Hurricane Evacuation Plan

A Team Effort

Patrick Graves
Director of Operations

Air Logistics
Phase One
Weather Watch and Evaluation
( 72 to 96 Hours before Projected Impact )

• Surveillance of Current Tropical Activity
  – Forecast Time Lines
  – Projected Tracks
    • Impact to Customer Operations
  – Advanced Solicitation of Customer Transportation Requirements
    • Strategic Allocation of Assets
Phase Two
Preparation for Evacuation
(48 to 72 Hours before Projected Impact)

- Surveillance of the Tropical Activity
  - Updated Forecast Time Lines and Projected Tracks
    - Implementing Customer Plans for Non-Essential Personnel
  - Setting Customer Time Lines
    - Varies by Geographic Location and Infrastructure
  - Plans for Air Logistics Asset Evacuation
    - Examining Options for Direction of Deployment

Air Logistics
Phase Three
Evacuation
(36 to 48 Hours before Projected Impact)

- Updated Forecast Time Lines and Projected Tracks
  - Customer Evacuation
    - Implementing Customer Plans
  - Setting the Air Logistics Time Line
    - Decision made as to the Direction of Deployment
    - Implementing the Plan for Asset Evacuation
Re-Deployment
( 6 to 12 Hours After Actual Landfall )

• Challenges to resuming customer operations
  – Impact to shore bases and infrastructure
  – Impact to customer locations and infrastructure offshore
    • Fuel stations
    • Expanding the Flight Following Network Area of Coverage
  – Impact to “OUR” Employees
After Action Review
(The Good the Bad and the Ugly)

- Evaluation of the Plan
  - Convening the “STAFF”
  - Successes and Failures
    - Planning and Implementation
    - How well did we meet the customers expectations?
    - How well did we meet “OUR” employee expectations?
Marine Vessel Support

Planning
# APPENDIX 2 PHASE III / YELLOW ALERT CALCULATION SHEET

**TODAY'S DATE:**

**PRESENT OPERATION:**

**NOTE:** ENTER N/A FOR NON-APPLICABLE PROCEDURES.

<table>
<thead>
<tr>
<th>OPERATION CONFIGURATION</th>
<th>TIME REQ'D</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 M/W Warm Up Hydraulics for Slinger</td>
<td></td>
</tr>
<tr>
<td>2 Insert Lay Down Head in Station</td>
<td></td>
</tr>
<tr>
<td>3 Perform NDE on joint in Station 3</td>
<td></td>
</tr>
<tr>
<td>4 Weld on Lay Down head (ST1, ST2, ST3)</td>
<td></td>
</tr>
<tr>
<td>5 Connect A&amp;R Cable to Lay Down Head</td>
<td></td>
</tr>
<tr>
<td>6 Transfer Tension To A&amp;R winch</td>
<td></td>
</tr>
<tr>
<td>7 Commence Laying Down of Pipe-Line</td>
<td></td>
</tr>
<tr>
<td>8 Abandon pipe with A &amp; R Cable (with or without ROV)</td>
<td></td>
</tr>
<tr>
<td>9 Reposition anchors or bring in anchors of wet store anchors</td>
<td></td>
</tr>
<tr>
<td>10 Jack in Slinger</td>
<td></td>
</tr>
<tr>
<td><strong>Option Taken – Bring in Anchors or Wet Storage Anchors Barge Under Tow</strong></td>
<td></td>
</tr>
<tr>
<td>11 Bring in 2 Anchors</td>
<td></td>
</tr>
<tr>
<td>12 Hook up Tow Bridle to Tug</td>
<td></td>
</tr>
<tr>
<td>13 Wet Storage remaining anchors in field (pick up later if possible)</td>
<td>Grand Total</td>
</tr>
</tbody>
</table>

---

# SECURE AND EVACUATION TIME FORM

**DATE:**

**VESSEL:**

**TIME:**

**LOCATION:**

**MORNING WEATHER REPORT CONDITION:**

**HOURS:**

<table>
<thead>
<tr>
<th>TIME DESCRIPTION</th>
<th>CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A.</strong> SECURE FROM PRESENT OPERATION:</td>
<td>III I IV</td>
</tr>
<tr>
<td><strong>B.</strong> RECOVER ALL ANCHORS:</td>
<td></td>
</tr>
<tr>
<td><strong>C.</strong> TOW FOR A SAFE HARBOR, SET-UP/SECURE</td>
<td></td>
</tr>
<tr>
<td><strong>D.</strong> TOW FOR DESIGNATED ANCHORAGE, AND SET-UP/SECURE</td>
<td>OR</td>
</tr>
<tr>
<td><strong>E.</strong> TOW AWAY TO FAIR WEATHER:</td>
<td>+ + + +</td>
</tr>
</tbody>
</table>

**TOTAL TIME:**

**CONDITION III - STORM WATCH RADIUS**

\[ (A) + (B) + (C OR D OR E) \times (\text{STORM SPEED}) = \text{STORM WATCH RADIUS} \]

\[ (____) + (____) + (____) \times (______) = (______) \]

**CONDITION IV - STORM WARNING RADIUS**

\[ (B) + (C OR D OR E) \times (\text{STORM SPEED}) = \text{STORM WARNING RADIUS} \]

\[ (____) + (____) \times (______) = (______) \]

**CONDITION V - STORM EVACUATION RADIUS**

\[ (C OR D OR E) \times (\text{STORM SPEED}) = \text{STORM EVACUATION RADIUS} \]

\[ (____) \times (______) = (______) \]
Communications
Management Contingencies
Remob after Hurricane
T. T. “Tommy” Laurendine, P.E.  
Chief, OSTS  
Field Operations, GOM Region  
tommy.laurendine@mms.gov  
(504) 736 – 5709  
Fax (504) 736 - 1747

2005 Hurricane Preparedness

- Hurricane Cindy
  - Tripod under construction toppled
  - State Platform Oil Spill

- Hurricane Dennis
  - SEMI under construction listed
United States Department of the Interior
Mineral Management Service
Gulf of Mexico OCS Region

Map of the area affected by Hurricane Ivan

Platforms Requiring Level II Inspection

Fixed Jacket Facilities
- No Damage: 75%
- Destroyed: 6%
- Major Damage: 14%
- Minor Damage: 6%

Attachment "A"
Platforms Destroyed by Hurricane Ivan
Jacket Details:
- 250 ft. water depth
- 8 Legs
- 24 Conductors

Environmental Load Distribution

Design Code
Section 17 Assessment of Existing Platforms

Is an excellent procedure for determining if a platform meets an ACCEPTABLE failure criteria.

Assessments Reported

- 88% Platforms Reported
- 12% Not Reported

3187 Platforms Needing Assessment

Data as of 4/26/2005
Structure Types Reported

- 6-P, 92, 3%
- > 6-P, 93, 3%
- Unknown, 194, 7%
- TRI, 220, 8%
- 4-P WP, 271, 10%
- 8-P, 403, 14%
- CAS, 732, 26%

2795 Platforms Reported Data as of 4/26/2005

Assessment Screening Results

- Passed, 2292, 72%
- Not Reported, 392, 12%
- Failed, 316, 10%
- Incomplete, 187, 6%

3187 Platforms Needing Assessment Data as of 4/26/2005
Assessment Initiators Triggered

Data as of 4/26/2005

316 Platforms Failed Screening

Damage Found | Inadequate Deck Height | Increase Load | Others | Addition of Personnel | Addition of Facility
---|---|---|---|---|---
143 | 134 | 25 | 8 | 3 | 3

Deck Height Required (API RP 2a - 21st Edition)

- New Design
- Assessment High
- Assessment Med
- Assessment Low

Deck Height from Elevation of underside of deck

MLLW (ft)
GOM Structures by Age

3922 GOM Structures

Data as of 4/26/2005
GOM Structures by Water Depth

Platform Installations and Removals by Year

Average No. of Platforms Installed per Year = 137
Average No. of Platforms Removed per Year = 132
GOM Structures by Type

- **FLOATERS, 31, 1%**
- **FIXED, 2367, 60%**
- **CAIS. & WP, 1524, 39%**

Platforms that fail assessment require an approved mitigation plan

**Typical Approved Mitigations:**
- Removal of Well Conductors
- Raising of Decks
- Installing New Platform (Replace/Reinforce)
- Strengthen Existing Platform
- Platform Removal
API RP 2SIM JIP DISSEMINATION MEETING IN SEPTEMBER

?’s
Hurricane Ivan Storm Path
### Hurricane Ivan Topside Damage

- **Major Process Reconstruction**
  - South Pass 62 A/B/C/D Platforms
  - Main Pass 290 A/B Platforms
  - Main Pass 296 B/C/D Platforms
  - Main Pass 311 A/B Platforms

- **Moderate Process Reconstruction**
  - Main Pass 275 A
  - Main Pass 310 A

### Hurricane Ivan Pipeline Damage / Repair

- Main Pass 275 A – Pipeline Displaced / New Pipeline Installed
- Main Pass 151 A – Oil & Gas Pipeline Displaced / Abandoning Field
- Mississippi Canyon 148 A – Parted 3” Riser / Repaired
- Main Pass 290 A – Parted 6” Riser / Repaired
Hurricane Ivan Structural Damage

- Main Pass 290 A
  - Jacket damaged by falling wreckage.
  - Hyperbaric Weld Repair Required (-218’)
- South Pass 62 A/B/C
  - Local Buckles in Thin Wall Jacket Leg Section
  - Sec. 17 Reassessment Model Indicates No Repair Necessary
- MP 289 B / MP 296 B / MP 311 B – Redundant Member Removals
- Main Pass 289 B – Damaged Well Conductors (Plugging Wells)
- Main Pass 296 A – Failed Conductor Bay (Removing Structure)

Hurricane Ivan Repair Cost Estimates

- Estimated Offshore Construction Man-Hours: 700,000
- Estimated Final Gross Cost: $94,000,000
Ivan – It Could Have Been Worse

- No Apache Personnel Were Directly Injured by the Storm.
- Ivan Moved Through a Lower Producing Area for Apache.
- Resources Were Available for Quick Response.
- Apache Suffered Minimal Pipeline Damage.
- Our Structural Fleet Survived the Storm Reasonably Well.

QUESTIONS OR COMMENTS?

CARL S. HEINRICHES
OFFSHORE CONSTRUCTION MANAGER
APACHE CORPORATION
GULF COAST REGION
713.396.6443
CARL.HEINRICHES@USA.APACHECORP.COM
Some Implications

- Fixed Platforms
- Observations for Floaters
- Issues?

Design

- Provide a series of loads and conditions that will result in a structure that will adequately perform – support loads – during the lifetime use of the facility.
- Often establish envelopes of combinations knowing that none will exactly match actual conditions
Underlying Assumptions

- Performance for individual structures
- Spatiality inherent with % of fleet impacted
- Patterned after land code strategies
- Generally more stringent than land codes
  – industry choice based on risk
- Levels introduced – cost/risk driven

Storms & Facilities

- Level 4 Winds
- 100 yr. wave or greater
- Reach of Hurricane Winds
- Storm Path
Implications

- Lower level allows lower force
- Generally direct relationship between level and production
- Life safety and environment are drivers
- Economics, once life and environment addressed, drive selection
Implications

- Lower level allows lower force
- Generally direct relationship between level and production
- Life safety and environment are drivers
- Economics, once life and environment addressed, drive selection

Role of Code

Safe, fit-for-performance facilities, meeting safety objectives while economically viable
There will always be a load greater than the design point/capacity of a structure.

Where is the correct balance of design point to risk?

Structural?

Non-Structural?
Shell’s Experience with Hurricane Ivan

G. E. Sgouros
W.M. Pritchett
D.R. Schafer
D.L. Jones

Shell Exploration and Production Co.
API – 2005 Hurricane Readiness and Recovery Conference

Objectives

➢ Describe Hurricane Incident Command Team

➢ Describe Response Post Landfall

➢ Describe Damage and Repairs on Shell Assets
Hurricane Incident Command Team

- Team members include:
- Team is multi-disciplined.
  - Drilling
  - Production
  - Construction
  - Logistics
  - Regulatory Affairs
  - Engineering
- Equipment and Resources secured.
- Evacuation and recovery plans updated and changed as hurricane approaches.
- On September 13, 2004, 850 people evacuated safely.

Path of Ivan
Response Post Landfall

- Damage Assessment
  - Non Severe Storm → Use helicopter operations
  - Severe Storm → Use Fixed Wing Planes
- Fixed wing plane was used Post Ivan.
- Fixed wing plane mission to determine suitability for helicopter operations.
- Damage assessments performed as soon as heliports were okay.

Cognac Description

- Mississippi Canyon 194 A (Cognac) is a drilling and production platform in 1025 ft of water, installed in 1978.
Damage Assessments – MC 194

- Evidence of Green Water in the deck, 45 feet above the water line; platform 100 miles from the eye of the storm.

- Platform damage consisted of:
  - Missing Grating and Handrails
  - Minor Facilities equipment
  - Gaugers Shack
Main Pass 252 Description

- The Main Pass 252 complex consists of 2 bridge connected platforms in 300 feet of water. The 252 complex primarily supports 7 subsea wells.

Damage Assessments – MP 252

- Evidence of Green Water in the deck, 50 feet above the water line. Platform was near the eye of the storm.

- Estimated wave height 65 - 70 ft which corresponds to the maximum design wave of 72 feet.

- Platform damaged consisted of:
  - Missing Grating and Handrails (100 % at boatlanding to 20 % on lower deck)
  - Facilities equipment, cable tray and mostly support utilities
Damage Assessments – MP 252

Viosca Knoll 956 A Description

- Viosca Knoll 956 A (Ram Powell) is a TLP in 3214 feet of water.
Damage Assessments – VK 956

- Evidence of Green Water in the deck, 90 feet above the water line. Platform near the eye of the storm.
- Estimated wave height at this location is around 100 ft. Design wave was around 87 ft.
- Platform damaged consisted of:
  - Drilling rig moved off location
  - FGC 2 exhaust
  - Missing Grating and Handrails (100 % at boatlanding to 20 % on lower deck)
  - Facilities equipment, cable tray and mostly support utilities.
Damage Assessments – VK 956

Sheared Completions Spool

W16 beams

3” Thick

13 5/8” Diameter Completions Spool
50 ksi Material
Damage Assessments – VK 956

2 1/2” Diameter A325 Bolts
8 out of 64 sheared. Clamp system designed to resist 930 kips of uplift and 1400 kips of horizontal force.

VK 956 A – Drilling Rig Recovery

– Challenges
  ➢ Rig was located in potentially unstable position.

  ➢ Rig had to be secured to prevent further damage.

  ➢ 2500 ton rig to be a) lifted vertically then slid back into position or b) disassembled and then reassembled.

  ➢ Option a) was selected
VK 956 A – Drilling Rig Recovery

– Strategy

➢ Secure rig using hold down brackets.

➢ Hold down brackets designed for additional hurricane force conditions.

➢ Use a system of strategically placed jacks, cylinders and grippers to recover rig.

Brackets load tested by Tropical Storm Matthew
VK 956 A – Drilling Rig Recovery

– Vertical Recovery:
  ➢ Weld reaction and jacking beams in place.
  ➢ Use 500 ton and 200 ton vertical jacks in combination to lift rig vertically. Actual force to lift the rig 3 inches was 1300 kips.
  ➢ Apply lubricant to skidding surfaces.

– Horizontal Recovery:
  ➢ Use hydraulic horizontal cylinder and horizontal gripper to “square” rig on support beams and pull back to proper operating location. Actual force required was around 500 kips.
Conclusions / Learnings

- Rig tie-down criteria exceeded.
- Wave design criteria probably exceeded.
- Shell participating in industry-wide efforts to address findings.
- An equipment replacement strategy is an enabler.
- Consider temporary offshore housing vs. day tripping.
- Coordinated approach allowed synergy.
- Repairs executed without major safety or environmental incidents.
Ivan the Terrible

Dominion E & P, Inc.

Ivan’s Path Through DEPI Fields

Red is Producers/Discoveries
Yellow is Exploratory
Platform Description

4 pile, 9 slot, drilling and production platform
307 feet of water
Installed 1997 (API RP 2A, 19th edition)
Three decks (average size = 85’ x 135’)
66” diameter piles
Cellar deck TOS at 52’-10”
Manned
Facility capacity: 20,000 bopd, 180 mmcf/d
Can support a 1500 HP platform drilling rig

Dominion - Main Pass 281 “A”
Sub-Cellar Deck Beams
(TOS = +53”)

Deck Beam Ripped from Girder
# Sump Tank Supports

![Image of Sump Tank Supports](image1.jpg)

## Jacket Leg A-1 (SE)

<table>
<thead>
<tr>
<th>Water Depth</th>
<th>(-) 58’</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jacket Leg Wall</td>
<td>0.750” A-572 Gr 50</td>
</tr>
<tr>
<td>Pile Wall</td>
<td>2.250” A-572 Gr 50</td>
</tr>
</tbody>
</table>

- Compression

- Full system break

![Image of Jacket Leg A-1](image2.jpg)
Jacket Diagonal

26 x 0.500”
A-572 Gr 50
Jacket Leg B-2 (NW)

Water Depth (-) 6'

Jacket Leg 1.25” wall A-572 Gr 50

Pile 2.25” wall A-572 Gr 50

1” Annulus

Mag. Particle Inspection

Level IV Inspection
Fugro Consultants LP
Pasadena, Texas

Hole Cut in Leg for ROV

66” x 2.25” leg can
12” x 12” hole
cut out stabbing guide
Some Observations
Petronius and Vk 900

Dave Wisch

2005 Offshore Hurricane Readiness & Recovery
26-27 July 2005

Fleet Impact

Ivan Track

Platform Damaged
Platform Undamaged
Wind Damage

Elevations
Punching Shear – What Overload Looks Like

Activities Since Ivan

- Inspection
- Damage Assessment
- Repair Design
- Ambient Vibration Baseline
- Multiple Grouted Clamp Repairs
- Ambient Vibration Delta
- Fully Operational
- Working Question – How valuable is vibration in determination of damage?
Viosca Knoll 294 A

Viosca Knoll 294 A – After Ivan
Petronius – Pre-Ivan

Clustered Damage
What a Little Water Does

Repairs in Progress
Design vs. Ivan

- Current Directions
- Wave (48 ft)
- Wind (99 mph)

- Wind (98 mph)
- Wave (43.3 ft)
- Current (per table)

Ivan – Max Wave Critical Direction
Design – Max Wave Critical Direction
**Petronius**  
**Design vs. Ivan**

- **Level Shear (kips)**: 0, 500, 1000, 1500, 2000, 2500, 3000, 3500, 4000, 4500, 5000
- **Elevation above Mudline (ft)**: 0, 200, 400, 600, 800, 1000, 1200, 1400, 1600, 1800, 2000

- **Design Case - Diagonal**
- **Design Case - Orthogonal**
- **Ivan - Max. Wave**
- **Ivan - Max. Current**

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**Structural Codes**

- **Minimum Capacity**
- **With Implicit Margins**
- **100 Year Design Point**
- **Likely Minimum Capacity due to margins & actual strengths**
Directionality

Design Capacity

Load
Virgo Platform (Viosca Knoll 823)
Hurricane Ivan Impact & Recovery

7/27/2005

Richard Case

Virgo – Viosca Knoll 823

- Installed 1999
- 3 deck levels @ 100’ x 200’ each
- 1130 ’ w. d.
- 4 Main Pile Structure
- 6 Pile Upper Jacket
- 13 Wells - Originally (including the 3 dual completions)
- 9 Wells Currently Producing
- Production – Sept. 2004 (Pre-Ivan)
  - ~ 24 mmcfd
  - ~ 600 bcpd
Virgo – Viosca Knoll 823 OPERATIONS

- Wells & Wellheads / Structure / Jacket / Decks owned by Virgo Operating Partners (Total, El Paso, Nippon, and Pogo)

- Total is the Operator of the wells for Virgo Operating Partners

- Topsides Process System / Facilities owned by Dauphin Island Gathering Pipeline Partners (DIGP)

- Duke Energy is Ops. representative for DIGP

- Total is the on-site Operator of the topsides process system for Duke Energy

Virgo (VK823) – Pre-Hurricane Ivan
Virgo (VK823) – Pre-Hurricane Ivan

September 13: Hurricane Ivan Enters the GoM

First Priority: ensure the safety of personnel by evacuation
Ivan Hits on Sept. 15

Virgo (VK823)

Damage Evaluation
Post Ivan Integrity Inspection

- Assess structurally soundness with a helicopter fly around.
- Board and perform initial 3rd Party visual checks with the operations team (Sept. 16, ’04)
- Topside Inspection – Utilized a rope access team to visually inspect all structural components (General visual, close visual and ACFM)
- Analyzed a damaged topside beam to assess its residual strength
- Performed overall structural analysis of the facility, using sea conditions that existed during Ivan, in order to assess the overall loading on the facility and to identify connections subject to the highest loads.
- Performed underwater ROV inspection covering structural integrity, selected weld integrity, anode condition, debris, scour risers.
- Performed flooded member inspection on most members.

Power / Control Cables & Trays

Cable Trays under Prod Deck
Power / Control Cables & Trays
Power / Control Cables & Trays

Power / Control Cables & Trays
Power / Control Cables & Trays

Cable Trays under Prod Deck

Power / Control Cables
Cables / Handrails / Sewage Treatment / Generator

Generators (knocked off skid mounts)
Generators (knocked off skid mounts)
Generators / Power – Control Cables & Trays

Essential Generator
Essential Generator

E-Gen

Total E&P USA, Inc.

Essential Generator

Total E&P USA, Inc.
Gas Compressor #2 Controls

Parts – Tool Storage Building
Structural – Stairways
Structural – + 10’ Area – Handrails & Grating

Structural – Pipeline Riser Clamp
Structural – Crane Pedestal

Firewater – Deluge Piping + Cables & Trays
Firewater – Deluge Piping

Motor Control Center
Living Quarters – HVAC

Virgo (VK823)

Reconstruction Project Development
### Project Planning

- Habitation – (Oct. 25, ’04)
  - Life Support
  - Accommodations
  - Safety / USCG / MMS
- Facility: Estimated 6 month repair (ie: April 2005)
- Project Meeting with Partners & DIGP
- Project Scope Development (detailed)
- Project Management Support (Nov. 4, ’04)
- Primary Reconstruction Contractor
  - Construction / Mechanical
  - Instrumentation / Electrical

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### Virgo (VK823)

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### Reconstruction Staffing & Safety
Construction Camp

SAFETY FIRST

- Daily Safety & Job Planning Meeting
SAFETY FIRST – Recovery Training

SAFETY FIRST – Additional Life Saving

- 2 ea. – 25 person rafts + 5 ea. – 12 person rafts
SAFETY FIRST – Additional Life Saving

- 2 ea. – 25 person rafts + 5 ea. – 12 person rafts

Virgo (VK823)

Reconstruction
Reconstruction – Sub-Cellar Scaffolding

Reconstruction – Sub-Cellar Scaffold Deck
Reconstruction – Cable Tray Installation

Reconstruction – Cellar Deck Piping Installation
Virgo (VK823)

Mid-Project Performance Re-Evaluation

- Primary Reconstruction Contractor Performance Issues
  - Itemized task sheets for reconstruction job packs
  - Adequate number of qualified craft personnel
  - Material delivery
  - Contractor Management support
- Resulted in the canceling (demanning) of mechanical / instrument / electrical craft services
- Hand-picked quality craft personnel from several different support contractors
  - Re-manned with new craft personnel
Reconstruction – Electrical & F&G Wiring

Reconstruction – Electrical & F&G Wiring
Reconstruction – Electrical & F&G Wiring
Reconstruction – Marshalling Cabinet Wiring
Reconstruction – Bondstrand (Firewater/Deluge)

Reconstruction – Bondstrand (Firewater/Deluge)
Reconstruction – Bondstrand (Firewater/Deluge)
Reconstruction – Deluge Valving

Reconstruction – Generator(s) Refurbishment
Reconstruction – Generator(s) Refurbishment
Virgo (VK823)

Post Reconstruction

Post Reconstruction – Cellar Deck
Post Reconstruction – Cellar Deck

Post Reconstruction – Cellar Deck
Post Reconstruction – Cellar Deck
Post Reconstruction – Production Deck
Post Reconstruction – Production Deck

Post Reconstruction – Production Deck
Post Reconstruction – Riser Fireproofing
Post Reconstruction – Riser Fireproofing
Post Reconstruction – Riser Fireproofing
Summary

Virgo (VK823) – Post Hurricane Ivan
Overview – Schedule

- Hurricane – Sept. 13, 2004
- Multi-company review and project approval – Mid-Oct. 2004
- Habitation able (Oct. 25, ’04)
- CFT / Bid Award - Project Management / Technical Support (Nov. 4, ’04)
- CFT / Bid Award - Primary Reconstruction Vendor (C-M-I&E)
- CFT / Bid Award / Mobilization - Camp Facilities
- Mobilization of initial reconstruction crews
- Christmas Break (Dec. 23-26, ’04)

Overview – Schedule (cont.)

- Primary Reconstruction Vendor Performance Re-evaluation – Feb. ’04
- Mobilization of New Support Crews (hand picked personnel) – Feb. ’04
- Pre-commissioning (early – where possible)
- Initial Re-Start of Production – April 21, 2005
- Final Post Reconstruction Demobilization
Overview - Highlights

- Maximum of up to 75 persons (including 8 Total Operations Personnel)
- 135 days from initial manning to Re-Start
- Over 10 different contractors with craft personnel working together simultaneously
- In EXCESS of 125,000 man-hours
- NO LOST TIME ACCIDENTS
- On Budget

Virgo (VK823) – Post Hurricane Ivan

?
**Pompano - Hurricane Ivan**

VK989A (Pompano)

4 leg structure
(with 4 intermediate legs to -75' elev.)

12 skirt piles
(3 at each leg)

Water depth: 1284-ft*

Year installed: 1994

Long. -88°37'13.5”
Lat. 28°59’11”

*The bottom horizontal is at -1284' on the Row 1 side and -1276' on the Row 4 side to compensate for the seabed profile
Hurricane Damage: -

- Hurricane Ivan Damage to Pompano: -
  - Top of jacket handrails majority missing
  - Cable trays & panels damaged on sub-cellar deck
  - Piping and equipment damaged on sub-cellar deck
  - Damaged & missing grating
  - Damage to lights

Hurricane Ivan Damage (Sept 2004) – Pompano

- Top of Jacket Handrails missing
- Damaged Cable Trays
  EL (+) 63 ft
Hurricane Ivan Damage (Sept 2004) – Pompano

- Mica Pig Launcher shifted
- Sub-Cellar North Extension Damage
- Sub-Cellar East extension building damage
- Sub-cellar deck light damage
- Sub-Cellar handrail damage
Hurricane Ivan Damage (Sept 2004) – Pompano

- Sub-Cellar deck NW walkway minor lateral displacement
- Sub-Cellar typical panel and ancillary piping damage

Jacket Inspection Results

- No damage or significant anomalies reported
Assessment Criteria:

- API RP2A 19th Edition design criteria
  - Base comparison to original design
- API RP2A 21st Edition Section 2 L-1 design criteria
  - Today’s design criteria
- API RP2A 21st Edition Section 17 L-1 design & ultimate criteria
  - Today’s assessment criteria
- Hurricane Ivan Criteria
  - Hindcast study upper bound

Assessment results - base shear comparison (kips)

<table>
<thead>
<tr>
<th>USFOS Analyses</th>
<th>End-on</th>
<th>Broadside</th>
<th>Diagonal</th>
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<tbody>
<tr>
<td>API 21st Section 17 Ultimate Criteria (74 ft Max)</td>
<td>12,713</td>
<td>10,662</td>
<td>13,932</td>
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<tr>
<td>API 21st Section 2 L-1 Design Criteria (71.2 ft Max)</td>
<td>11,401</td>
<td>9,632</td>
<td>12,535</td>
</tr>
<tr>
<td>API 19th Section 2 Design Criteria (72 ft Max)</td>
<td>11,931</td>
<td>11,900</td>
<td>11,665</td>
</tr>
<tr>
<td>API 21st Section 17 L-1 Design Criteria (57 ft Max)</td>
<td>8,273</td>
<td>7,664</td>
<td>8,286</td>
</tr>
<tr>
<td>Hurricane Ivan</td>
<td></td>
<td></td>
<td>21,926</td>
</tr>
</tbody>
</table>
Pompano - Hurricane Ivan

Postulated Hurricane Ivan Wave 105 ft

API RP2A 72 ft Design Wave

Damage EL (+) 63'-0"

Drilling EL (+) 97'-6"

Production EL (+) 72'-0"

Sub-Cellar EL (+) 55'-9"

Damage Observations:
- No wave run-up
- Damage on wave approach side of platform
- Damage to cable trays above sub-cellar deck
Pompano - Hurricane Ivan

Ivan peak $H_s$ vs GUMSHOE return period values @ 28.26°N

- Ivan
- $R=100$
- $R=1000$
- $R=10000$

$Ivan \ H_{max} = 1.75 \times H_s = 96 \text{ ft}$

$H_{max} = 1.75 \times H_s = 80 \text{ ft}$
Ivan Wave Observations: -

Pompano: -

- Observed damage to cable trays at EL (+) 63 ft.
- 3rd order stream function, 55% of wave above MSL
- Estimated wave height = 105 ft assuming 6ft tide & surge.
- Ultimate strength analyses correlate to Pompano surviving event.

Ivan Track at Virgo: -

- Observed damage to cable trays at EL (+) 70 ft.
- 3rd order stream function, 55% of wave above MSL
- Estimated wave height = 116 ft assuming 6ft tide & surge.

Ivan Return Period: -

- 10,000 year return event considered not possible in GOM due to extremely low central pressure required.

- Return period estimated at 500 to 600 years using 1.8 multiplier. (Rough Engineering Estimate for 100 yr Hmax = 113 ft)

- Return period estimated at 200 to 300 years using 2.15 multiplier.

- Using Hs multiplier of 2.15 provides good correlation with observed damage on Pompano and on Ivan storm track.
Images from GIS Application for Hurricane Emergency Response Planning – 2004 Prototype

Hurricane Ivan Cat. 3 just North of Tobago

Hurricane Ivan proceeding into GOM increasing to Cat. 4

Hurricane Ivan making landfall as Cat. 3 hurricane

Damage NE Mooring Porch – Debris
Nakika - Hurricane Ivan

NE Mooring Porch – Damage to Drag Chain Storm Brace
SE Mooring Porch
Points for discussion/consideration going forward:

- API earthquake design practice considers both a design (strength) event and extreme survival (ductility) event, also draft API RP 2FB and ISO 19902
- Modern GOM fixed platforms considered likely to survive 1,000-yr event, 10,000-yr survival less likely or unknown?
- GOM fixed platforms have wave-in-deck for extreme storm waves between 100 & 1,000 year return period?
- What would be a suitable GOM survival event? 1,000-yrs? What is that wave height? What are the associated wind and current?
- Should deck heights for fixed platforms be set to a survival criteria or alternatively platforms designed for wave inundation to this criteria? or are we ok with current practice?