P-34 Incident: Use of a Stability Tool to Support the Salvage Actions in an Offshore Emergency

Mauro Costa de Oliveira, *Petrobras*

Carlos Gomes Jordani, *Petrobras*

ABSTRACT

This paper presents the use of a numerical tool to support the decisions taken after the incident with the P-34 FPSO in 13th of October 2002 in Barracuda field, offshore Brazil, to bring the platform to a safe condition. The objective of these analyses was to verify the stability in the heeled condition, in order to guarantee the safety of the team that approached the platform and to analyze the proposed measures to bring the platform to a situation of even keel fluctuation. The support team stayed on duty 24 hours, supplying analyses of the situation of the platform and comparing them with the draft measurements executed by the support vessel Salgueiro. These services continued up to the 17th of October, when the platform reacquired an upright and safe floating position, without the loss of lives nor leaks of oil.

Keywords: *stability incident, heel, salvage*

1. INTRODUCTION

This paper presents the situation after the incident with the P-34 FPSO in 13th of October 2002 and the actions taken to bring the platform to a safe condition. In the Sunday, 13th of October, 2002, the P-34 FPSO suffered a pane in the electrical system and soon after it heeled up to an angle estimated in 32 degrees. The systems of the platform had been turned off, the wells closed and the crew abandoned the unit. In the meantime the Contingency Plan has been put into action, and an offshore Coordination Group has been sent to P-10 platform nearby. Still in the Sunday night technicians initiated the confection of the model for the program of simulation of loading conditions and stability SSTAB (See Coelho, Jordani and Oliveira, 2003). The distribution of weights on board was estimated from information of the crew. This model was concluded in the dawn of Monday (14th of October of 2002) and, immediately afterwards, the analyses of stability and evaluation of the loading condition of the unit with introduction of ballast water in selected tanks. The objective of these measures was to verify the stability in the heeled condition, in order to guarantee the security of the team that approached the platform and to analyze the measures to get the platform to back to a situation of even keel fluctuation. The team stayed on duty 24 hours in the UN-Rio offices, supplying analyses of the situation of the platform and comparing them with the measurements executed by the support vessel Salgueiro. These services continued up to the 17th of October, when the team has been demobilized.

2. THE P-34 FPSO

2.1 Main Characteristics

The FPSO P-34 has a bow turret and is the result of the conversion of the Presidente Prudente de Moraes tanker. The FPSO started to operate in September 1991 in the Barracuda / Caratinga fields, in Campos Basin, offshore

Brazil, in a water depth of 840 m. The process plant has a capacity of 45.000 bopd. The storage capacity is of 58.000 m3. A total of 11 wells were connected to the turret.

Table 1 Main particulars

Length over All	240.3m
Length Between perpendiculars	231.10 m
Moulded Breadth	26.0 m
Moulded Depth	16.87 m
Minimum Draft	5.0 m
Maximum Draft	12.76 m
Deadweight (approx.)	50.000 t
Lightweight (approx.)	15.600 t

Figure 1 FPSO P-34 in Operation in Campos Basin

Figure 2 FPSO P-34 and Barracuda/Caratinga Fields

3. THE INCIDENT

After a failure in the electrical system, the main generator stoped to operate in the 13th of October, 2002 at 15:05. The Emergency Generator A started automatically and the Emergency Generator B was manually set in operation. After that there was a freezing of the Central Control Station (ECOS), with indication that the starboard valves were open. A logical problem in the automation system, has caused the undesirable opening. The attempts to manually operate the valves wasn't successful and the Contingency Plan was put into action at 15:15 and the platform was evacuated at 16:35.

The oil stored in the starboard tanks flowed to the central and starboard tanks, as the valves were opened, leading to a heel angle of approximately 32 degrees.

4. THE SALVAGE OPERATION

Petrobras has set up an Offshore Coordination Group, located at the platform P-10 and afterwards in the SS-37. A Stability Support Team has also been assembled in order to produce information for the Offshore group. The routine workflow of this team, during the emergency operations, was to produce estimates of the cargo oil distribution after the incident, based on the analysis of the draft measurements, send this data to the Offshore Group and assess the proposed measures to bring the platform to the upright position.

4.1 The SSTAB Model of P-34

The first task of the Stability Support Team was the confection of the P-34 model. There was already a model made for previous analyses, and that was the base to proceed with this activity.

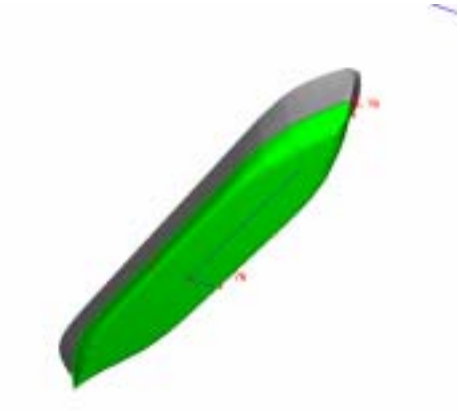

Figure 3 SSTAB model of P-34 hull

5. INITIAL ANALYSES - 14/10/2002

Initially the studies have been carried out with a global weight distribution, without a separation by categories. The displacement, draft, trim and heel have been estimated from the Salgueiro measurements. In this way the following prelimar weight has been assumed:

Table 2 Total Weight Estimate

Weight	LCG	TCG	VCG
(ton)	(m)	(m)	(m)
32165.0	2.50	2.00	9.40

The main purpose of this evaluation was to guarantee that the FPSO had enough initial stability and also to verify the GZ for large angles. The calculations have been performed using the SSTAB program.

Table 3 Initial Stability Data

Displacement	32165	ton.
Reference Draft	6.47	m
Heel	-32.46	Deg.
Trim	-0.02	Deg.
KB	4.98	m
KG	9.4	m
Transv. GM	4.49	m
Longit. GM	578.39	m

The Draft Marks read from the program are the following:

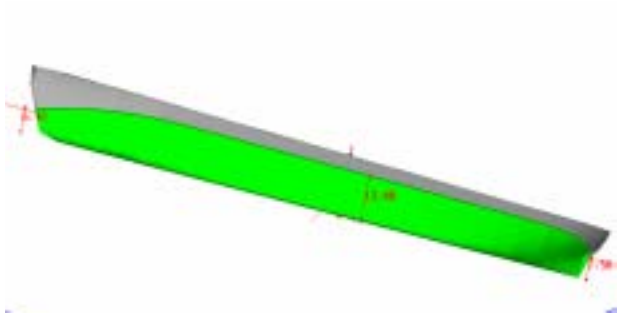

Figure 4 Draft Marks in SSTAB model of P-34 hull (in red)

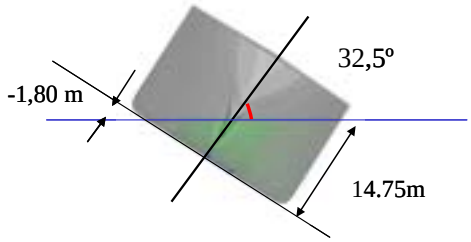

Figure 5 Scheme of the Draft Measurement SSTAB Model

Table 4 Draft Marks from SSTAB Model

Draft Mark	Draft (m)	Depth (m)
FW Perp. PS	6.43	5.42
MidShip SB	-1.80	-1.51
MidShip PS	14.75	12.44

The GZ curve correspondent to this situation is shown below:

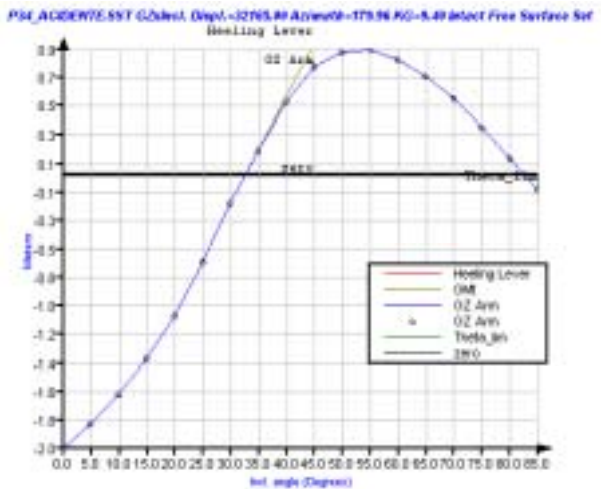

Figure 6 GZ Curve in the Situation After the Incident

6. CARGO OIL CONDITION AFTER THE INCIDENT

An important information for the rescue operations was the distribution of oil in the cargo tanks after the incident. Considering the design data, the stability model of P-34 in the SSTAB program and the draft readings offshore, it was possible to estimate this crucial information. In this way from the draft measurements, from the vessel documentation and from the loading condition before the incident, a preliminar distribution of the cargo oil could be evaluated during the incident. The final amount of oil on board could only be precisely calculated on the 17th. The data presented is the result of studies carried out during the investigation phase.(Costa and Castro, 2002)

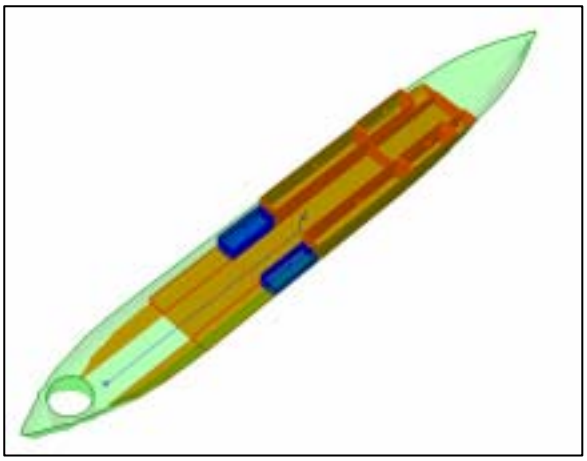

Figure 7 Cargo Oil Situation before the Incident

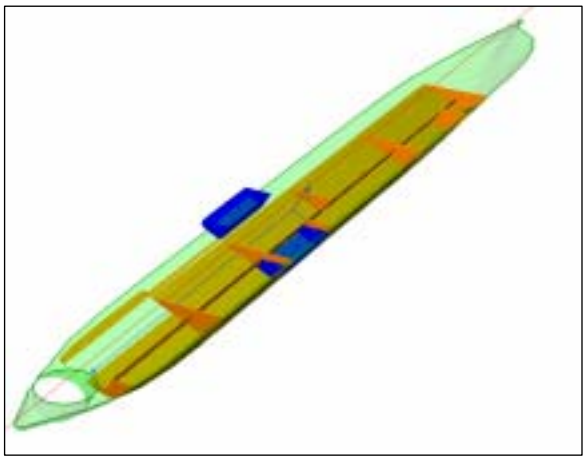

Figure 8 Cargo Oil Situation after the Incident

Table 5 Loading Condition Items Before the Incident

Weight Class	Weight	% of Total	LCG	TCG	VCG
Light_weight	15597.3	46.49	2.14	0.02	13.26
Liquids	1842.27	5.49	-67.58	0.15	10.54
Mooring_lines	658.6	1.96	95.71	0	1.2
Risers	732.6	2.18	95.71	0	-0.95
Miscelaneous	83	0.25	1.06	0	12.34
Ballast_Tanks	1537.5	4.58	14.69	-0.63	3.12
Cargo Tank	13100.89	39.05	-29.05	0.15	4.46
Total Weight	33552.16	100	-9.42	0.05	8.66

Table 6 Loading Condition Items After the Incident

Weight Class	Weight	% of Total	LCG	TCG	VCG
Light_weight	15597.3	46.59	2.14	0.02	13.26
Liquids	1842.27	5.5	-67.58	0.15	10.54
Mooring_lines	658.6	1.97	95.71	0	1.2
Risers	732.6	2.19	95.71	0	-0.95
Miscelaneous	83	0.25	1.06	0	12.34
Ballast_Tanks	1537.5	4.36	14.84	1.97	3.18
Cargo Tank	13100.88	39.14	4.39	6.74	4.14
Total Weight	33552.16	100	3.62	2.74	8.55

Table 7 Cargo Oil Tanks Before and After the Incident

Tank	Use Before (%)	Use After (%)
CARGO_TK_4_SB	60.31	0.00
CT_1	0.00	3.96
CT_2	5.45	22.21
CT_3	1.74	21.92
CT_4	4.83	20.52
CT_5	40.83	19.46
SLOP_BE	30.52	0.00
SLOP_BB	42.61	51.43
CARGO_TK_1_PS	2.23	60.12
CARGO_TK_2_PS	11.71	61.06
CARGO_TK_4_PS	60.47	55.76
CARGO_TK_5_PS	65.44	51.57
CARGO_TK_1_SB	1.71	2.17
CARGO_TK_2_SB	11.60	0.26
CARGO_TK_5_SB	0	0

Table 8 Stability Characteristics after the Incident

Displacement	33550.0	ton.
Reference Draft	6.89	m
Heel	-34.01	Deg.
Trim	0.40	Deg.
KB	5.34	m
KG	8.55	m
Corrected KG	9.50	m
Correct.Transv.GM	15.25	m
Correct.Logit.GM	1056.88	m

7. CORRECTIVE ACTIONS TO BRING THE PLATFORM TO A SAFE POSITION

Technical people embarked in the platform at 9:37 of the 14th of October, to close the starboard valves in order to stop the communication of oil among the tanks. After that, with the support of the simulations carried out by the Stability Team, the following sequence has been applied to bring the P-34 FPSO to an upright position:

Day	Time	Action	Heel (deg.)
14/10	19:50	Start pumping ballast water in the tank T3SB	34
15/10	13:30	Finish the pumping of 1600 m3 of ballast in T3SB	30.25
15/10	16:30	Start pumping ballast water in the cargo tank T4SB	-
16/10	17:45	Finish pumping of 4900 m3 of ballast in the tank T4SB	10.28
16/10	17:45	Connect T4PS to T5SB leveling the oil	-
17/10	11:17	Finish of oil transfer (748 m3) from T4PS to T5SB	0.63

Figure 9 Condition after the Incident

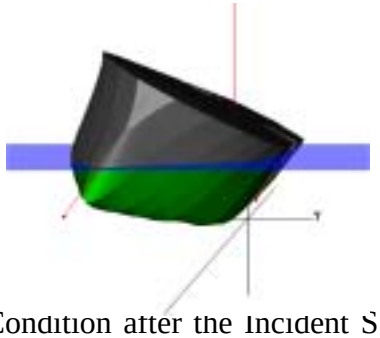

Figure 10 Condition after the Incident SSTAB Model

Figure 11 Condition After Pumping Ballast in T3SB and T4SB

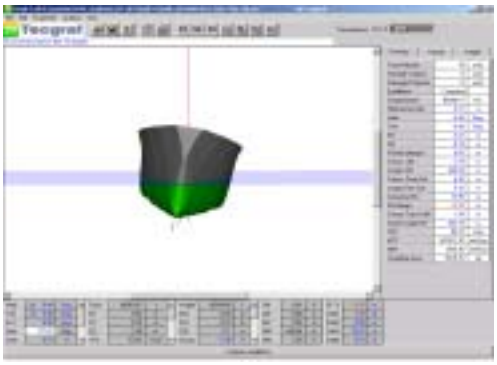

Figure 12 Condition After Pumping Ballast in T3SB and T4SSB – SSTAB Model

Figure 13 Condition After Equalization of T4PS and T5SB

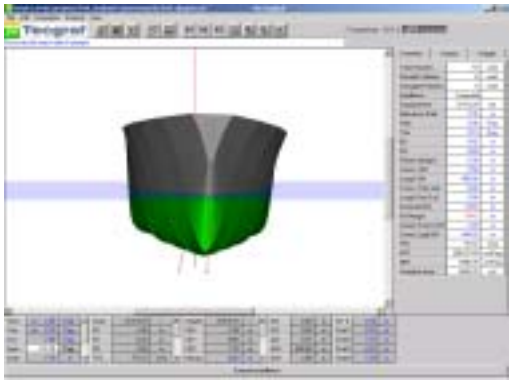

Figure 14 Condition After Equalization of T4PS and T5SB – SSTAB Model

8. ANALYSES CARRIED OUT DURING THE EMERGENCY

During the 4 days that the salvage efforts lasted, the Stability Support Team has performed several analyses to predict and assess the possible options to return the P-34 to a safe condition. Basically two main procedures were available: Pump ballast to the starboard tanks or open the valves to communicate some of the portside and starboard oil tanks. The second alternative had the advantage to avoid the increase of weight on board. The comparison between the field predictions and SSTAB calculations can be seen in Table 9 below, with the Salgueiro draft measurements.

9. CONCLUSIONS

The P-34 FPSO has been successfuly rescued from a careened position offshore Brazil, without the loss of lives nor leaks of oil. The Contingency Plan has been put into action, with a coordinated effort of all involved departments of Petrobras and contracted companies.

The SSTAB program has proven to be a reliable and useful tool to support the decision making process during offshore salvage operations.

SSTAB software is currently employed in the Emergency Module of the GIEN program (Naval Engineering Integrated Management). This program has been set up to update and organize all the relevant engineering documentation, as well as, creating an emergency response procedure applicable to all floating platforms of Petrobras.

Table 9 Sequence of Draft Measurements and Pedicted Heel Angles

Date	Time	DRAFT (star board)		Heel P-34 Field Prediction	Heel P-34 SSTAB Prediction
		fore (m)	aft (m)		
14/10/2002	02:50	7.50	6.50	31.7	34
	04:14	7.50	6.50	--------	
	06:34	7.50	6.50	--------	
	09:30	7.20	6.70	--------	
	10:50	7.40	6.60	---------	
	15:30	7.40	6.60	---------	
	16:15	---------	---------	---------	
	17:30	---------	---------	---------	
	18:00	---------	---------	---------	
	20:30	---------	---------	---------	
	21:10	7.80	---------	---------	
	22:35	8.00	6.80	30.5	
15/10/2002	01:50	8.00	6.80	---------	
	02:50	8.10	6.90	29.6	
	04:40	8.10	6.90	---------	
	06:40	8.20	7.00	28.7	
	09:00	8.20	7.00	---------	
	10:30	8.20	7.00	---------	
	12:00	8.40	7.10	---------	
	13:55	8.40	7.10	27.6	30.25
	16:00	---------	---------		
	18:00	8.40	7.10	27.3	
	19:45	8.40	7.10	26.3	
	21:40	8.40	7.20	25.2	
	23:45	8.40	7.20	º	
	23:45	8.40	7.20	20.2	
16/10/2002	01:45	8.40	7.40	19.9	
	03:30	8.50	7.50	18.5	
	05:40	8.60	7.60	17.6	
	07:10	8.70	7.70	16.7	
	08:20	8.70	7.70	15.6	
	10:00	8.50	7.80	14.62	
	11:05	------	------		
	12:30	8.40	7.90	13.5	
	16:05	8.40	8.00	12.2	
	19:20	8.40	8.20	7	10.3
	24:00	8.40	8.30		
17/10 /2002	03:10	8.60	8.40		
	06:00	8.50	8.30	2.5	0.6

10. ACKNOWLEDGEMENTS

The Stability Support Team had the participation of Paulo Maurício Videiro, Carlos Gomes Jordani, Luis Augusto Petrus Levy, Álvaro Maia da Costa, Marcos Donato Auler da Silva Ferreira and the Projemar group led by Ricardo Portella.

11. REFERENCES

Coelho, L.C.G., Jordani, C.G., and Oliveira, M. C., 2003, “Equilibrium, Ballast Control And Free-Surface Effect Computations Using The Sstab System”, Proceedings of 8th International Conference on Stability of Ships and Ocean Vehicles, Madrid, Spain.

Costa, A. M., Castro, G. A.V, 2002, “Simulação do Equilíbrio Hidrostático da Plataforma P-34 no Acidente de 13 de Outubro de 2002”, Comunicação Técnica PDP-MC-35/2002 Petrobras Internal Report, Rio de Janeiro, Brazil.