What is a Floating Articulated Stinger and how does it work?

2 Aug 2014

WIN – EXECUTE – SAFE DELIVERY

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Agenda

- Introduction – type of stingers
- EMAS AMC's stingers
- McDermott's Articulated Stingers
- Other types of stingers in operation
- Pipelay analysis – Articulated v Trussed Stingers (past examples)
- Discussion – difference in lay criteria between articulated and fixed/ trussed stingers

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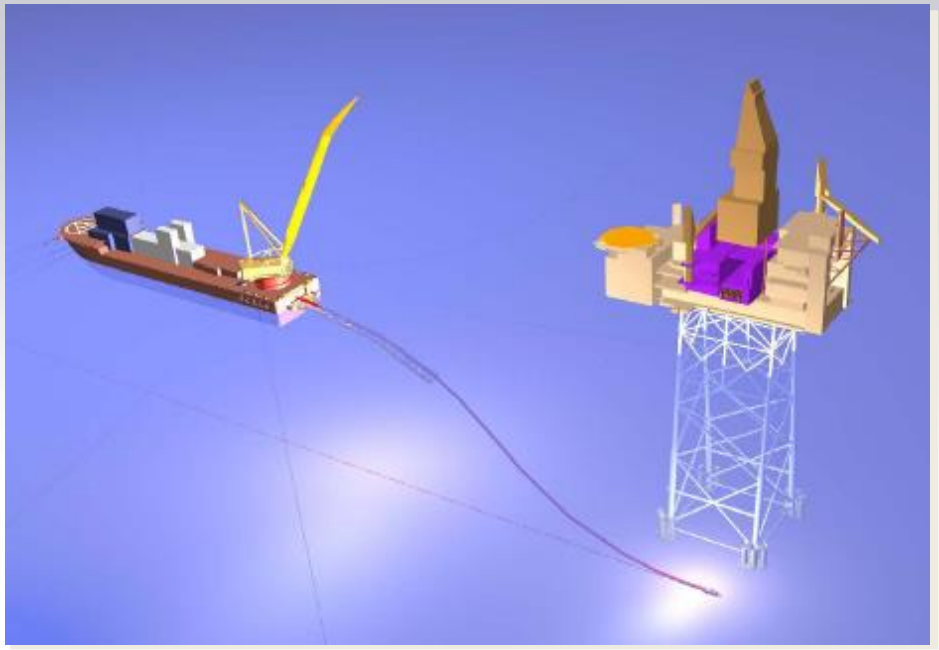
Types of Stingers

No general consensus on definition of S-lay stinger but in my view, stingers are generally classified as:

- *Fixed stinger*
- *Trussed Stinger – Floating and Rigid*
- *Articulated stinger – Floating and Rigid*



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Examples of Fixed Stinger

Stingers are negatively buoyant & are restrained from downward & upward movement

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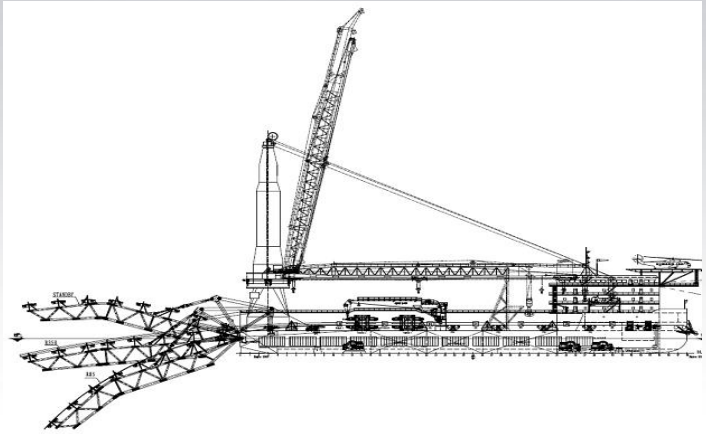
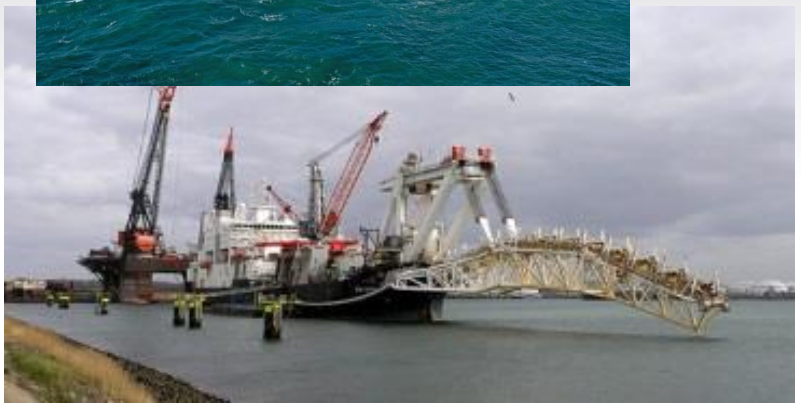
Examples of Articulated & Trussed Stingers

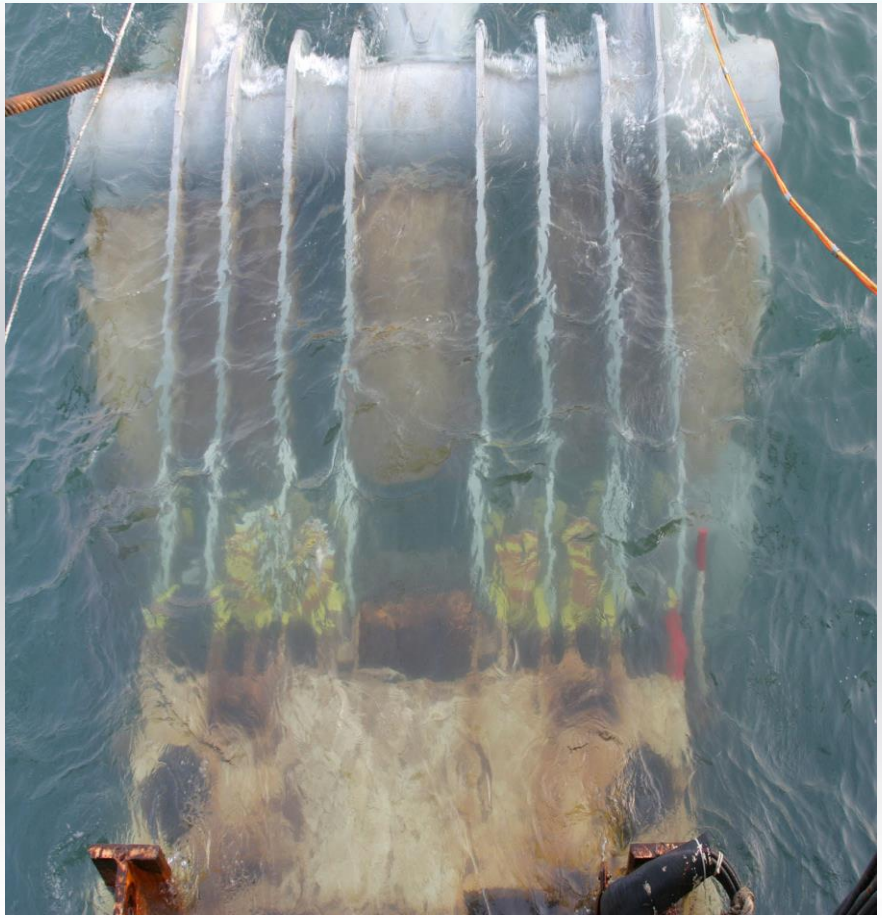
Articulated stinger





'Rigid' Trussed Stinger is negatively buoyant and restrained from downward movement only

Typical Floating Trussed Stinger (Global Industries) & 'hitch point' at stern of lay barge



Floating trussed stinger is positively buoyant and can move in vertical direction

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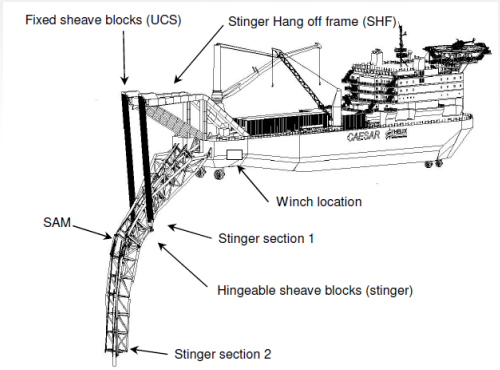
S-Lay
EMAS AMC's LEWEK CENTURION

Is this a Trussed Stinger or Rigid Articulated Stinger?



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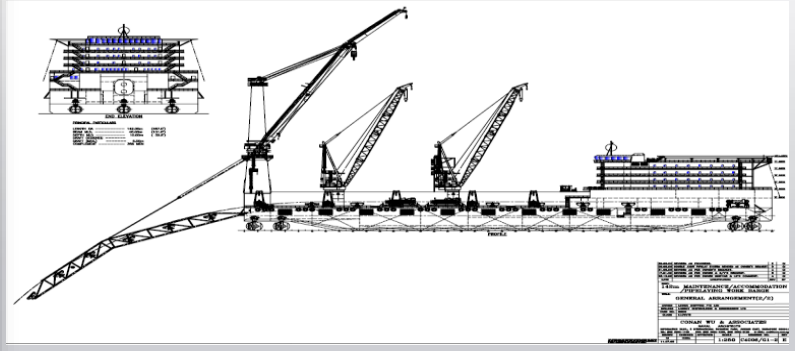
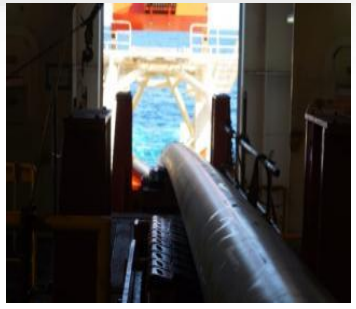
S-Lay
EMAS AMC's LEWEK CHAMPION

Is this a Trussed Stinger or Rigid Articulated Stinger?





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McDermott's SEA-06 Articulated Stinger Segments

Top Left: Hitch segment – only one required

Above: Intermediate segment (up to 4 can be used)

Left: Sled segment: only one is used

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McDermott ‘s Articulated Stinger during beach pull start-up

During beach pull start-up stinger shape changes as pipe is pulled to shore

During beach pull start-up, stinger is almost straight at the beginning but slowly assume the shape of the initial portion of pipeline as more pipe is pulled to shore

Hitching up of McDermott ‘s Articulated Stinger in strong current & subsequent ‘jacket start-up’

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Rigging up of McDermott's Articulated Stinger for Pipelay Inititation

- Picture shows McDermott's ME2009 articulated stingers being connected to laybarge
- In adverse weather condition, pipeline is abandoned but the stinger is kept hitched to the laybarge
- However, it extreme weather conditions, the stinger is decoupled from the laybarge and removed

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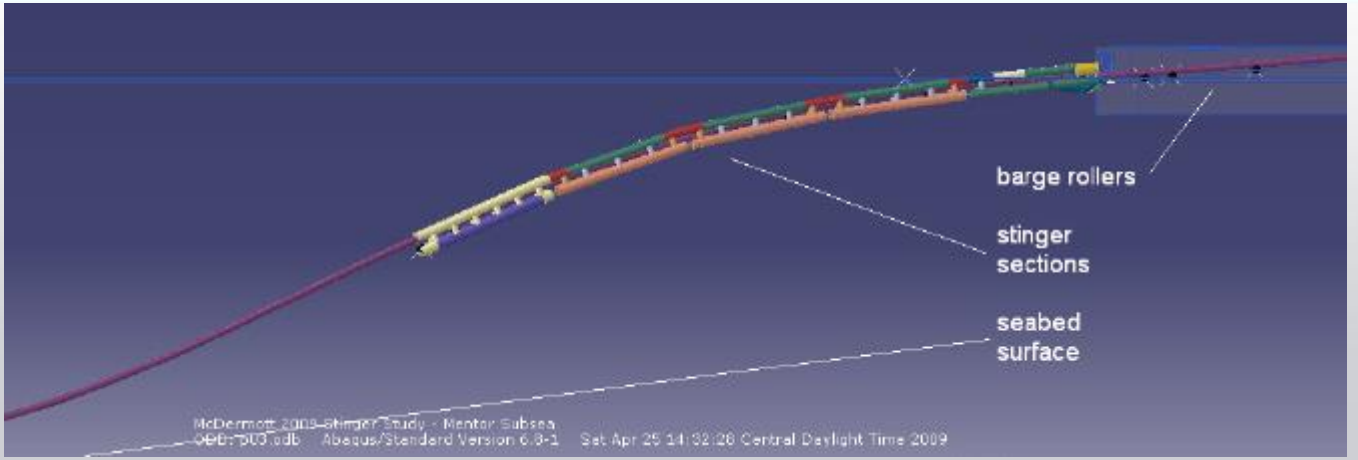
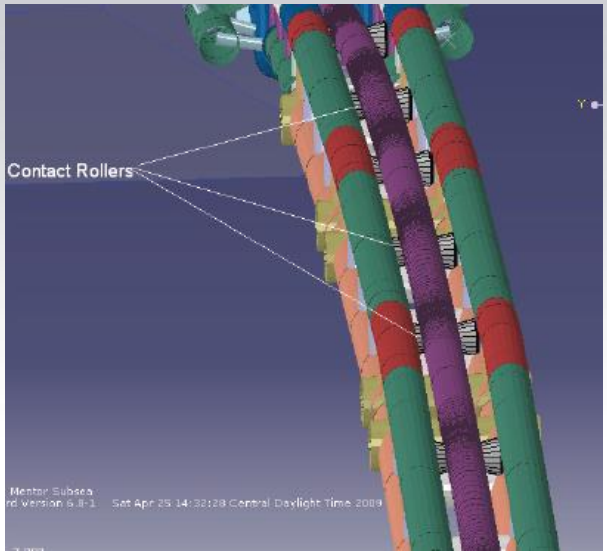
McDermott's Articulated Stinger simulation





Extracted from OTC paper 21848: "Coupled Dynamic Analysis of Stinger and Pipeline by McDermott

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Geocean's hybrid stinger: Combined Trussed with floating articulated 2nd segment

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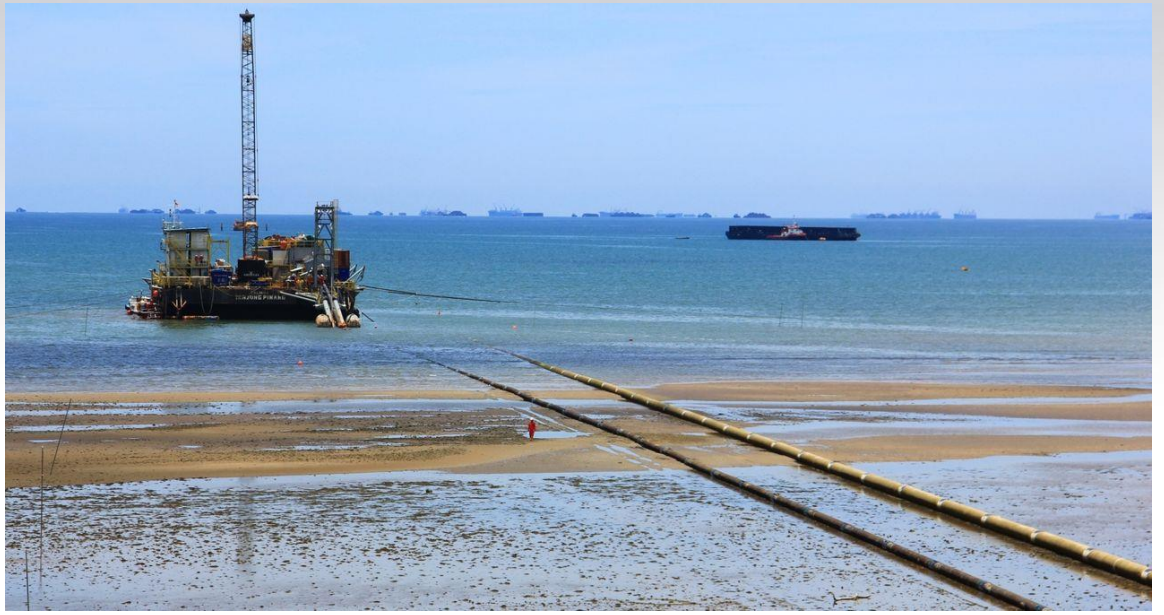
‘Push-Pull’ Method of Pipeline Installation at Shore Approach (by Geocean)



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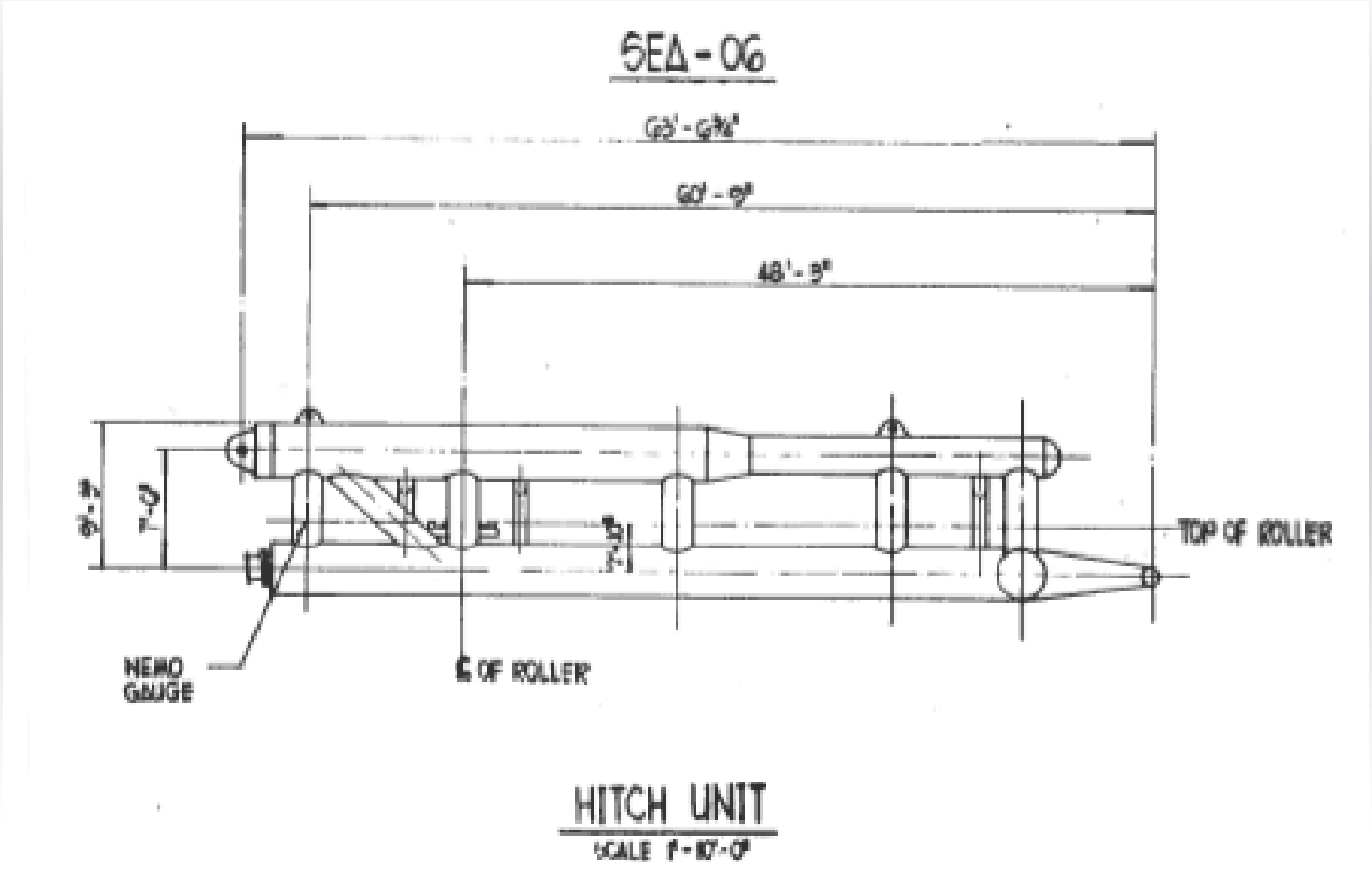
McDermott's Articulated Stinger - Hitch Unit



Note: Only one unit can be used at one time

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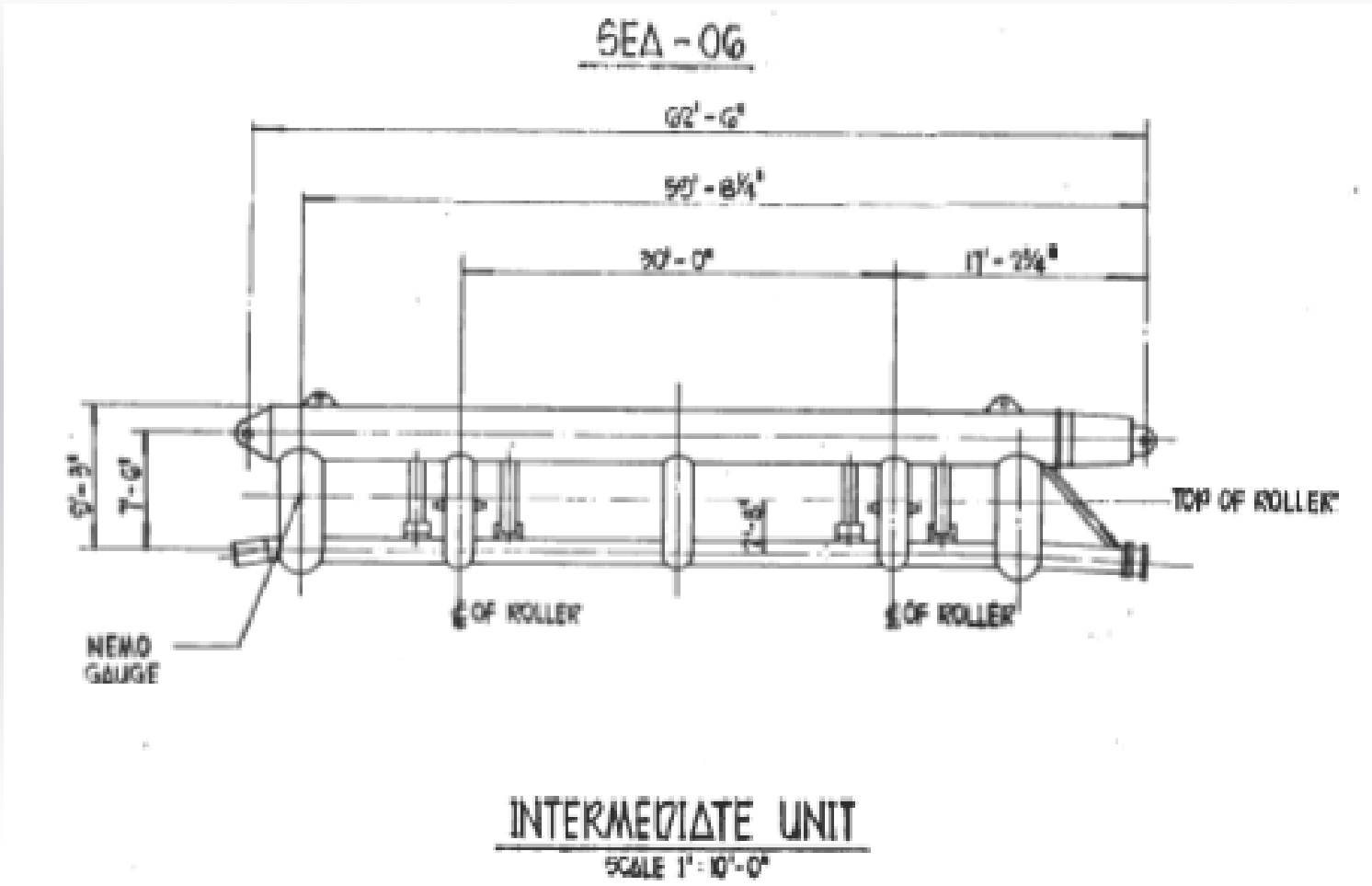
McDermott's Articulated Stinger - Intermediate Unit



Note: Up to four (4) units can be used at one time

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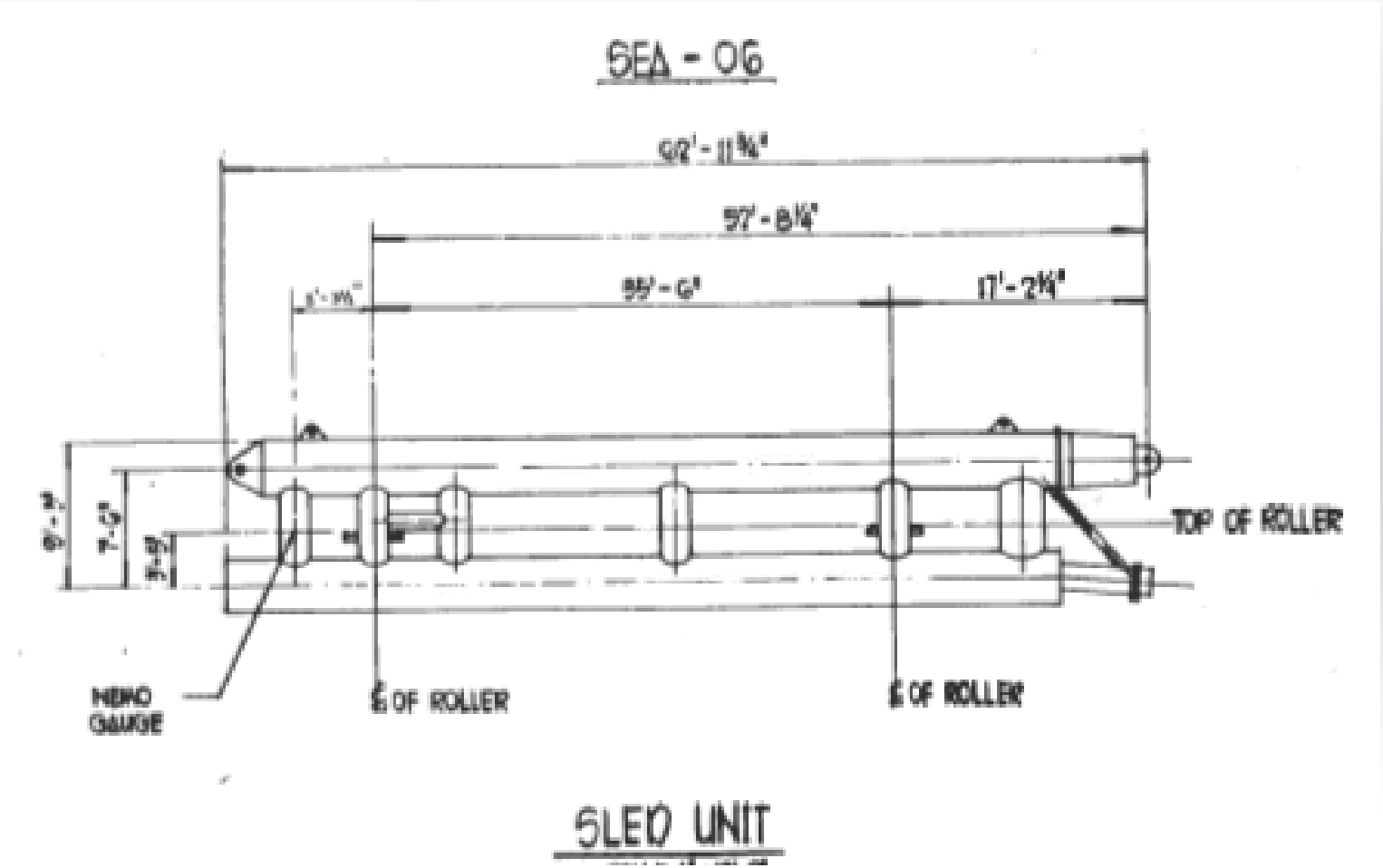
McDermott's Articulated Stinger - Sled Unit



Note: Only one unit can be used at one time

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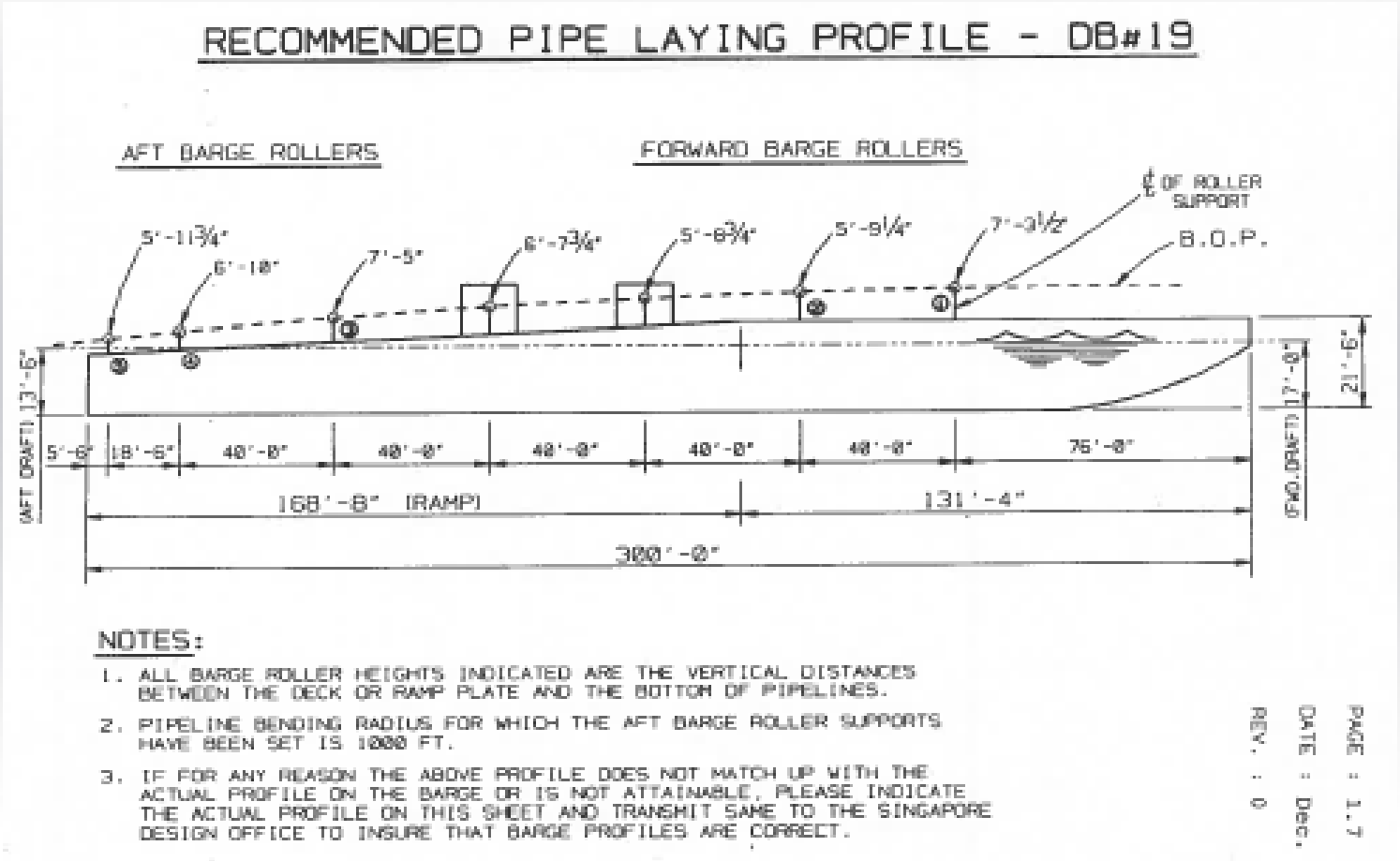
Example 1: DB19 with 3 segments articulated stinger (1 of 6)



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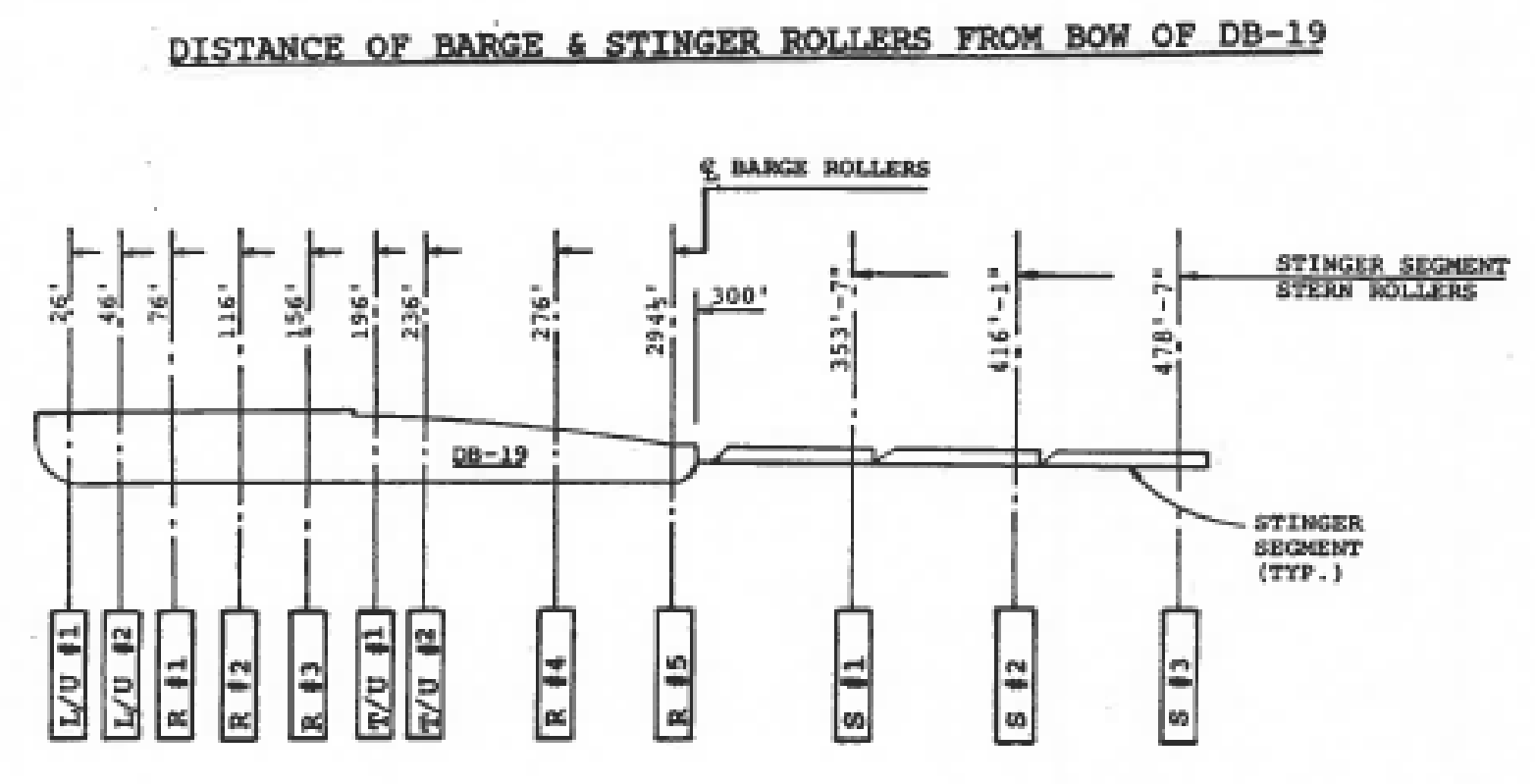
Example 1: DB19 with 3 segments articulated stinger (2 of 6)



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Example 1: DB19 with 3 segments articulated stinger (3 of 6)

RESULTS OF LAY STRESS ANALYSIS
FOR INSTALLATION OF 8" PIPELINE BETWEEN THE SHORE AND GAMMA-1 PLATFORM
USING DB-19 AND 3 SEGMENTS OF ARTICULATED STINGER RS-1

TOTAL PROCHE ORIENT

PROJECT NO. 53888

Optimised stress on barge & stinger

CONCRETE THICKNESS @ DENSITY	WATER DEPTH (FT)	BARGE TENSION (KIPS)	MAXIMUM PIPELINE COMBINED STRESSES (KSI/% YIELD)		
			ON BARGE	ON STINGER	IN SAG BEND
3.15" @ 190 pcf	40	40	30/58	28/55	35/66
3.15" @ 190 pcf	60	50	34/66	35/68	35/67
2.25" @ 190 pcf	60	30	28/53	28/53	36/69
2.25" @ 190 pcf	85	40	34/66	35/67	32/62
1.75" @ 140 pcf	85	20	25/48	25/48	32/61
1.75" @ 140 pcf	115	20	31/59	31/60	35/68

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Example 1: DB19 with 3 segments articulated stinger (4 of 6)

PROFILE CONTROL DATA
FOR INSTALLATION OF 8" PIPELINE BETWEEN THE SHORE AND GAMMA-1 PLATFORM
USING DB-19 AND 3 SEGMENTS OF ARTICULATED STINGER RS-1

TOTAL PROCHE ORIENT

PROJECT NO. 53888

CONCRETE THICKNESS @ DENSITY	WATER DEPTH (FT)	BARGE TENSION (KIPS)	B.O.P. ELEVATION AT STINGER ROLLER (FEET)		
			NO. 1	NO. 2	NO. 3
3.15" @ 190 pcf	40	40	(-)3.9	(-)13.7	(-)25.1
3.15" @ 190 pcf	60	50	(-)4.7	(-)16.8	(-)32.1
2.25" @ 190 pcf	60	30	(-)4.7	(-)17.0	(-)32.7
2.25" @ 190 pcf	85	40	(-)5.4	(-)19.8	(-)39.2
1.75" @ 140 pcf	85	20	(-)5.5	(-)20.2	(-)39.6
1.75" @ 140 pcf	115	20	(-)6.4	(-)23.7	(-)47.6

NOTE: 1) Negative sign indicates depth below water surface.

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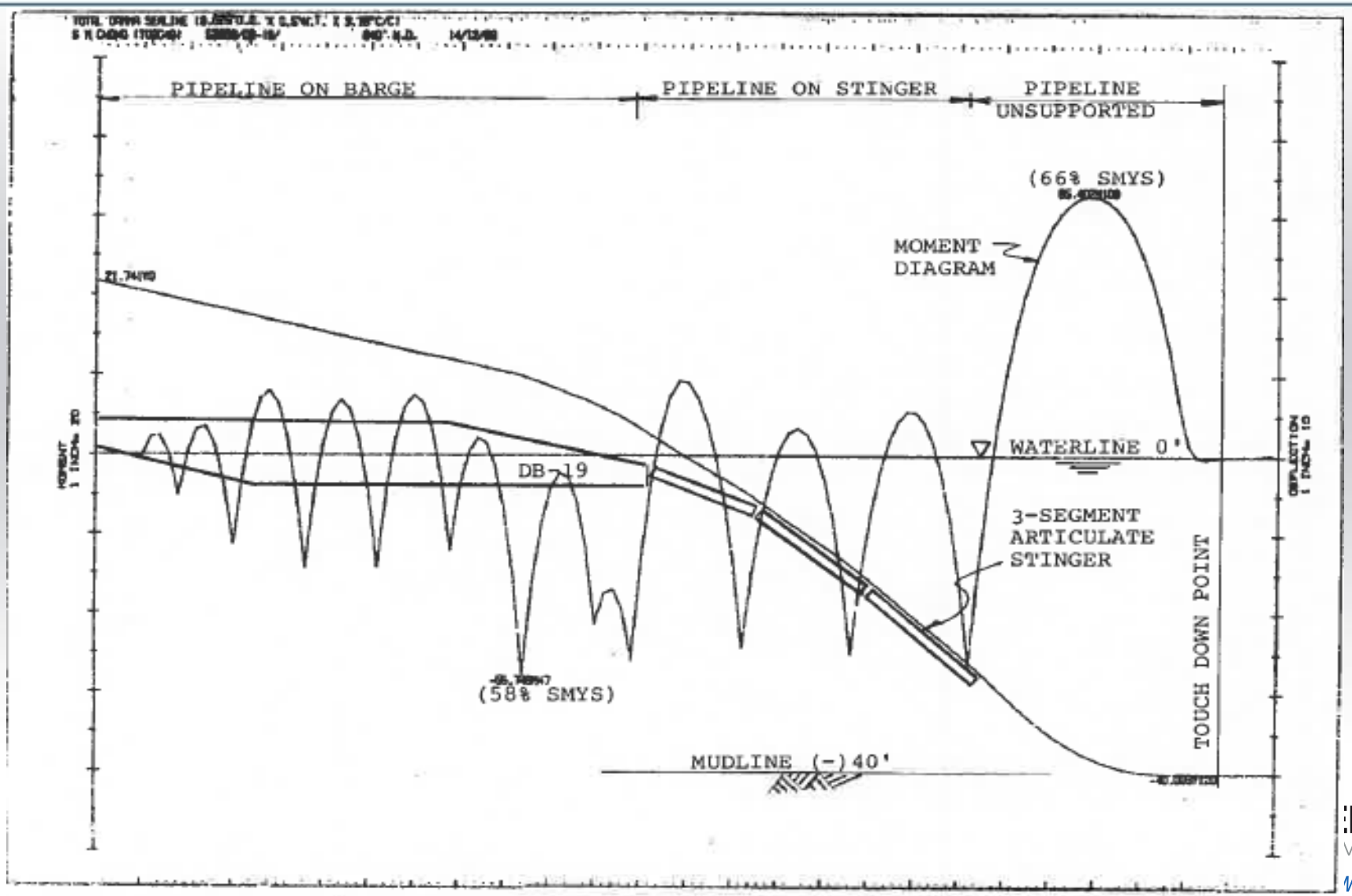
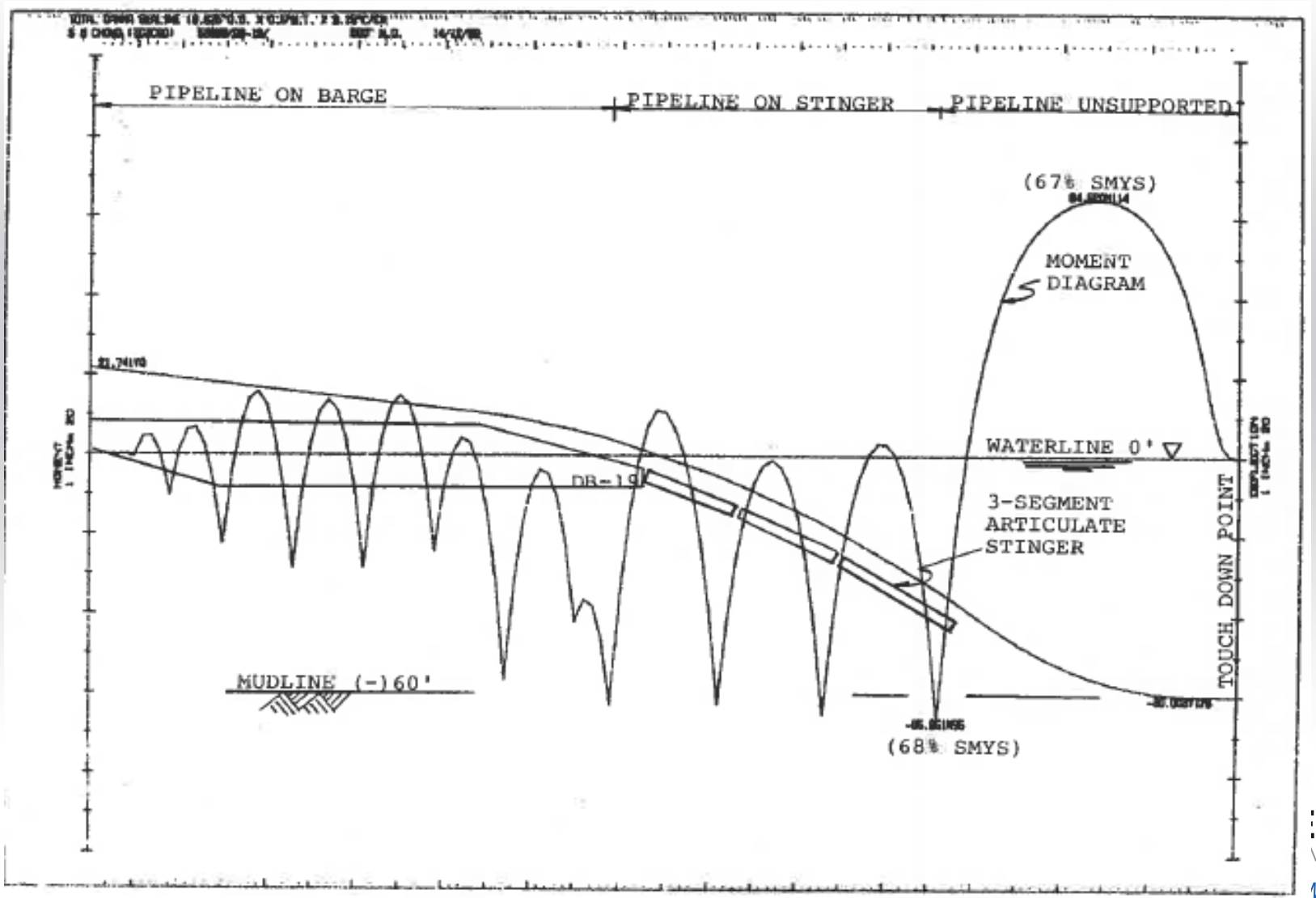
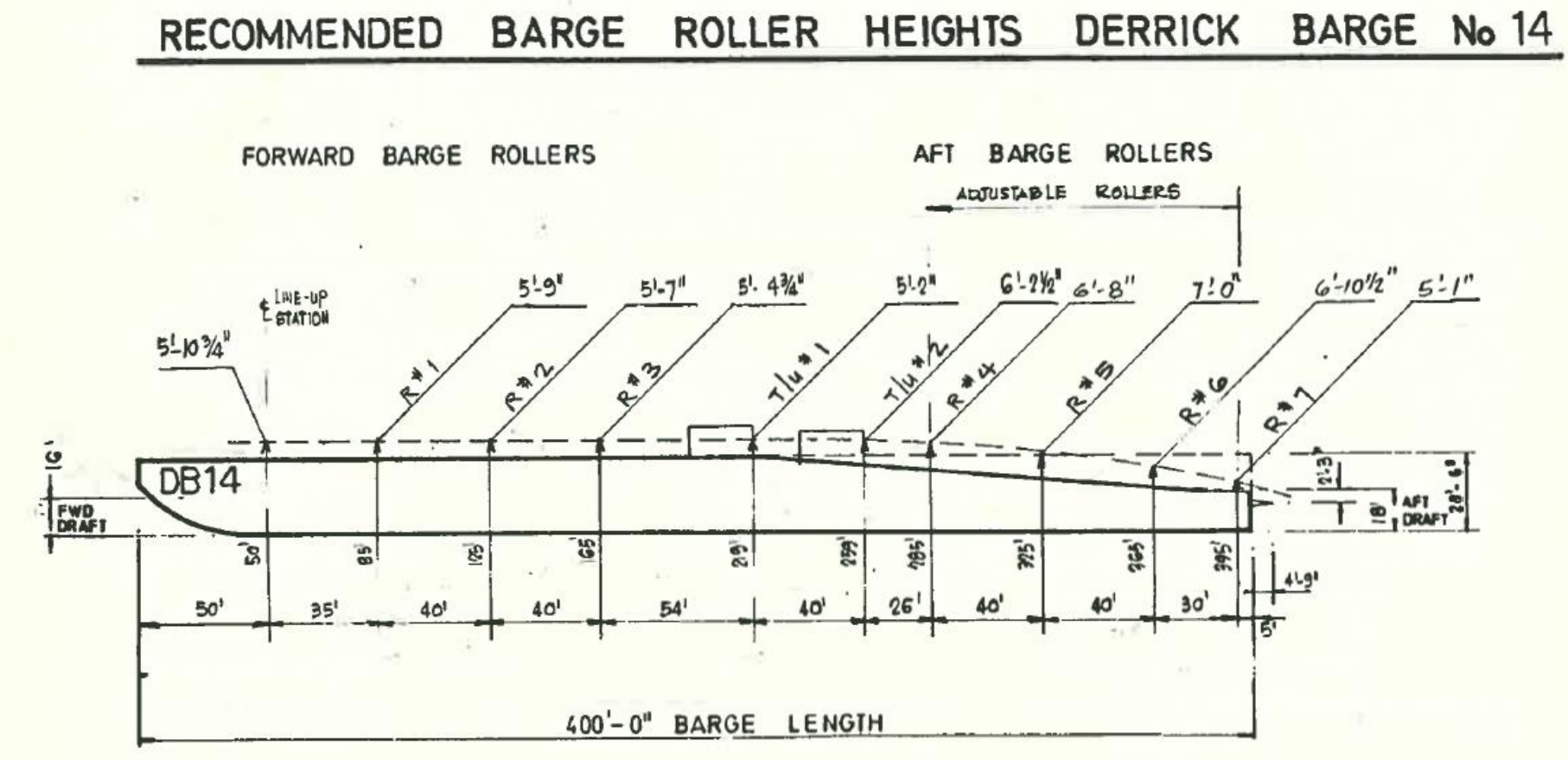
Example 1: DB19 with 3 segments articulated stinger (5 of 6)



Example 1: DB19 with 3 segments articulated stinger (6 of 6)



Example 2: DB14 with Trussed Stinger SEA-013 (1 of 8)



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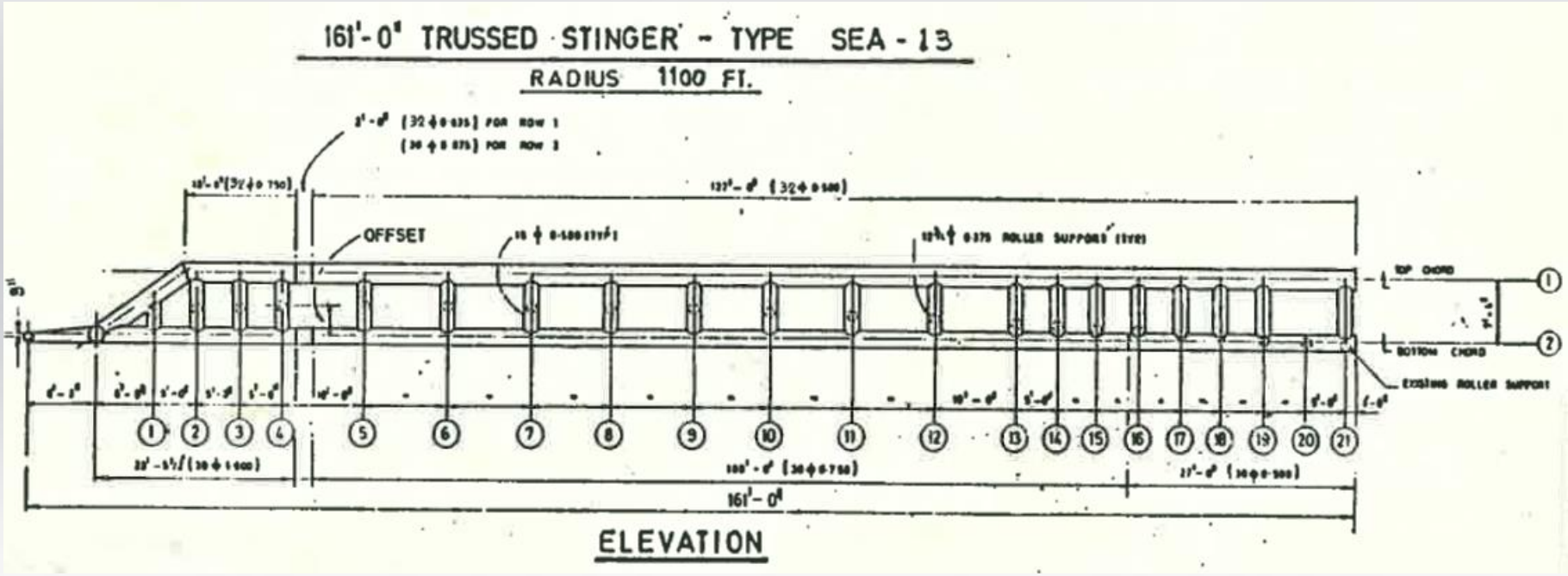
Example 2: DB14 with Trussed Stinger SEA-013 (2 of 8)



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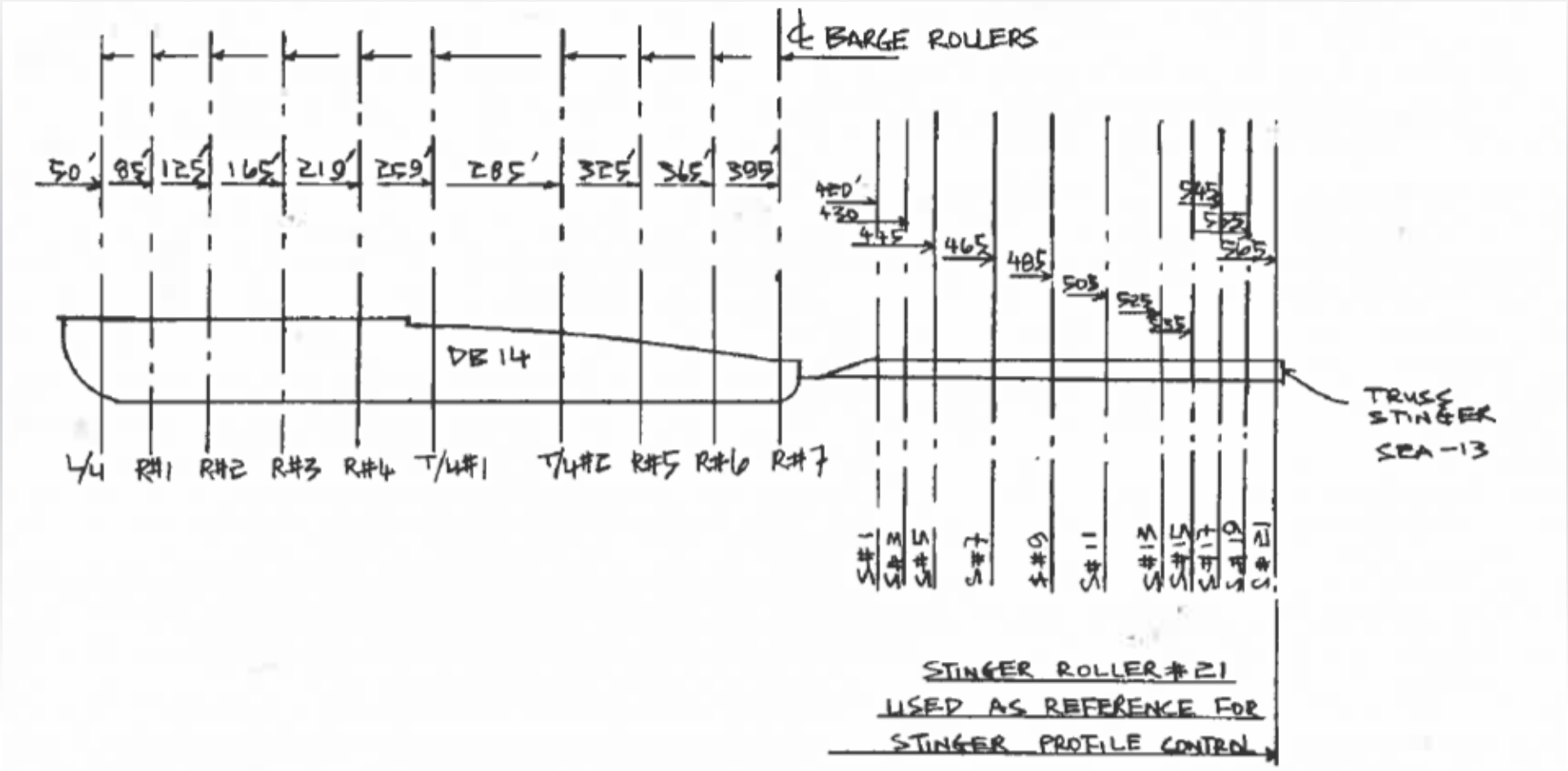
Example 2: DB14 with Trussed Stinger SEA-013 (3 of 8)



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Example 2: DB14 with Trussed Stinger SEA-013 (4 of 8)

PROFILE CONTROL DATA - STERN STINGER ROLLER ELEVATION
FOR INSTALLATION OF 6" PIPELINE
USING DB-14 AND TRUSS STINGER SEA-013

ORIENTAL ALCORN PHILIPPINES

PROJECT NO. 53701

WATER DEPTH (FT)	BARGE TENSION (KIPS)	STERN STINGER ROLLER (NO. 21) ELEVATION (1)
80	25	(-)30
120	25	(-)36
160	25	(-)42
200	25	(-)44

NOTE: 1) Negative sign indicates depth below water surface.

2) Stinger Roller Height indicates B.O.P. elevation at the last roller of respective stinger segment.

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Example 2: DB14 with Trussed Stinger SEA-013 (5 of 8)

RESULTS OF LAY STRESS ANALYSIS
FOR INSTALLATION OF 6" PIPELINE
USING DB-14 AND TRUSS STINGER SEA-013

ORIENTAL ALCORN PHILIPPINES

PROJECT NO. 53701

WATER DEPTH (FT)	BARGE TENSION (KIPS)	MAXIMUM PIPELINE COMBINED STRESSES (KSI/% YIELD)		
		ON BARGE	ON STINGER	IN SAG BEND
80	25	17/32	11/22	9/17
120	25	27/52	25/47	9/17
160	25	39/74	31/60	9/17
200	25	42/81	43/83	9/17

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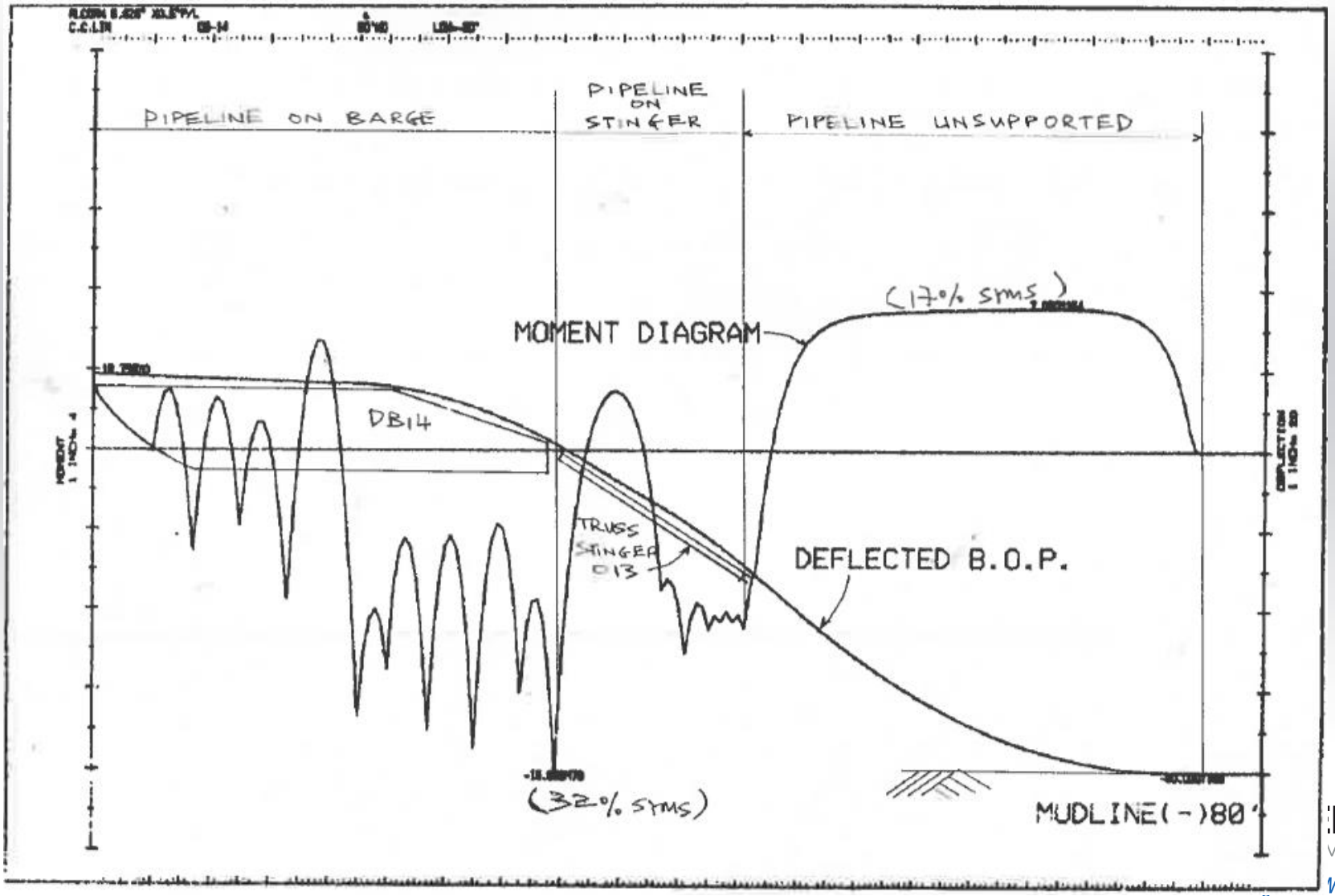
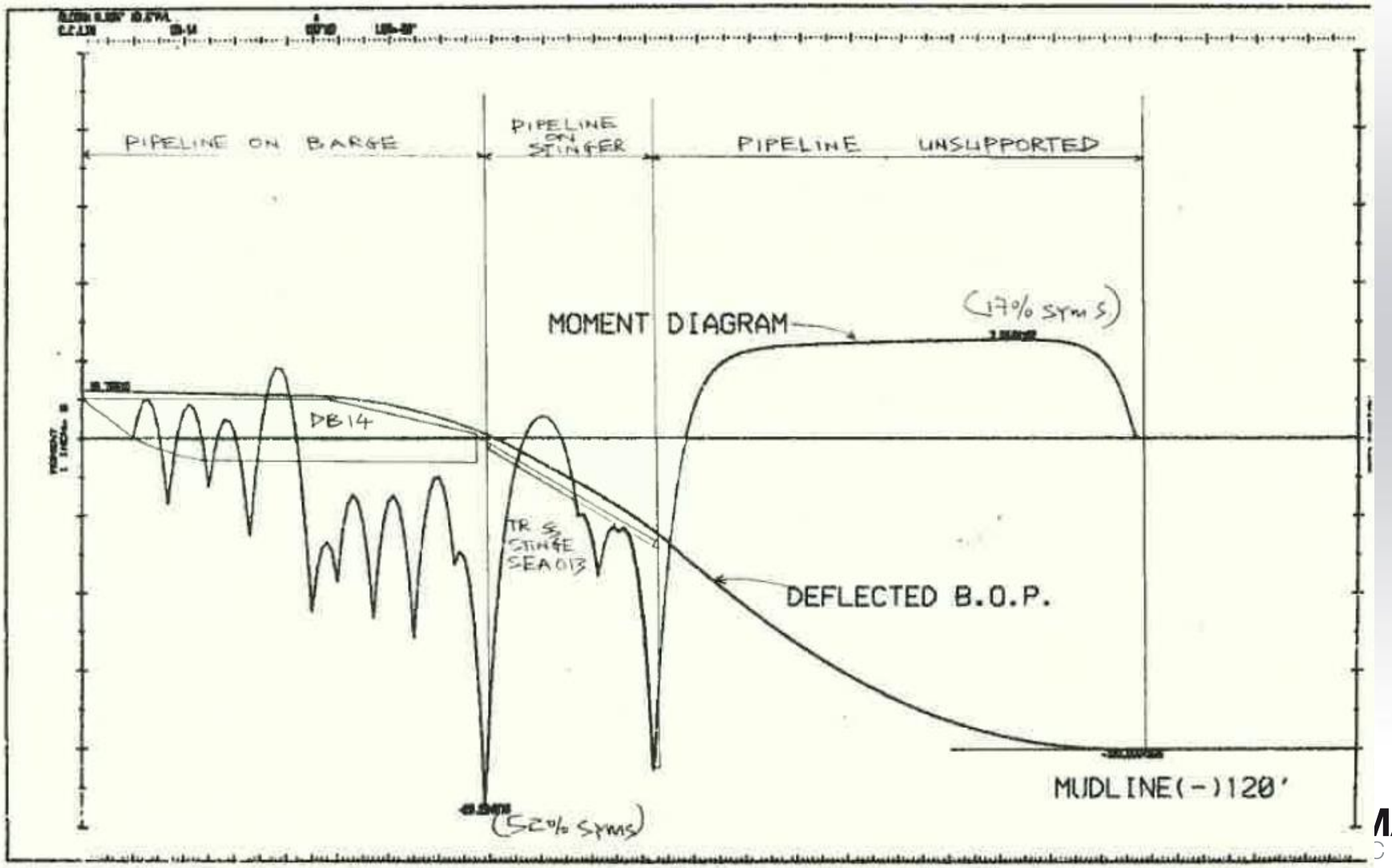
Example 2: DB14 with Trussed Stinger SEA-013 (6 of 8)



Example 2: DB14 with Trussed Stinger SEA-013 (7 of 8)



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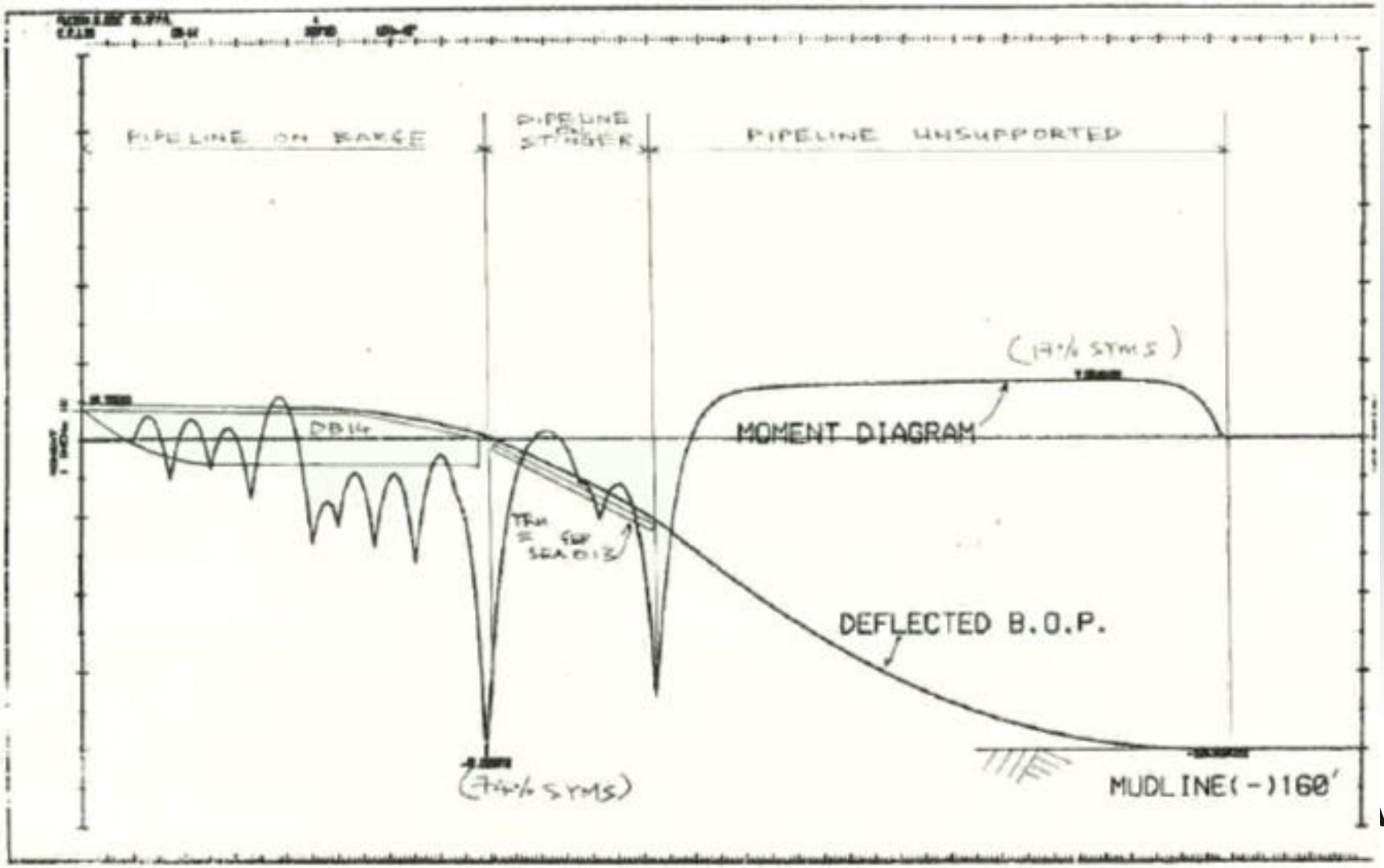
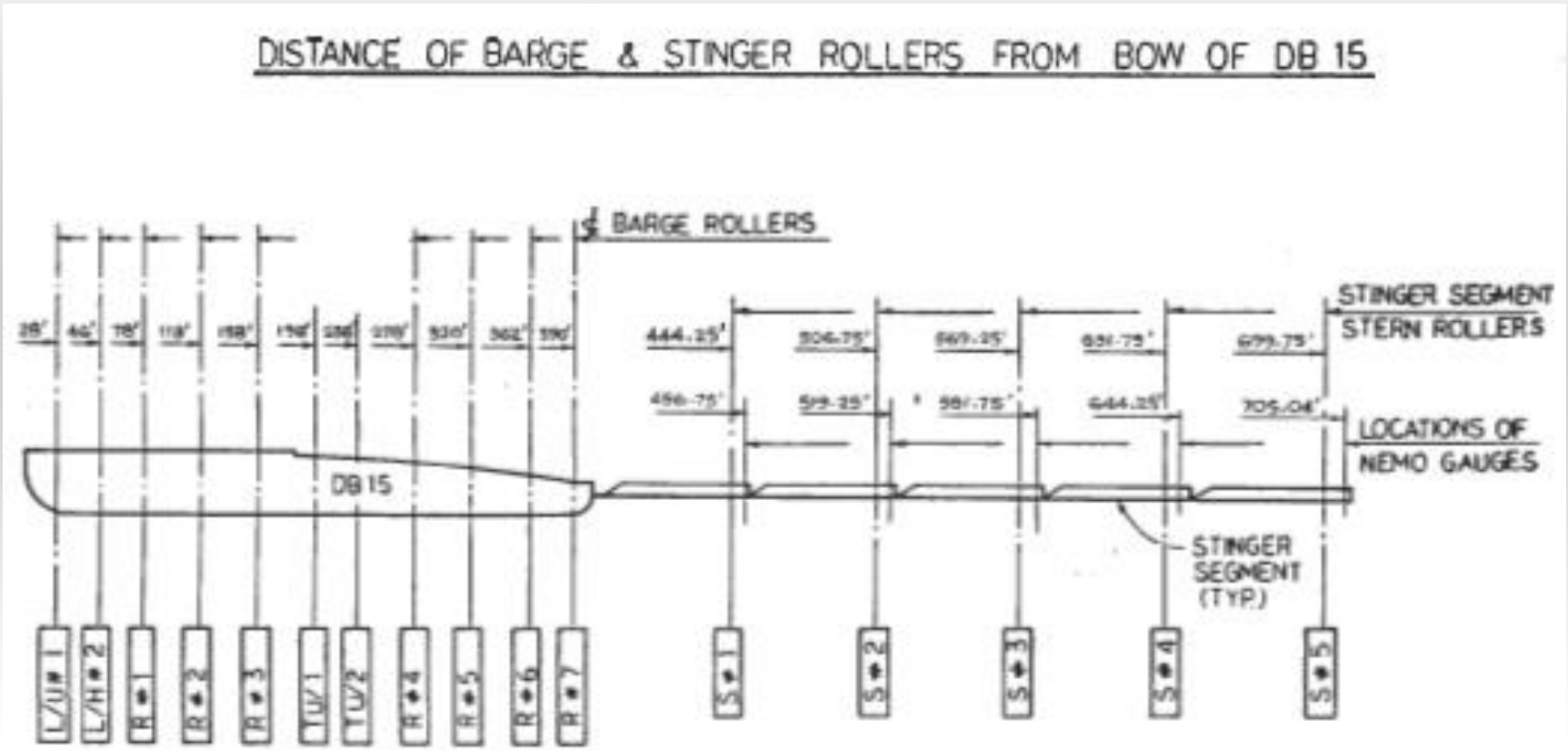
Example 2: DB14 with Trussed Stinger SEA-013 (8 of 8)



Example 3: DB15 with 5-Segment Articulated Stinger (1 of 3)



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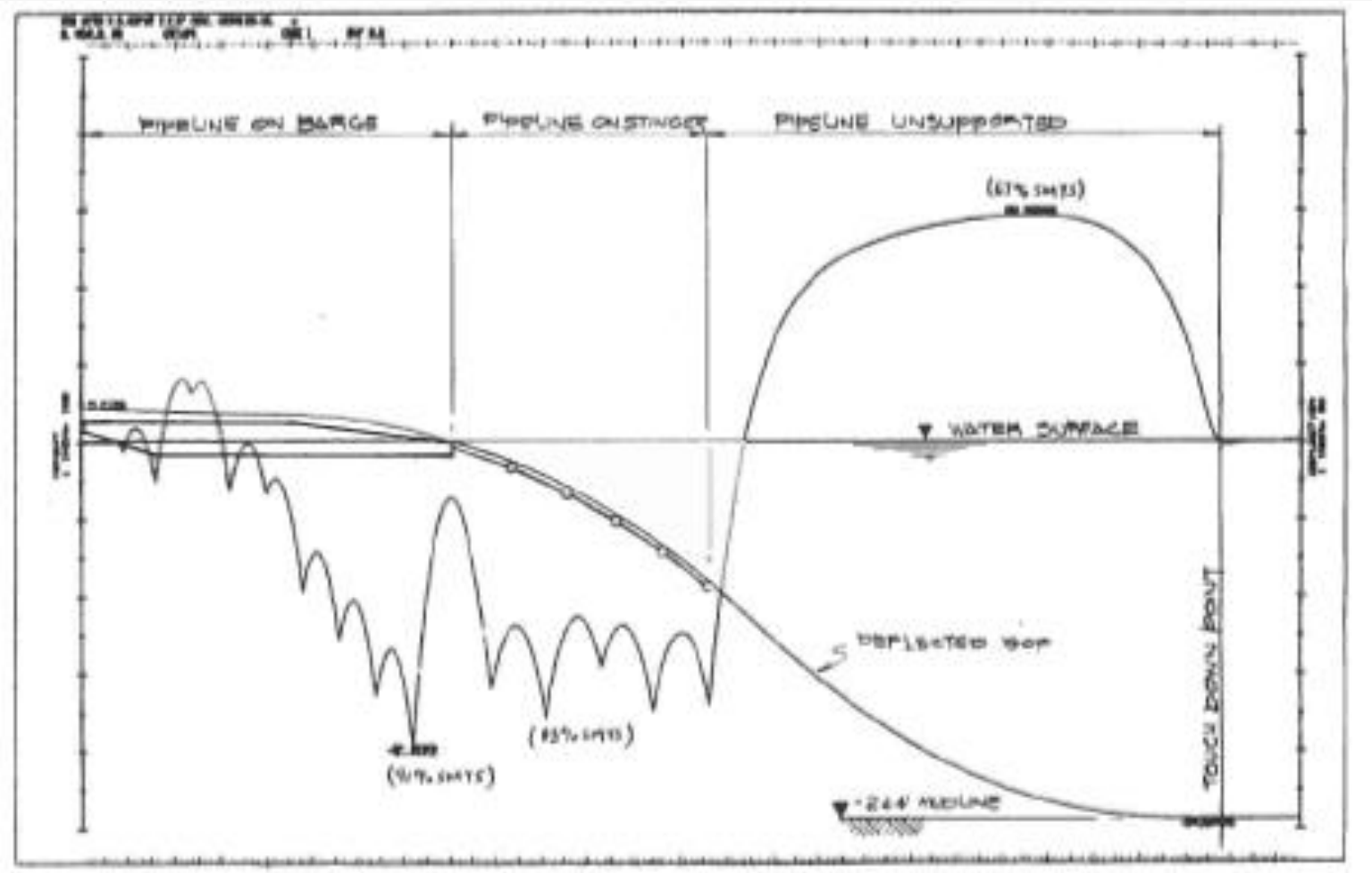
Example 3: DB15 with 5-Segment Articulated Stinger (2 of 3)



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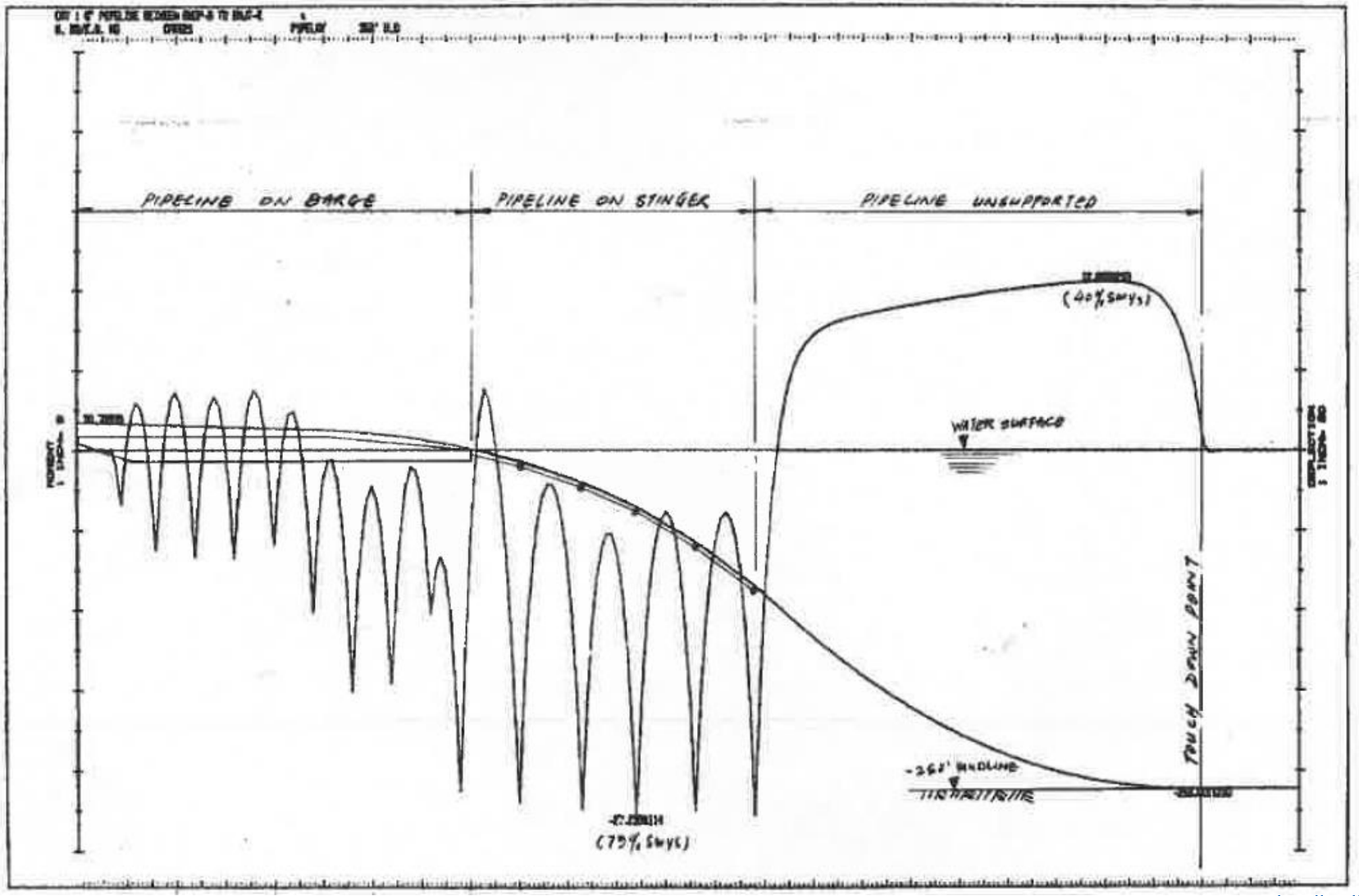
Example 3: DB15 with 5-Segment Articulated Stinger (3 of 3)



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Concluding Remarks: Articulated vs trussed stinger

- From operation point of view, articulated stingers are difficult to handle and subject to fatigue failure especially when it is not carrying pipeline
- After pipeline abandonment:
  - ❖ A 'rigid' trussed stinger can be lifted above waterline and avoid subjecting to hydrodynamic loads
  - ❖ A floating stinger (trussed or articulated) is subject to considerable load and risk failure at the hinge location(s).
  - ❖ A floating stinger may need to be disconnected in inclement weather to prevent failure
- From analysis view point:
  - ❖ Articulated stingers allow for even distribution of loads on the stinger and last barge roller – this allows for optimization of stress/strain or reduction of lay tension
  - ❖ Difficult to optimize load distribution on a trussed stinger – very often, loads are not evenly distributed
- Thus, generally:
  - ❖ Installation analysis engineers prefers the articulated stinger as it stresses are easier to control, whereas
  - ❖ Operational personnel prefers the trussed stinger as it is easier to handle offshore.

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Local buckling criteria as per DNV OS-F101

- Essentially, pipelaying check is to check for local buckling during installation and the support conditions play a part.
- The type of stinger will determine the support conditions i.e.
  - load controlled where the curvature may vary (e.g. articulated or hinged stinger) or
  - displacement controlled where the curvature is fixed (fixed stinger/ramp).
- A load-controlled condition is one where the structural response is primarily governed by the loads
- A displacement-controlled is one in which the structural response is primarily governed by imposed geometric displacements

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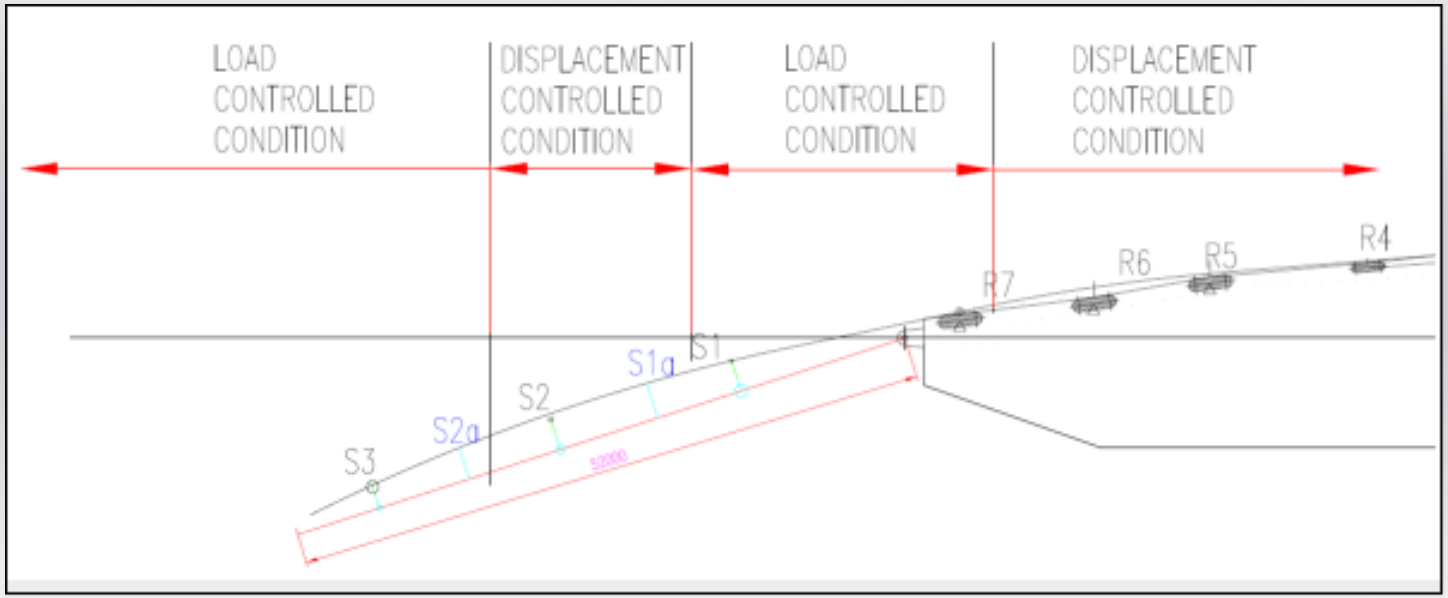
Pipelay Analysis: Local Buckling Criteria as per DNV

- For rigid stingers, displacement controlled criteria may apply to all rollers except at roller where stinger lift off the stinger



- For floating hinged trussed stinger :
  - Load controlled criteria is applied on rollers adjacent to stinger hinge and stinger tip
  - Displacement controlled criteria may be applied for intermediate rollers on the stinger

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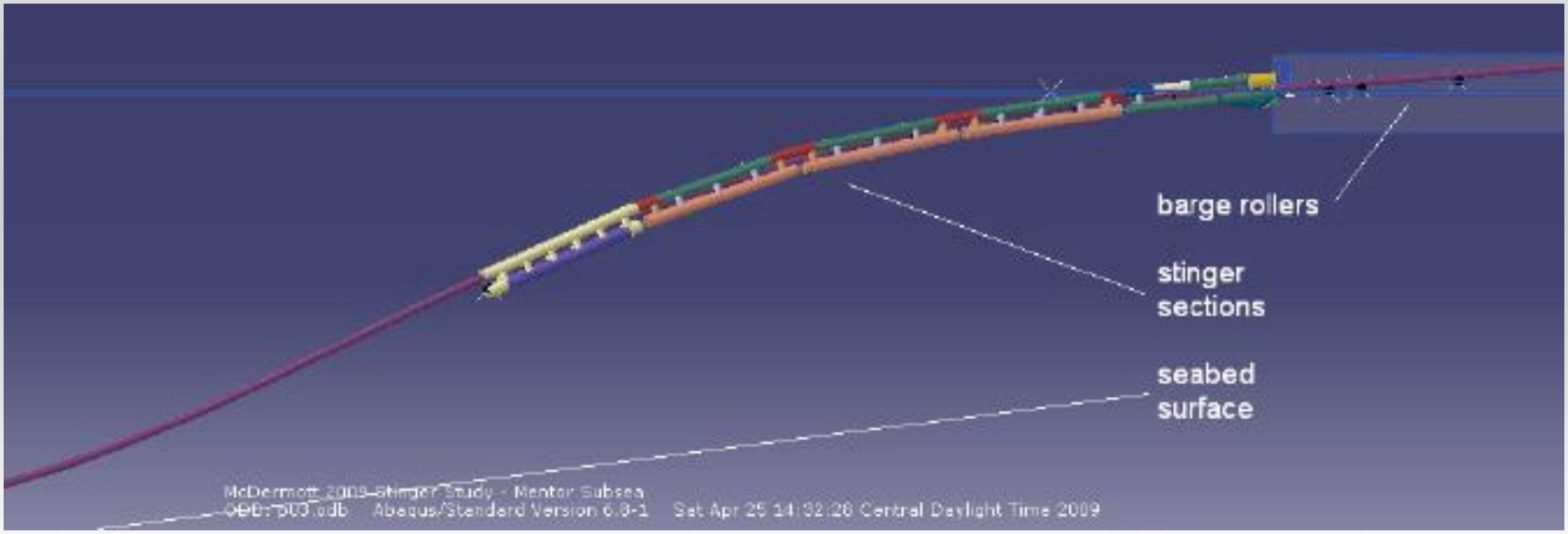
Pipelay Analysis: Local Buckling Criteria as per DNV (Cont'd)

In a case of floating articulated stinger, past experience with DNV as well as experiences of our own engineers are that these should be considered as load controlled condition.



Load controlled condition along entire floating articulated stinger, including stern barge roller

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Thank You!

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