>90	>90	>90	8.4	4.2	2.8	2.1
8	5.2	10.4	15.6	20.8	52.0	>90	>90	>90	11.0	5.5	3.7	2.7
10	4.2	8.4	12.6	16.8	42.0	84.0	>90	>90	13.7	6.8	4.6	3.4
12	3.5	7.0	10.6	14.1	35.0	70.0	>90	>90	16.2	8.1	5.4	4.0
14	3.2	6.4	9.6	12.8	32.0	64.0	>90	>90	17.8	8.9	5.9	4.4
16	2.8	5.6	8.4	11.2	28.0	56.0	84.0	>90	20.3	10.2	6.8	5.1
18	2.5	5.0	7.5	10.0	25.0	50.0	75.0	>90	22.9	11.4	7.6	5.7
20	2.2	4.5	6.7	9.0	22.0	45.0	67.0	90.0	25.4	12.7	8.5	6.4
22	2.0	4.1	6.1	8.2	20.0	41.0	61.0	82.0	27.9	14.0	9.3	7.0
24	1.8	3.7	5.6	7.5	18.0	37.0	56.0	75.0	30.5	15.2	10.2	7.6
26	1.7	3.4	5.2	6.9	17.0	34.0	52.0	69.0	33.0	16.5	11.0	8.3
28	1.6	3.2	4.8	6.4	16.0	32.0	48.0	64.0	35.6	17.8	11.9	8.9
30	1.5	3.0	4.5	6.0	15.0	30.0	45.0	60.0	38.1	19.1	12.7	9.5
32	1.4	2.8	4.2	5.6	14.0	28.0	42.0	56.0	40.6	20.3	13.5	10.2
34	1.3	2.6	3.9	5.3	13.0	26.0	39.0	53.0	43.2	21.6	14.4	10.8
36	1.2	2.5	3.7	5.0	12.0	25.0	37.0	50.0	45.7	22.9	15.2	11.4
42	1.1	2.1	3.2	4.3	11.0	21.0	32.0	43.0	53.3	26.7	17.8	13.3
48	0.9	1.8	2.8	3.7	9.0	18.0	28.0	37.0	61.0	30.5	20.3	15.2

Designed In Compliance With Industry Standards

Designed to control tensile rupture

In strain-based designs, sufficient testing must be done to ensure sufficient ductility and toughness.
Alleviating welds in the plastic zone and bending once as is the case with this design avoids most common issues with ductility and toughness.

-DNV-OS-F101
-PRCI, Second Generation Models for Strain-Based Design, 2011
-DNV-RP-F108

Designed without ratcheting

After passing the stinger the possibility for a single half cycle of plastic bending is added.
Ratcheting is not a consideration.

Designed to control local collapse

Strategy for prevention of local collapse is based on control of ovalization by the collars.
Annular clearance is kept to less than 0.005 diameters.

Designed In Compliance With Industry Standards

Designed for corrosion

- Thermal Spray Aluminum is applied.
- Electrical continuity of collars to pipe.
- DNV-RP-B401 Cathodic protection design.
- DNV-RP-F103 Cathodic protection of submarine pipelines.

Designed for purpose

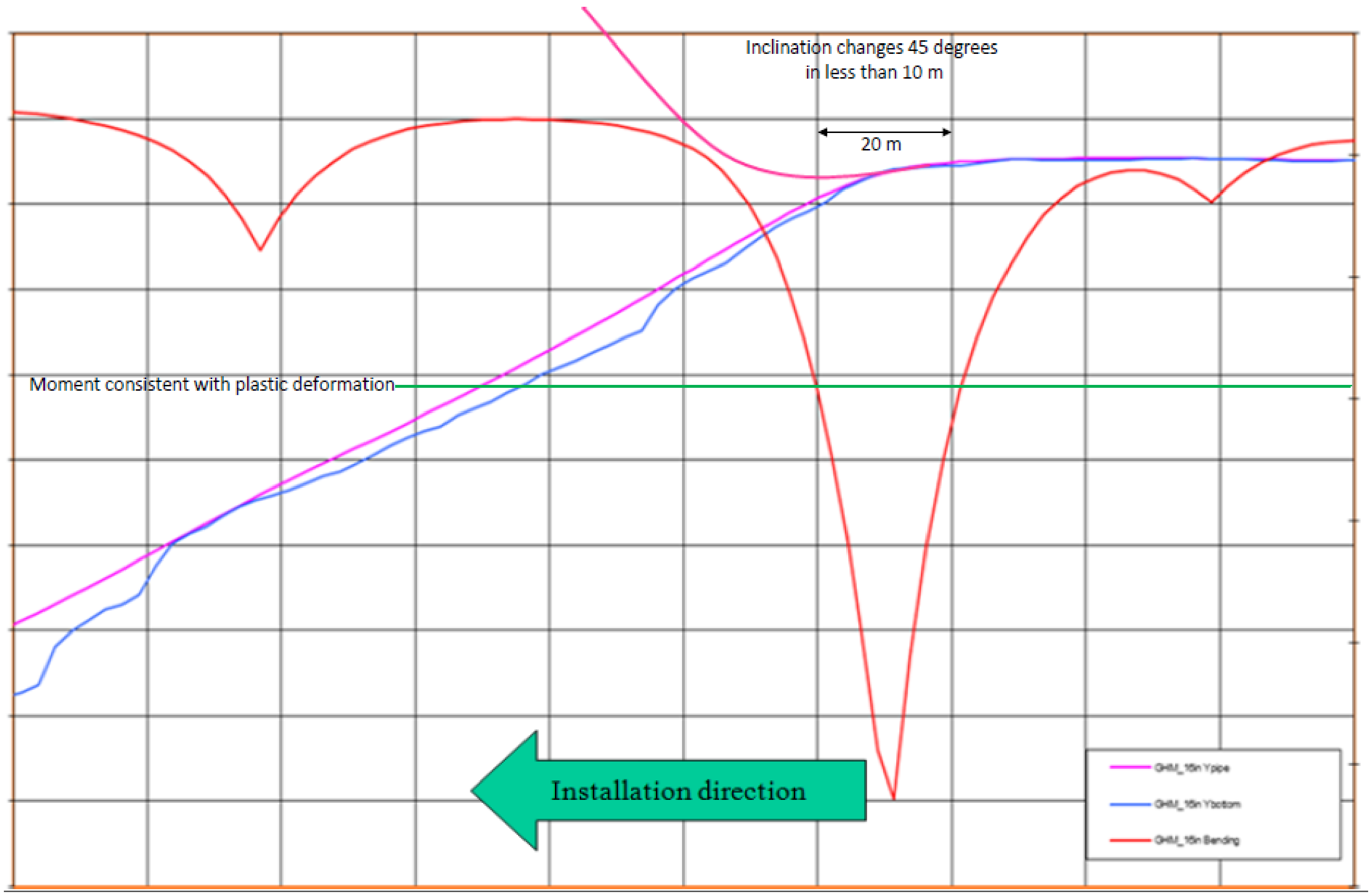
- Strength required of the bend restrictor depends upon the topography and the installation plan.
- Strength can be increased as required by increasing the thickness of the collars and diameters of the pins.
- Bend restrictor loads determined via installation analysis and can be verified by instrumentation during deployment.
- Strength design follows DNV-OS-F101.

Material Selection

- Collars limited to 120 ksi because of embrittlement.

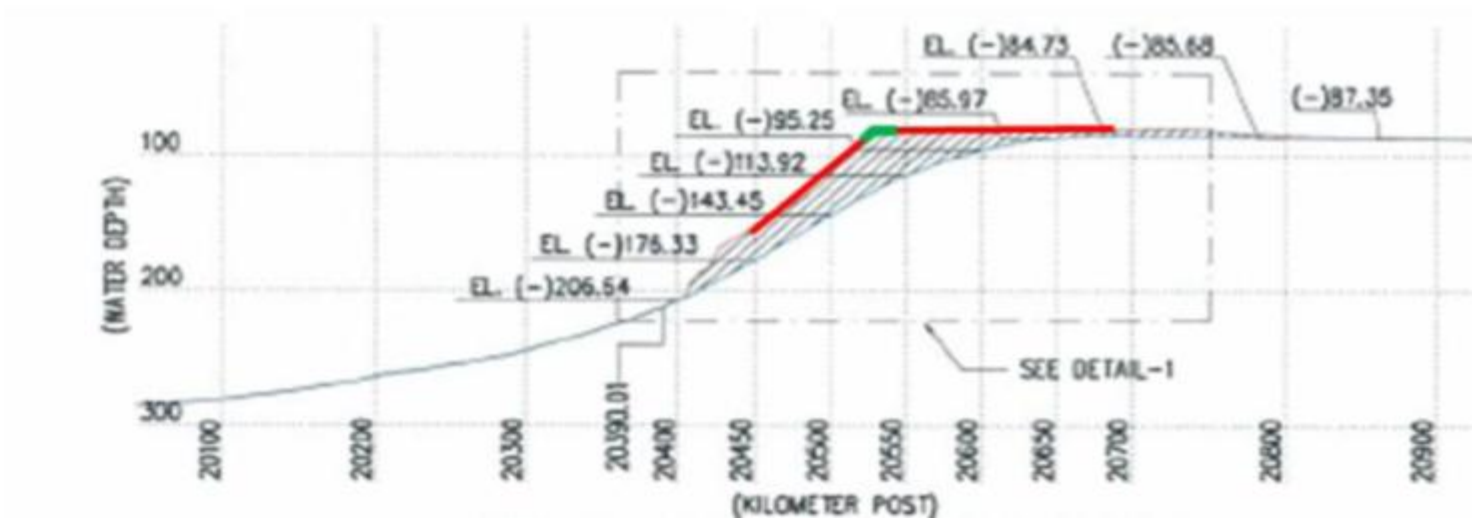
BENDING RESTRICTOR PIPE JOINT – IDD PROJECT

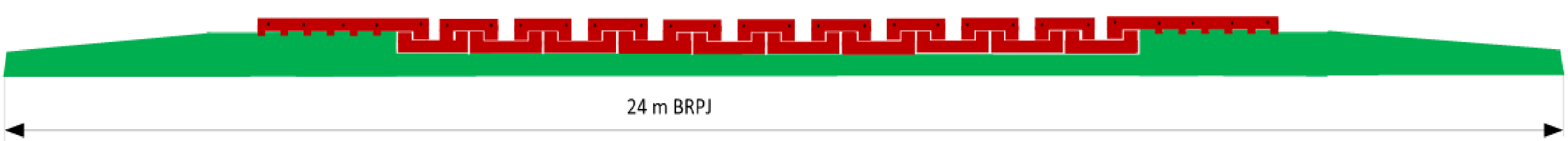
Crossing of the escarpment requires a 40 degrees bend for the 16-inch Gehem pipeline. Excavation of a 30-meter-deep trench with a soil friction angel of 30 degrees alleviated.



Solution for 16 inch diameter pipeline

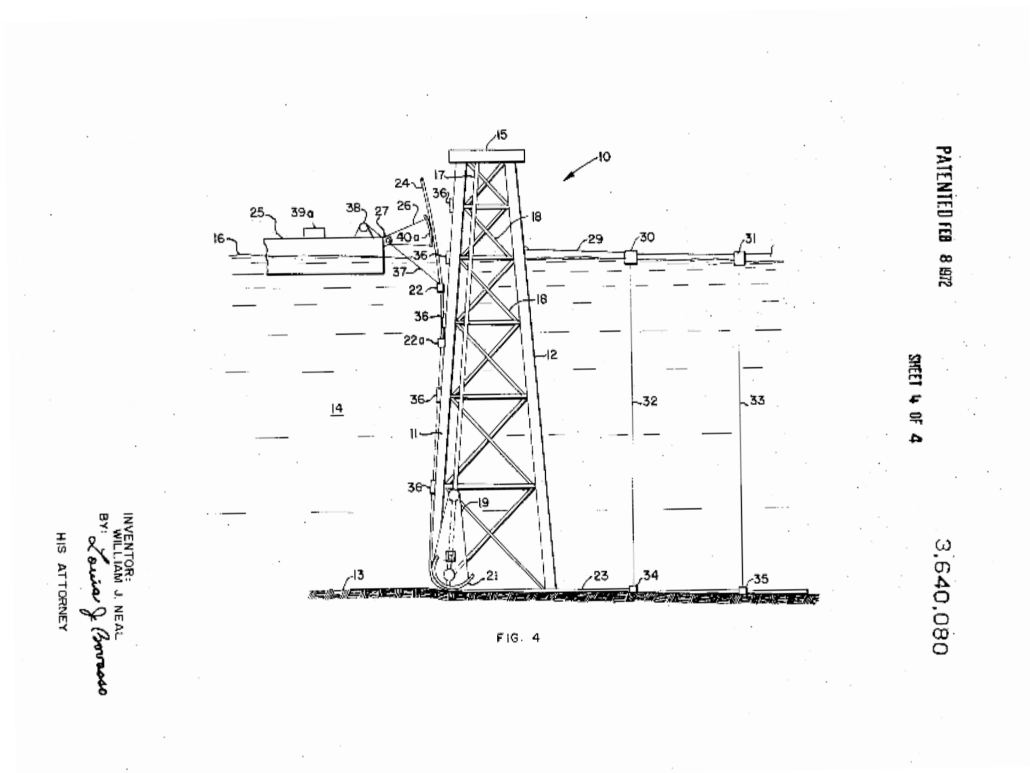
The below profile of the shelf break can be crossed using one 24 m BRPJ providing a 40-degree bend utilizing 1.5 % strain and an installation tolerance of +- 3 m.

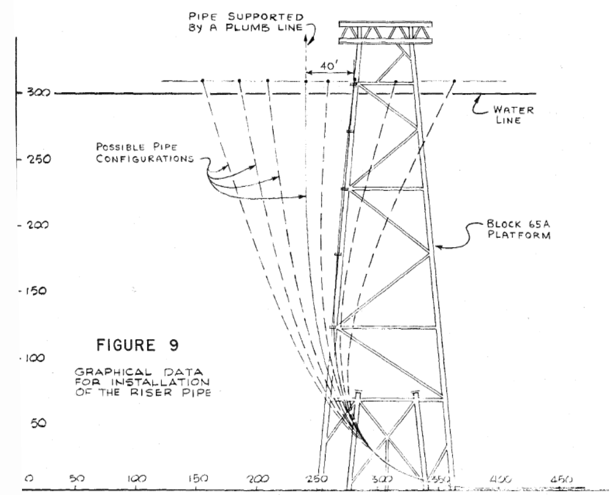




BENDING RESTRICTORS HAVE A LONG HISTORY

Cold bending of pipelines using bending restrictors were performed in
the South Pass area of the Gulf of Mexico in the early 1970-ties.
Technology is a development with the additional advantages of controlling the ovality of the pipe.



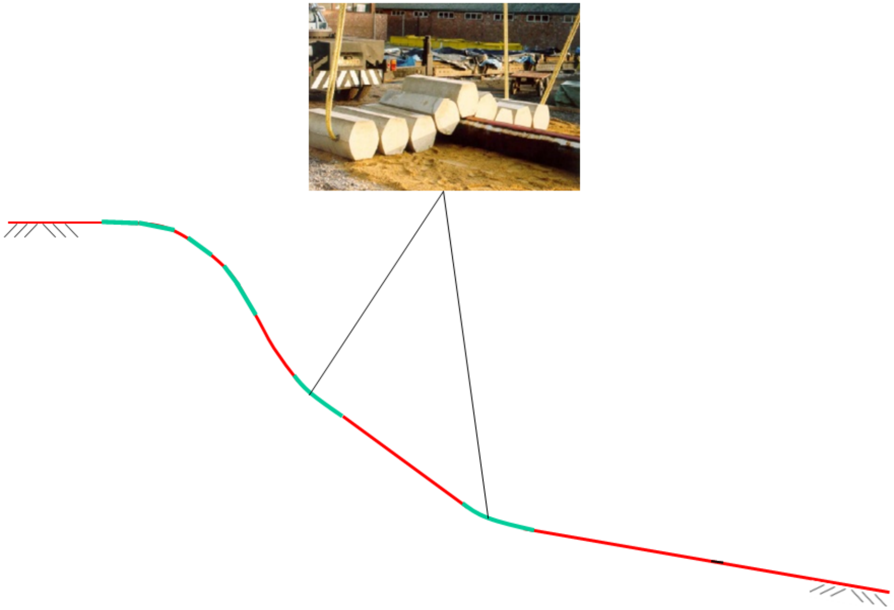


COLD BENDING IS COMMON PRACTICE

The design criteria for this method are the same as for cold bending
of pipelines using the Reeling, S Curve and J tube installation methods.
Facilitates omnidirectional bending in conformance with strain and ovality specifications.

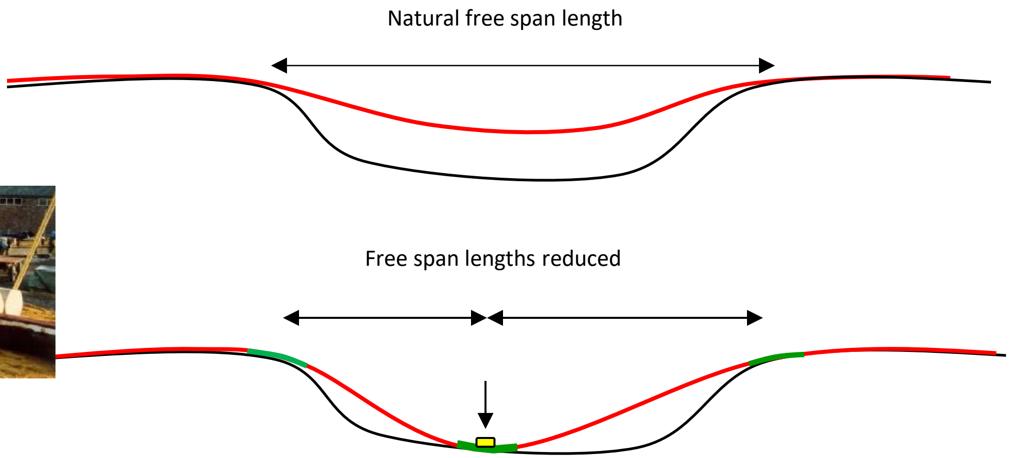
INSTALLATION AT ESCARPMENT

Excessive bending moment causes deformation of the pipeline when crossing obstructions.
The same excessive bending moment induces controlled bending by including bending restrictor units.
Progression of the bending increases the support angle resulting in the moment decreasing necessitating applying external loads such as concrete mattresses, which are left in place for hysteresis reasons.



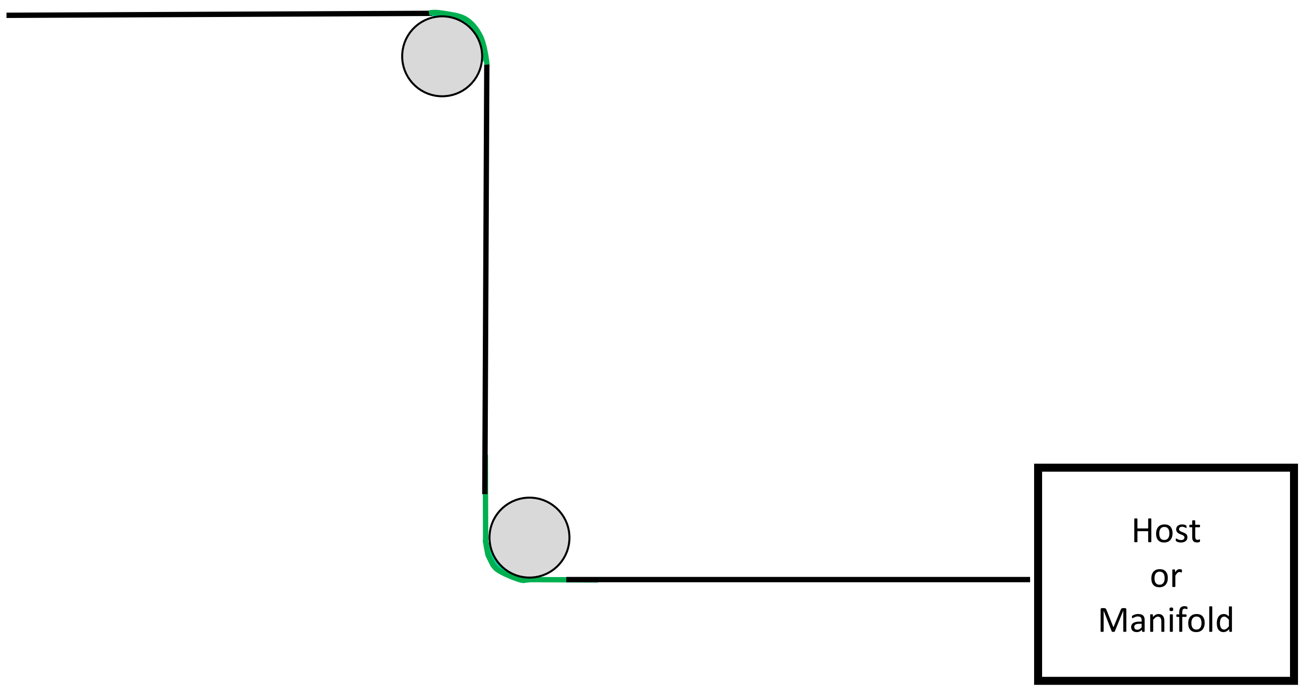
INSTALLATION ACROSS CHANNELS

Optimized with one to three bending restrictor assemblies.
External weight and or volume of water added in the sag bend to achieve the profile during the installation phase when additional pipeline length is created.



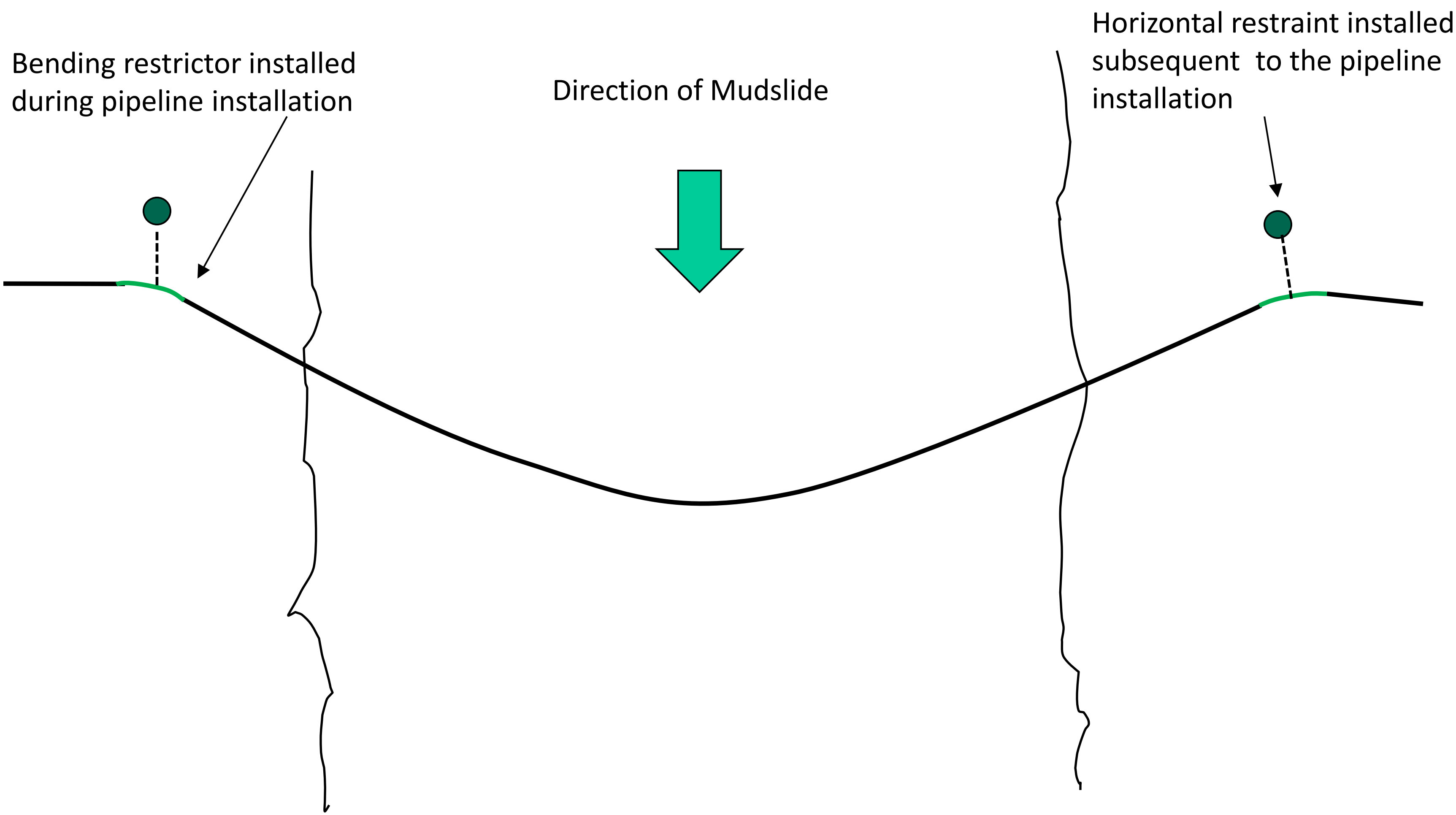
HORIZONTAL DEVIATION

Expansion loop and change in direction achieved through the heading of the installation vessel

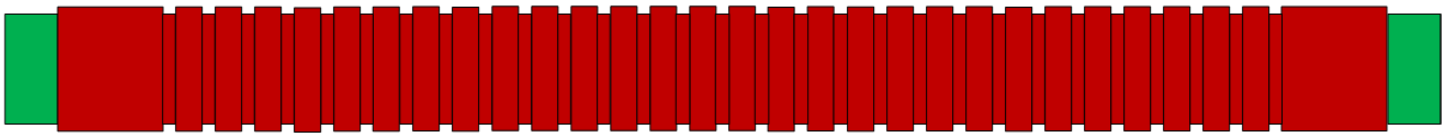


HORIZONTAL DISPLACEMENTS AT MUDSLIDES

Bending takes place if movement occurs



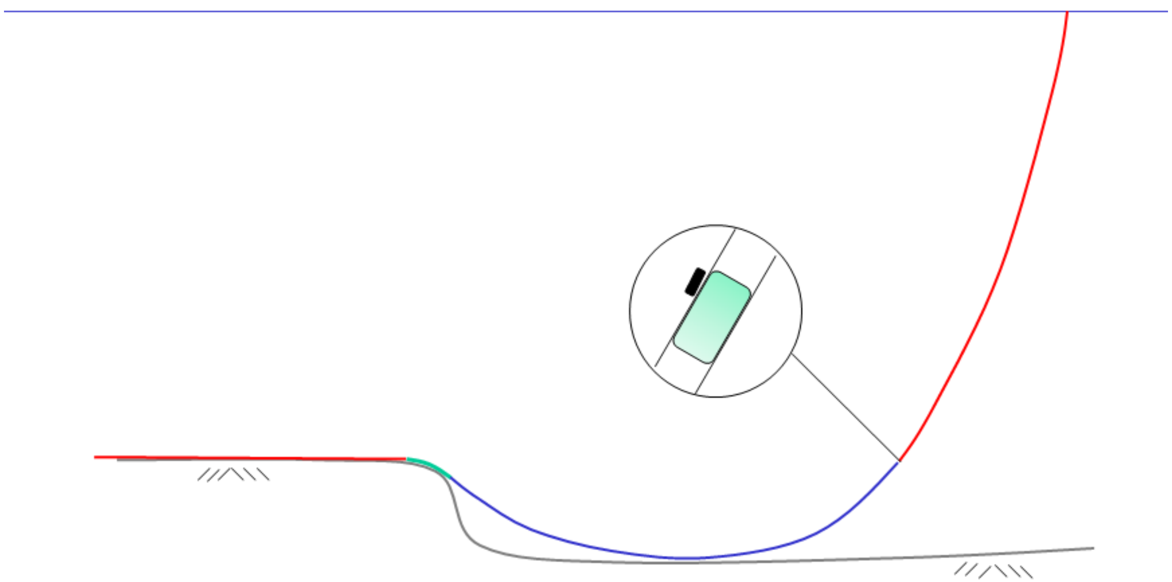
COMMON PROCEDURES USED DURING INSTALLATION OF BRPJ



- Prefabricated BRPJ is added to the pipeline on the installation vessel the same as common pipe joints
- Locating the BRPJ in the pipeline make up is governed by a long baseline acoustic array identically to terminating a pipeline
- Accuracy of ±1 meter achievable plus consideration for meandering of the pipeline
- Moment experienced during the installation phase induces the bending
- Final profile if required is achieved by placing weights at locations with the alternative of including a volume of water in the sag bend.
- Weights are left in place for hysteresis reasons.

CREATING INCREASED PIPELINE LENGTH DURING INSTALLATION

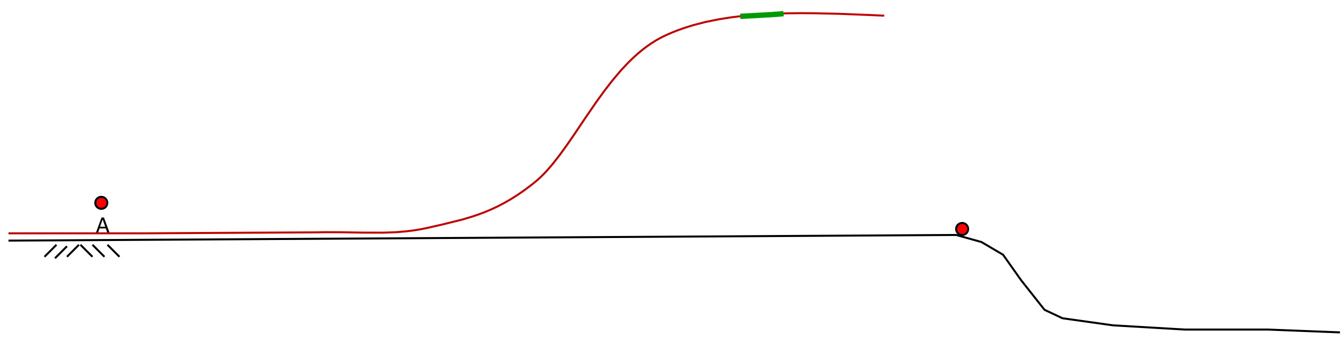
Volume of water contained with a pig is added in the sag bend to achieve the final profile.



INSTALLATION PROCEDURE

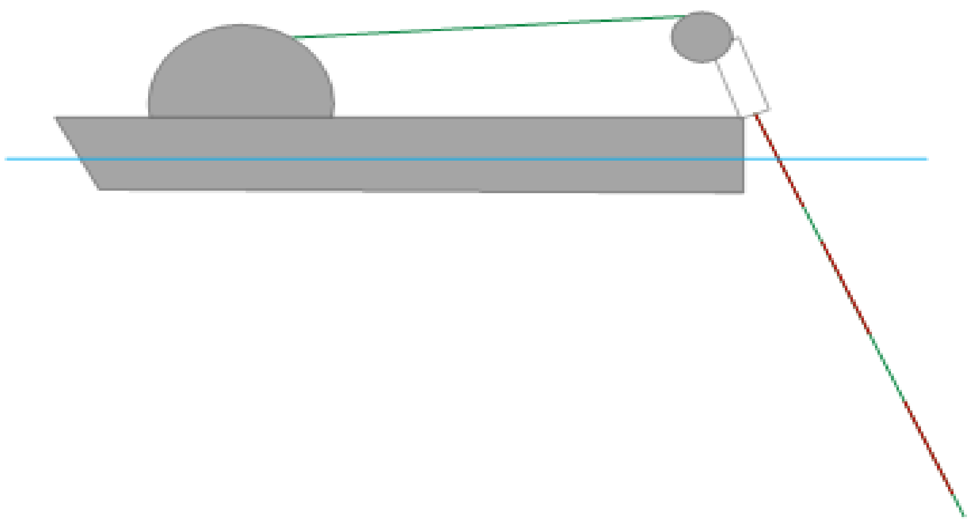
Locating BRPJ and BRS in the pipeline assembly

- Transponder placed at location for bending
- Pipeline marked at A when on installation vessel
- ROV with transponder located at A when resting on the seabed
- Distance between A and the bending location determined to an accuracy of ±1 m
- BRPJ and BRS located at the same distance from A by measuring the added pipe length
- Contingency for meandering of the pipeline during the installation and placement tolerance is considered

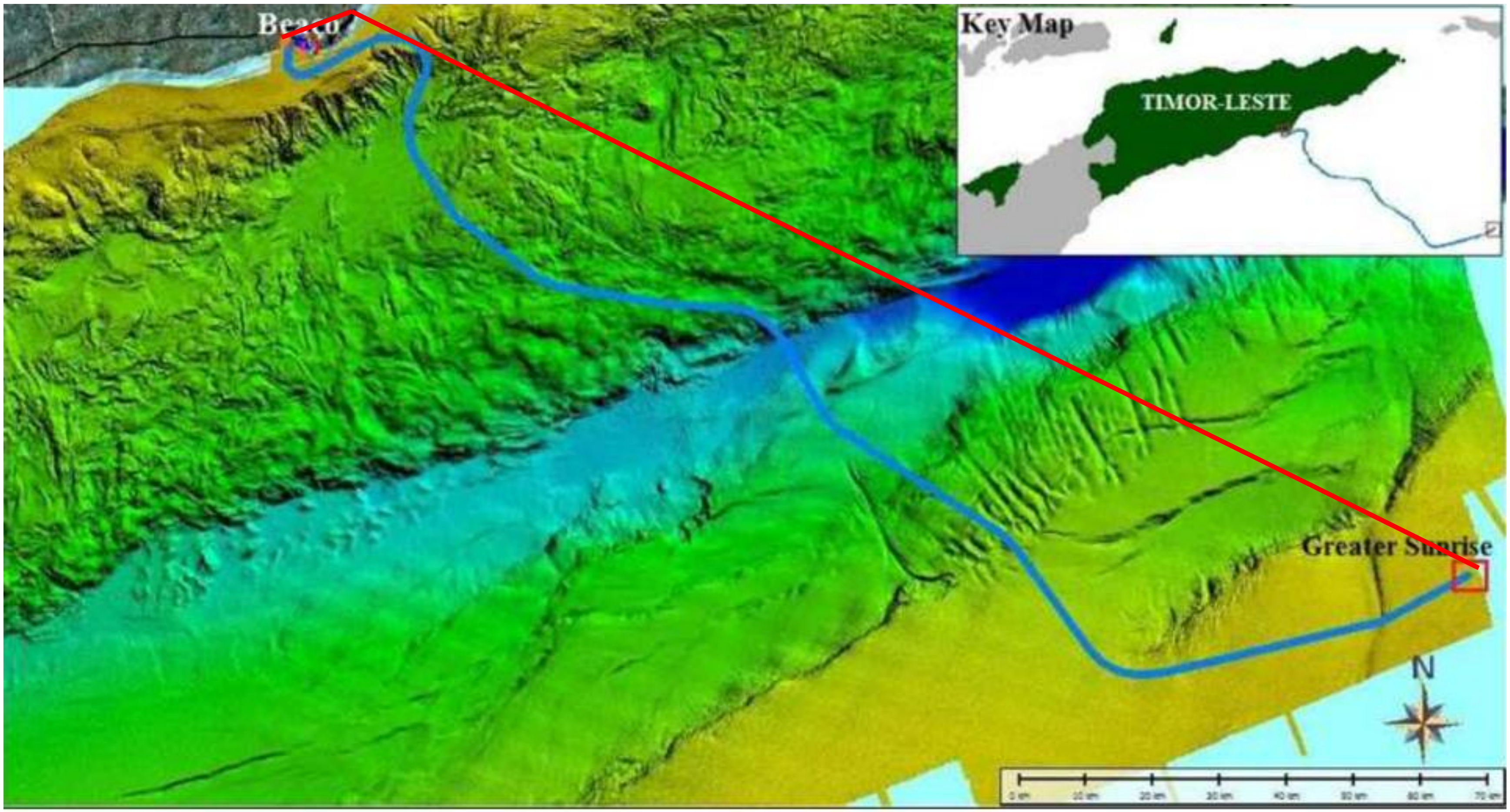


BENDING RESTRICTOR SLEEVE - INSTALLATION

BRS suspended at the pipe overboard location with the pipeline passing through.
Inflatable packer or spring-loaded friction connection engaged at the required location for conveyance of the BRS to the seabed.
Series of assemblies can be interconnected and spaced to fit the profile to be crossed.

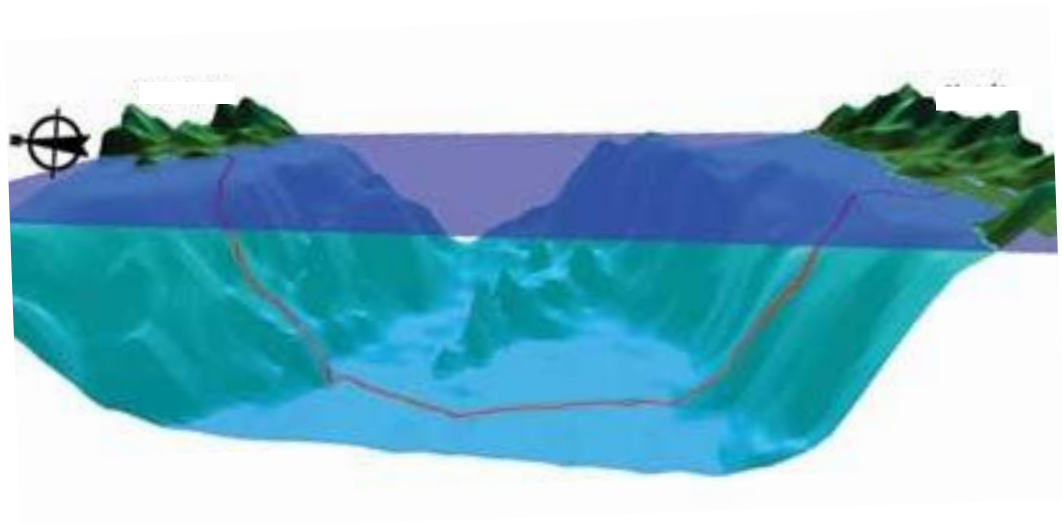


CROSSING OF OBSTRUCTIONS POSSIBLE IN GREAT DEPTHS ACHIEVING SHORTER ROUTES



SOLUTIONS FOR PIPELINE DISPLACEMENTS

The risk of unacceptable compressive stresses dynamically imposed due to lateral pipe displacement at faulting seabed, sediment movements and seismic activities. Including BRPJ and BRS at high-risk locations provide remedies for loadings.



PIPELINE SOLUTIONS OFFER

- Cold bending of submarine pipelines in any plane up to the maximum allowable strain criterium achieved during the installation phase.
- The bending takes place at the seabed during the installation operations when additional length required to follow an undulating seabed is created.
- Solutions are applied as a remedy when crossing seabed obstructions or environmental conditions, which otherwise require preparatory or remedial work.
- Benefits are realized when crossing escarpments, achieving a shorter direct route, contingency for mudslides, shore crossings and when short radius turns.
- Contingency for collapsing seabed results in bending at predetermined criteria and alleviates interruption of production.

Ocean

We thank you for your interest and are looking forward
to participating in your projects

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