



HISTORIQUE ET EVOLUTION DES PLATES-FORMES AVEC TETES DE PUIXS EN SURFACE (SPAR...) Les tendances pour le futur

Pierre-Armand Thomas
Technip

13 Juin 2006

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CONTENTS

- PRESENTATION OF SPAR
- PRESENTATION OF EXTENDABLE DRAFT PLATFORM
- DEEPWATER PRODUCTS – SPECIAL STRUCTURE EQUIPMENTS
- FUTURE EVOLUTION AND OTHER ENVIRONMENTS
 - OTHER ENVIRONMENTS
 - PRESENTATION OF EDP LATEST DEVELOPMENTS
 - EDP CASE STUDY
 - DESIGN OF STRUCTURE
 - COMPARATIVE ANALYSIS OF DIFFERENT DOMAINS OF APPLICATION
 - RESEARCH & DEVELOPMENT PROGRAMME

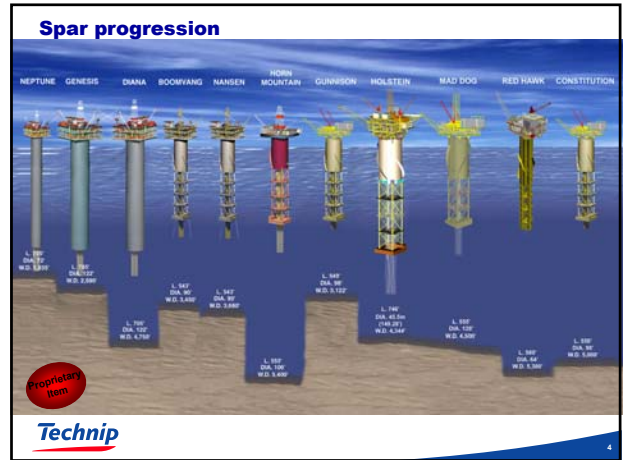
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2



DEEPWATER PRODUCTS

SPAR



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4

From Classic Spar to Truss and Cell Spar

- Significant improvements in many domains :
 - Risers suspension,
 - Mooring lines,
 - VIV approach,
 - Top tension risers.

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Ring section assembly at yard assembling rails



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Barge Harry at the end of assembly rails



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Evolution of construction model

- Dedicated investment to improve model delivery

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Chevron Tahiti Spar Dimensions & Weights

Basics

- Water Depth 4,000 ft
- Production and Quarters only, all subsea wells
- Topsides design throughput 125 MBPOD
- SITWHP 12,300 psig

Spar dimensions

- Diameter 128 ft
- Draft 500 ft
- Freeboard 55 ft
- Centerwell 50x50 ft
- Hard Tank Length 216 ft

Mooring

- 13 lines ; 6.2" chain, 10.2" polyester

Risers

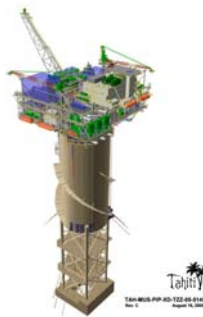
- 4 production, 2 test, 2 water injectors; all in pull-tubes
- Oil and gas export risers w/ flex-joints

Weights

- Topsides Weight 21,000 tons
- Fixed Ballast 23,700 tons
- Vertical Mooring Load 3,800 tons

Environment

- 100 yr Hurricane; Hs=39 ft Tp=12.7-15.3 sec, Wind=73.5 kt



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9

Tahiti First's

- Largest Single-Piece Spar Dry Transportation
- 360 degrees stroke coverage requires portion of strakes to be installed offshore
- First spar with utility/access shaft and dedicated pump room



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10

Holstein hard tank



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Cell Spar

RED HAWK

Both the hull and topsides were installed in March 2004.
(first gas in July 2004)



RED HAWK Dec 1, 2003



THIS WAS THE FIRST APPLICATION OF A CELL SPAR

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12

Cell Spar Installation

Upend Spar at Integration Site



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Install Fixed Ballast



Cell spar safest floater

- Hull unconditionally stable
 - 28 separate buoyancy compartments
 - Center of buoyancy above center of weight
 - Simple ballast system
 - Operator cannot sink vessel
 - No down flooding points
 - Mooring line failure can not capsize vessel
- Other hulls less safe
 - Fewer compartments
 - Happier upside down
 - Complicated ballast control system



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14

RESISTANCE TO HURRICANES
TO BE TAKEN INTO ACCOUNT
SERIOUSLY

Spar model for installation request

- Towing of Spar hull horizontally
- Upending at deep site > 200 m water depth
- Topsides installation by heavy crane for floatover
- Hook-up and commissioning offshore

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15

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16



Extendable Draft Platform (EDP)

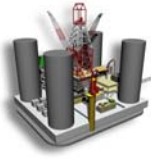


Tow to field



Operation

- Extendable Draft Platform (EDP) for production drilling / workover
- Full integration onshore - minimum offshore HUC / no flotel
- Suitable for large payloads, deep water & high well counts
- Composed of:
 - Barge-type Deck
 - Topsides facilities on top of deck
 - Legs (buoyant column + truss)
 - Pontoon (heave plate)

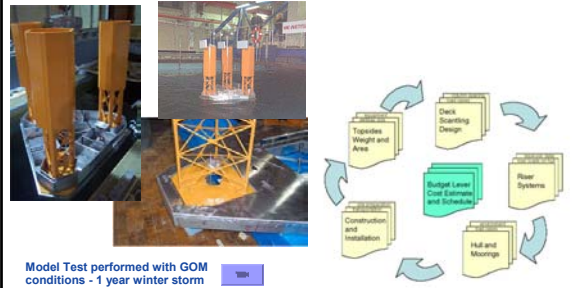



18

EDP installation

- Reminder of Spar installation requirements : 
- The EDP concept is offering a solution that mitigate these issues

EDP Model test/completion status



Model Test performed with GOM conditions - 1 year winter storm

Figure 2. Sizing Tool Integration for EDP Design

Tests have proven as good motion responses as Spar

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Special structure equipment

- Beside the hull design, the « ancillary equipments » capture a lot of attention to provide the best service for SCR behaviour and integrity and the best handling of surface trees

Platform-based mooring equipment

- Winching equipment
 - ➔ Rotary winches (wire)
 - ➔ Linear winches (wire)
 - ➔ Chain windlasses or capstans
 - ➔ Chain jacks or devil's claws
- Fairleads
 - ➔ Rotary-type
 - ➔ Bending shoe type
- Stoppers
 - ➔ Passive
 - ➔ Active



Examples : Pull tube hull equipment

- Kerr McGee Boomvang & Nansen
- Pre-Installed Pull Tubes

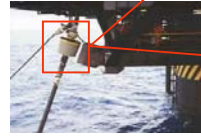
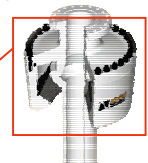


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Examples : porch – SCR interface

- Porch interface suitable for FlexJoint or Taper Stress Joint

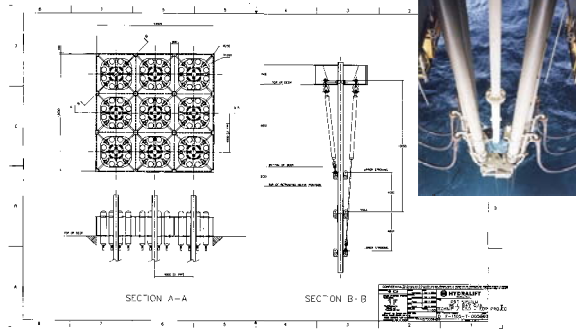


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26

EDP dry trees risers tensioners

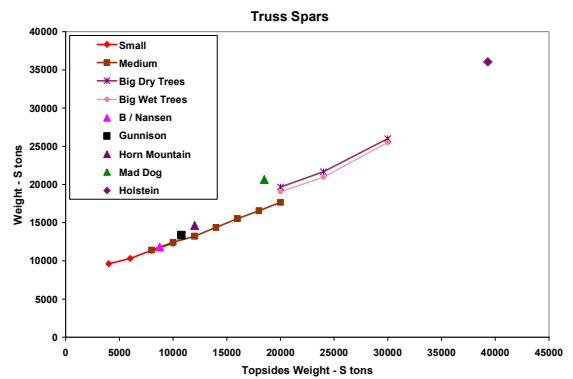
- Hydro pneumatic tensioners



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27

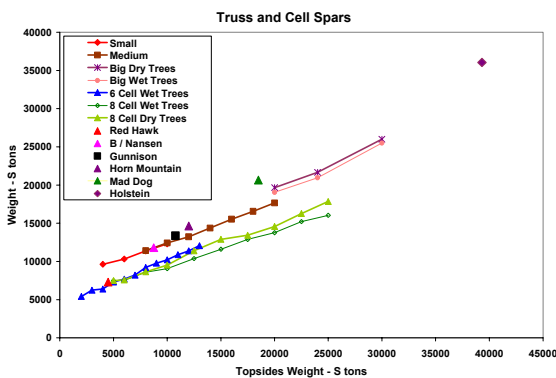
Hull weight comparison



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28

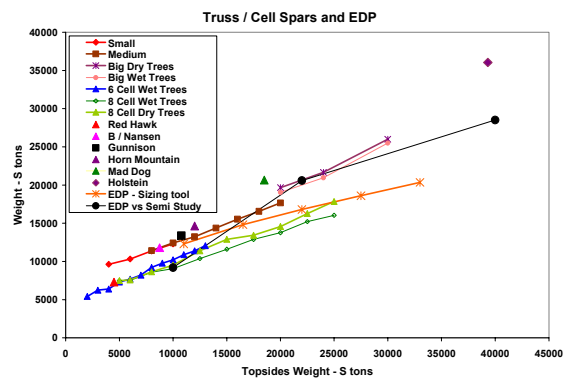
Hull weight comparison



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29

Hull Weight comparison



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30

Kikeh Spar Dimensions & Weights

Spar dimensions

- Diameter 106 ft
- Draft 430 ft
- Freeboard 35 ft
- Centerwell 55x55 ft
- Hard Tank Length 220 ft

Mooring

- 10 Lines; 142mm Chain, 108mm Spiral Strand

Risers

- 24 Prod + 1 Drilling TTR w/Riser Hydraulic Tensioners
- Tensioner Max Stroke 21 ft

Weights

- Topside Weight (w/workover) 6600 t
- Max Well System Load 4200 t (w/ 24 TTRs)
- Fixed Ballast 2900 t
- Vertical Mooring Load 2200 t

Environment

- 100 yr Typhoon; Hs=20.7ft Tp=16sec, Wind=30kt



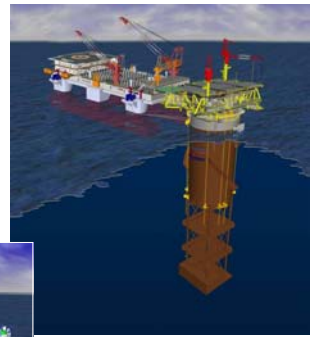
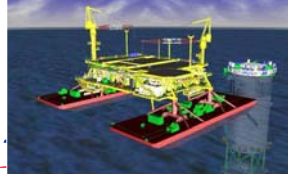
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31

Kikeh First's

- First SPAR Outside GoM
 - Hull, Topsides Constructed in Malaysia
 - TOF Supervision & Know-How
- Tender Assisted Drilling
- Direct Tensioner System
- Topside Floatover installation
- Global Project Execution
 - Kuala Lumpur / Pori / Houston / Perth / Paris

Topside Floatover

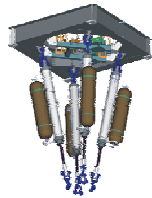


32

Kikeh Hull Fabrication at MMHE (Malaysia)



MMHE April 14th 2006



33

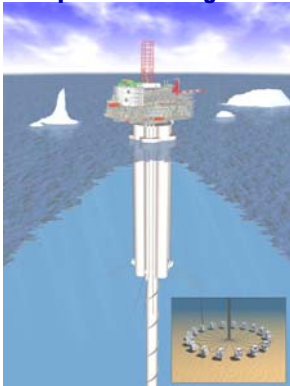
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34

Disconnectable Spar for Ice Regions



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35

Bottom section disconnected from Upper Hull



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36

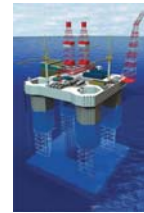
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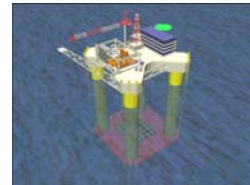
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37

Review of EDP Generation (1&2)



First Generation
1995 start developing TPG 3300

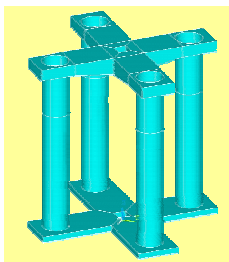


Second Generation

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38

Review of EDP Generation (3)



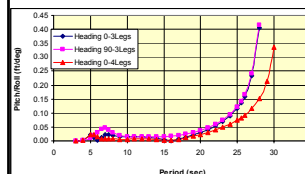
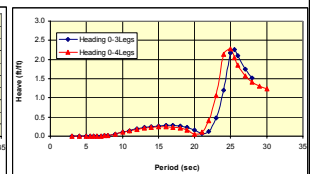
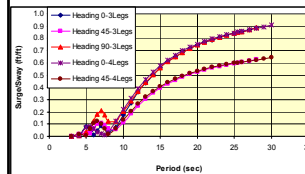
Third Generation

- We are currently working on Third Generation of Drilling EDP
- Design three Draft, 150 ft, 180 ft and 220 ft (payload 17,000 mton)
- Comparing EDP with Eirik Raude Drilling Semi
- Motion & Load Analysis of EDP During Installation

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39

Comparison between four legs and three legs

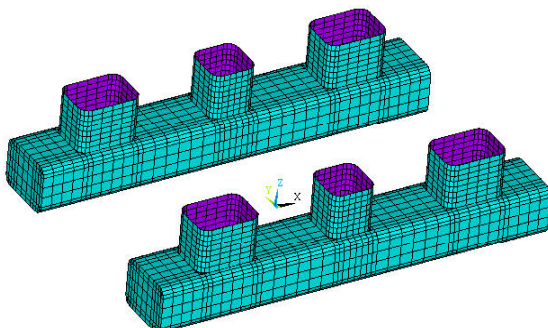


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Pitch RAO

40

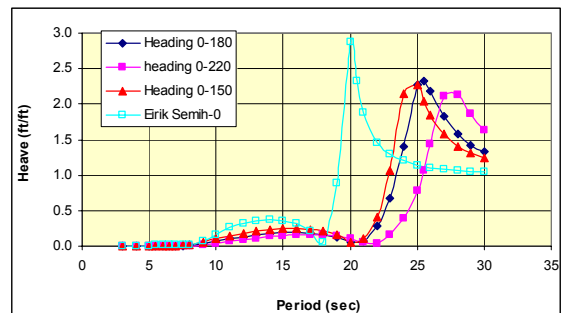
Eirik Raude Semi (payload 17,000 mtons)



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41

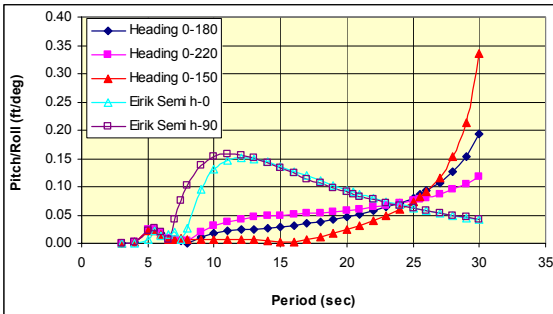
Heave RAO comparison



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42

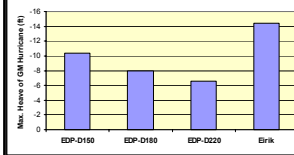
Pitch RAO Comparison



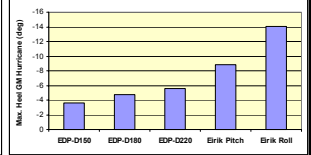
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43

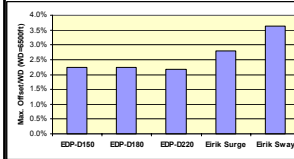
Maximum Motion Comparisons



Heave Motion



Pitch Motion

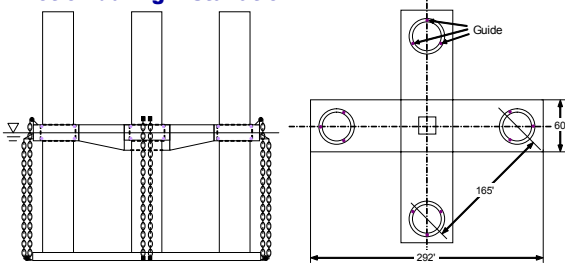


Offset

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44

Motion during Installation

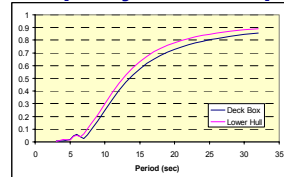


- Developed for Total's Laggan Field in West of the Shetlands
- Two parts are coupled hydrodynamically and mechanically
- Operation Draft 250 ft
- Deck draft for installation 8 ft

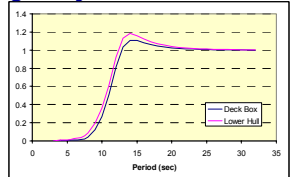
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45

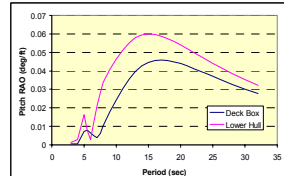
Frequency-domain coupling analysis



Surge RAO, Two body coupled



Heave RAO, Two body coupled



Pitch RAO, Two body coupled

Results	
Max. Compliant Guides Load:	100 kips
Chain Tension:	Pre-tension +735 kips
Relative Horizontal Motion:	0.32 ft (3.8")
Relative Vertical Motion:	0.45 ft (5.4")
Environmental	
Hs:	5 ft
Tp:	8.7 sec
Y:	2.0

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46

CONTENTS

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47

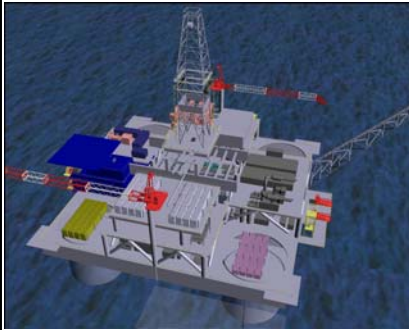
Presentation of the latest development for the EDP, showing a base case application to calibrate our sizing model

EDP CASE STUDY

A large deck extendable draft platform designed for ultra-deepwater in the Gulf of Mexico

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Topsides



Component	(s tons)
Product & Separation	4,040
Export	4,000
Chemical Injection	1,733
Center Well	3,991
Drilling	3,960
Living Quarters	1,630
Crane F-Boom P-Rack	952
Total	26,306

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49

EDP GoM DESIGN BASIS

Production Capacity and Composition

Flow Rates

Oil Rate	200,000 BPD
Total Gas Rate	475 MMSCFD (associated & non-associated)
Associated Gas Rate	275 MMSCFD (assumed)
Non-Associated Gas Rate	200 MMSCFD (assumed)
Produced Water Rate	60,000 BPD (assumed maximum)
Water Injection	None
Gas Injection	None
Artificial Lift	None

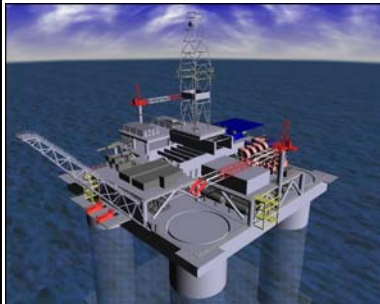
Water Depth = 8,500 ft

West Gulf of Mexico Environment

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50

Topsides

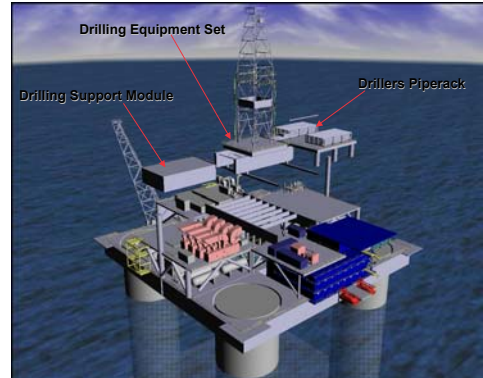


Component	(s tons)
Production & Export	20,398
Drilling & Bunks	8,395
Living Quarters	1,860
Topsides Structural Steel	9,286
Riser Tensions	12,500
Total	52,439

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51

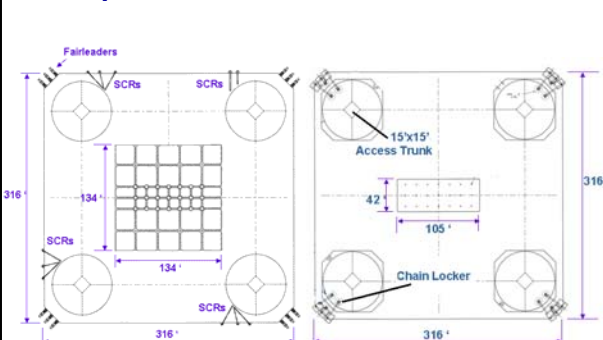
Drilling system



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52

Heave plate & deck



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53

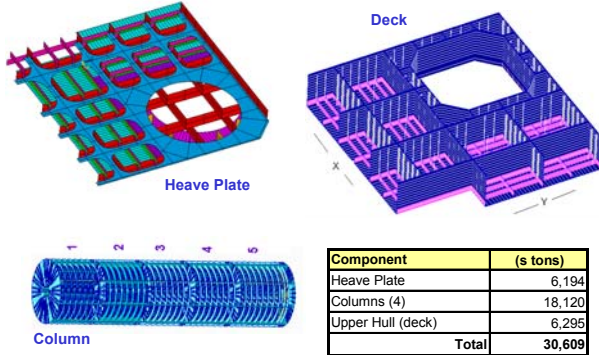
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54

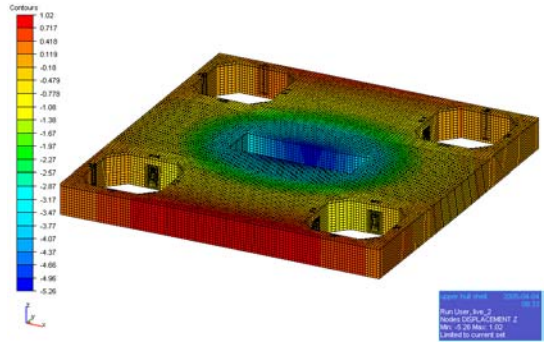
Structural models



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Deck weight moorings and risers installed in still water



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56

Moorings system

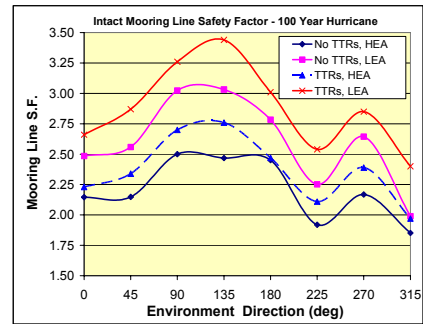
	Diameter (in)	B.S. (kips)	B.S. (Corroded) (kips)**	Length ¹ (ft)
Platform Chain	6	4,550	3,946	400-500
Polyester Rope	10.12	4,261	4,261	13,000
Anchor Chain	6	4,550	3,394	250

Platform Chain Length-Below Fairleader
** Assuming 12 mm corrosion and wear

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57

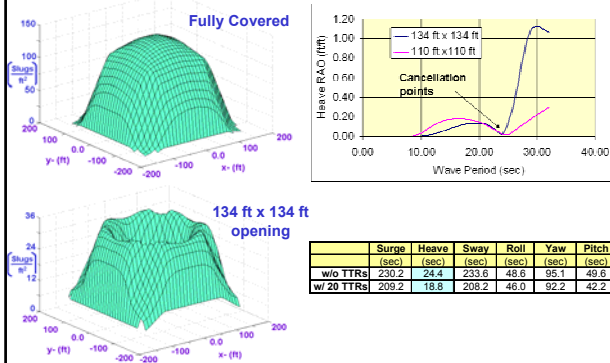
Moorings system



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58

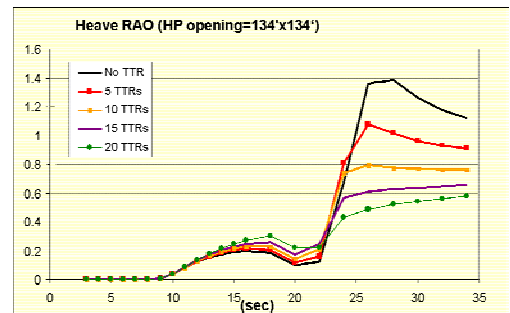
Added mass effects



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59

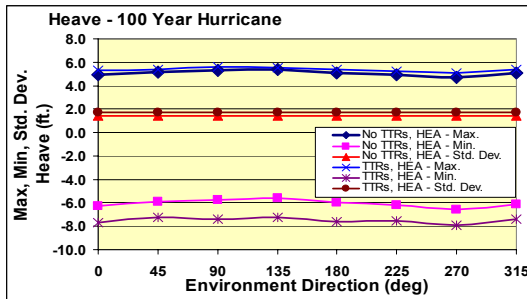
Heave response



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60

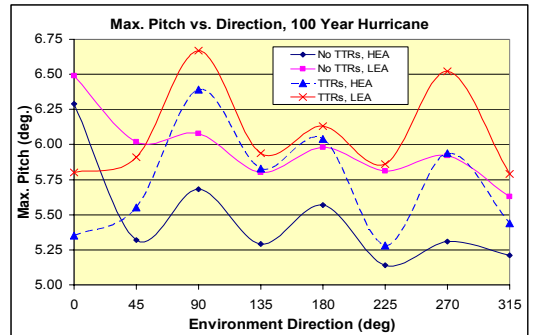
Heave response



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61

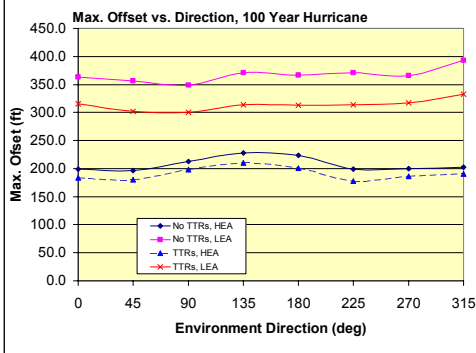
Hull response



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62

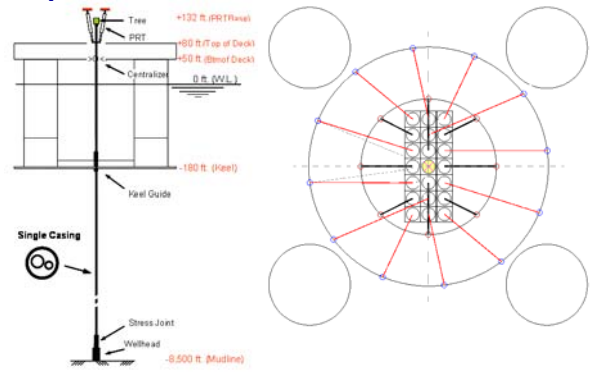
Hull response



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63

Top tensioned risers



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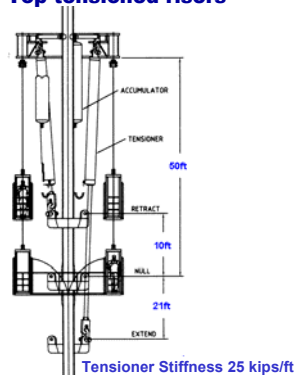
64

Top tensioned risers

Hydro pneumatic tensioners

Average Stiffness
40 kips/ft

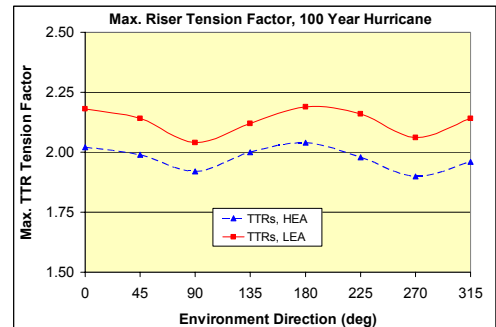
Max Stroke Range
Upstroke: 10 ft.
Downstroke: 21 ft.



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65

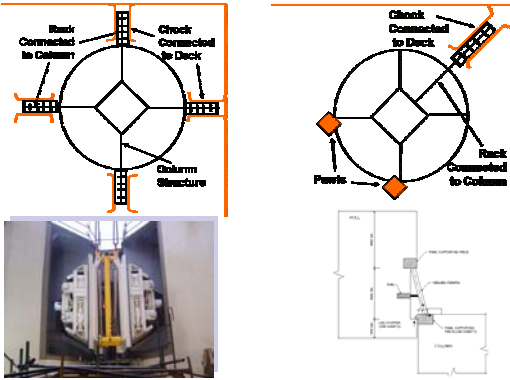
TTR tensions



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66

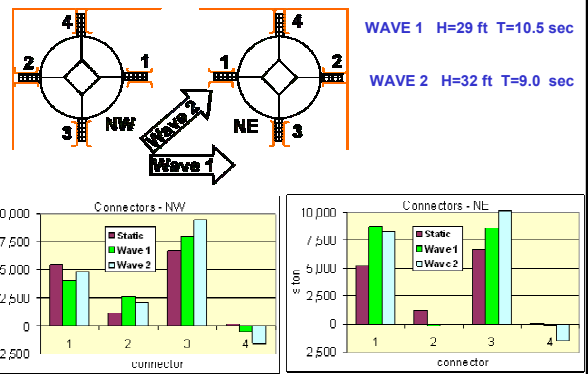
Deck connections



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67

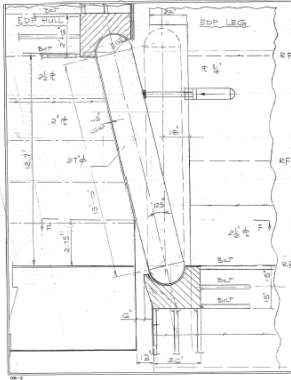
Connector analysis



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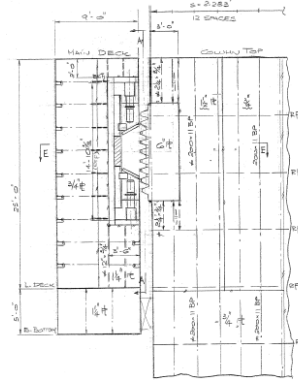
68

Pawl



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69

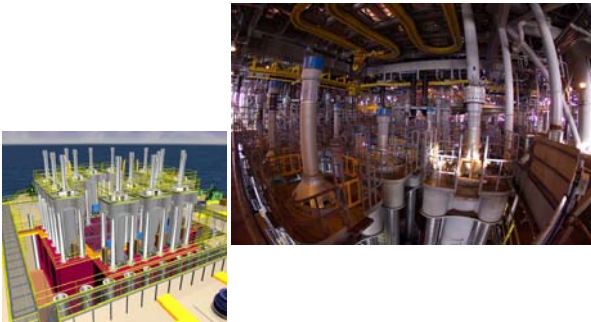


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70

Dry tree riser system options

Ram Type Tensioners

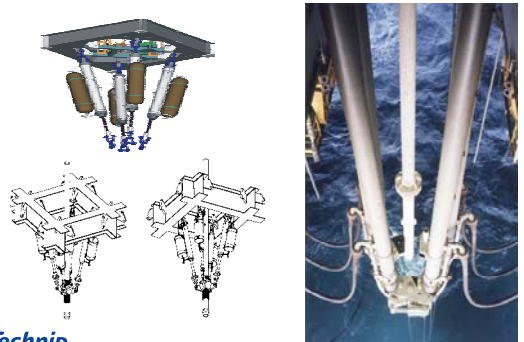


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71

Dry tree riser system options

Direct Acting Tension Type Tensioners



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72

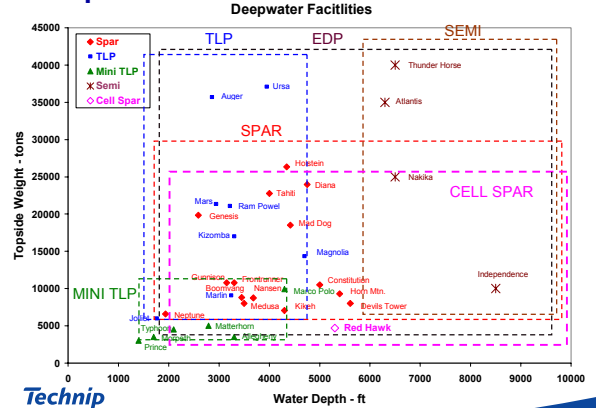
CONTENTS

- PRESENTATION OF SPAR
- PRESENTATION OF EXTENDABLE DRAFT PLATFORM
- DEEPWATER PRODUCTS – SPECIAL STRUCTURE EQUIPMENTS
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 - OTHER ENVIRONMENTS
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73

Cell spar installation



74

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75

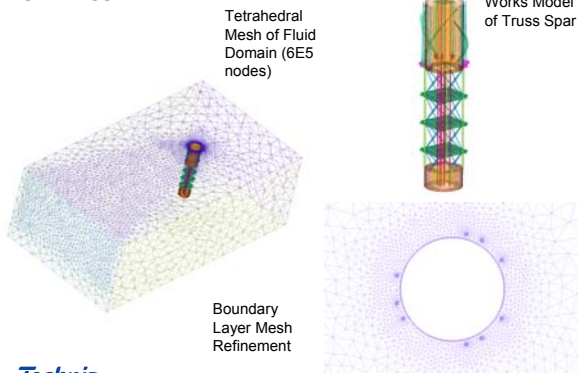
Current CFD efforts

- Spar VIM
 - Benchmark and validate model test data
 - Optimize and automate solution process
- Numerical wave tank
 - Generate 3D wave and current
 - Cell Spar wave run-up with 6 DOF
 - 2 body problem with 12 DOF (Spar and TAD)
- Riser VIV
 - AcuTechnip coupling of AcuSolve and ABAQUS for riser solution
- Collaboration with ChevronTexaco
 - Sharing CFD work and results so as not to duplicate the effort

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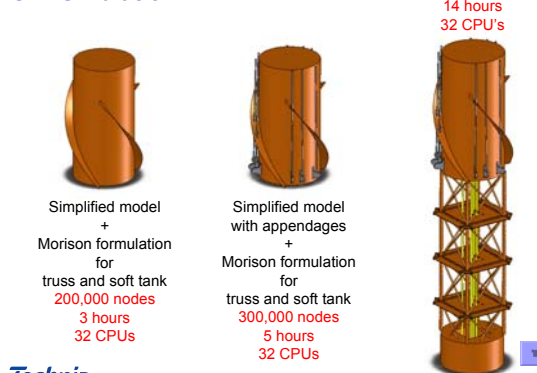
76

SPAR VIM CFD Mesh



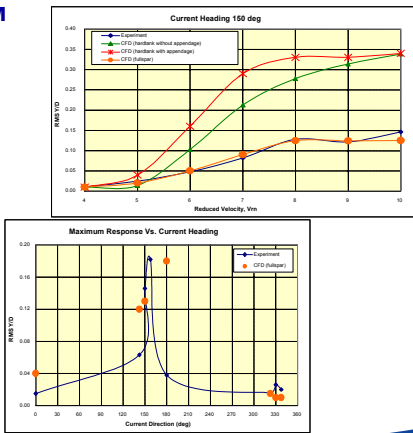
77

SPAR VIM CFD Simulation



78

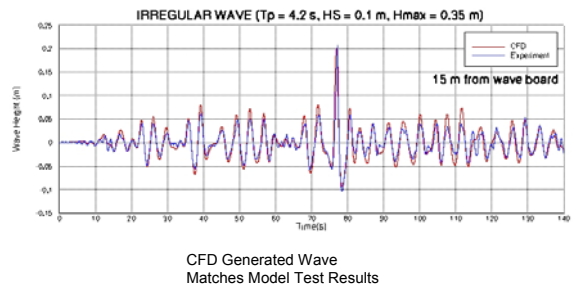
SPAR VIM Results



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79

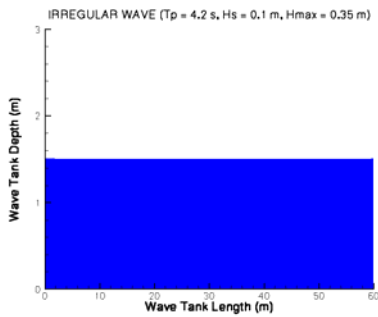
Numerical wave tank



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80

Numerical wave tank



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81

Risers tests in Shell's flume

1. One Bare riser
2. One Straked Riser
3. Two Straked Risers



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82