DESCRIÇÃO DO SISTEMA DE CONTENÇÃO E RECOLHIMENTO

São apresentadas a seguir as características do sistema de contenção e recolhimento que serão instalados nas embarcações OSRV que irão atuar na estrutura de resposta do projeto.

1. Nome do equipamento: Current Buster 6 integrado com o NORMAR Integrated Pump System

1.1 Capacidade nominal (CN): 100 m³/h

- Menor que a vazão utilizada no teste para identificação da eficiência do sistema

1.2 Eficiência (fe): 70%

- Menor valor arredondado para baixo dos testes executados com a barreira
- Devido a presença de bolsa para separação de água e óleo no Apex da barreira
- Esta bolsa também gera um ambiente abrigado que privilegia o recolhimento de óleo

1.3 Capacidade efetiva diária de recolhimento de óleo (CEDRO) oferecida:

- CEDRO = 1.680 m³/dia
    - CEDRO = 24 . CN . fe
    - CEDRO = 24 . 100 . 0,7

1.4 Forma de lançamento: Lançamento por popa ou por costado

1.5 Forma de reboque: Uso de sistema de aletas do tipo Boom Vane

1.6 Número de sistemas de contenção e recolhimento: 2 sistemas

1.7 Evidência de eficiência:

- Resultado do teste da Current Buster 6 no Wendy Schmidt Oil Cleanup X Challenge (Adendo A)
    - Eficiência entre 71,1% e 94,7%
    - Bomba com vazão de 200 m³/h
- Descrição do sistema Current Buster 6 com NORMAR Integrated Pump Recovery System (Adendo B)
- Comparação de taxa de varredura com barreira convencional
    - Barreira convencional
        - Comprimento = 200 m (Comprimento descrito na NT 03/2013)
        - Abertura = 127 m
        - Velocidade = 1 nó
        - Taxa de varredura = 235 m²/h
    - Current Buster 6
        - Abertura = 34 m

- Velocidade = 5 nós
- Taxa de varredura = 314 m²/h

- A taxa de varredura da Current Buster 6 é 33% maior que a de uma barreira convencional de 200 metros de comprimento
- Em condições de mar mais severas, nas quais as barreiras convencionais teriam dificuldades de operar (ondas de curto período), a Current Buster 6 consegue operar com uma velocidade de 3 nós, oferecendo uma taxa de varredura de 188 m²/h

High Capacity Advancing Oil Recovery System Performance Testing at Ohmsett for the Wendy Schmidt Oil Cleanup X CHALLENGE

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Abstract

Ohmsett - The National Oil Spill Response Research & Renewable Energy Test Facility was selected as the test venue for the $1.4 Million Wendy Schmidt Oil Cleanup X CHALLENGE. The competition was designed to inspire a new generation of innovative solutions for recovering spilled oil from the seawater's surface.

Ten finalists, selected from more than 350 entries from around the world, demonstrated oil cleanup systems during rigorous testing where they each had 10 days to demonstrate their individual technology in the Ohmsett test tank. In this head-to-head competition, a $1 Million Grand Prize was awarded to the team that demonstrated the ability to recover oil from the water's surface at the highest oil recovery rate (ORR) at oil recovery efficiency (ORE) of more than 70%.

This was the largest oil recovery test ever conducted at Ohmsett. This paper discusses the test setup and methodology used during the high capacity advancing oil recovery system performance testing at Ohmsett.

1 Introduction

The X PRIZE Foundation, a non-profit organization, selected Ohmsett as the test venue for the $1.4 Million Wendy Schmidt Oil Cleanup X CHALLENGE. This challenge, the Foundation's sixth major competition, was designed to inspire a new generation of innovative solutions for recovering spilled oil from the seawater's surface.

The $1 Million Grand Prize would go to the team with the highest oil recovery rate (ORR) provided the ORR was greater than 9500 liters per minute (L/min) (2500 gallons per minute (gpm)) and the system's recovery efficiency (RE) was greater than 70%. To put this in perspective, prior to the competition the largest capacity skimmer ever tested at Ohmsett achieved an ORR of approximately 3,400 L/min (900 gpm).

The X PRIZE committee determined that the competition should enable contestants to possibly recover 11356.2 L/min (3,000 gal min) of oil or greater. The advancing speed range was decided to be between one and four knots. To enable the contests to encounter that much oil, an 18.3 m (60 ft) swath width was chosen with a minimum tow speed of one knot. Based on the 18.3 m (60 ft) width at one knot tow speed, the required slick thickness was 25 mm (1 in), which equated to 11356.2 L/min (3000 gpm). This allowed contestants to choose a narrower swath width with higher speeds to encounter 11356.2 L/min (3,000 gal min) or greater. Later, the X PRIZE committee decided to reduce capacity to 9500 L/min (2500 gal) to meet performance goals.

Testing was conducted by Ohmsett staff with competition oversight by impartial judges provided by X PRIZE. The judges included personnel from industry and government agencies with oil spill response experience. To guarantee fairness, a judge was present whenever a team was on-site.

The competition took place from July through September 2011. Each team was given ten days at Ohmsett to demonstrate their system, including three full days of testing in the test basin. To ensure that the last team that tested did not have the advantage of additional development time, all team equipment had to be en route to Ohmsett by the same date. Tools and spare parts were required to be in the main shipment and additional parts and/or tools were not allowed to be brought to the facility at a later date.

2 Test Apparatus

2.1 Test Area

Ohmsett's test basin is 203 m long x 20 m wide (667 ft x 65 ft) with three moveable bridges that span the width of the tank. The bridges, mounted on rails that run the length of the tank, can travel at speeds up to 3.1 m/s (6 knots). For this competition, each team's oil recovery system was rigged between the Main Bridge and the Auxiliary Bridge. The team's ancillary equipment, such as hydraulic power units and control stands, were mounted on the Main and/or Auxiliary Bridge.

At the south end of the basin is a wave generator and at the north end is a wave attenuating beach system. Allowing for the wave-generating equipment, beaches, and acceleration and deceleration zones, the teams had approximately a 122-m (400-ft) long test area to operate their system under steady state conditions. The test tank is shown in Figure 1.

Figure 1 Ohmsett Test Tank with a 25 mm (1 inch) oil layer

2.2 Test Oil

Hydrocal 300 was used as the test oil because its properties would remain consistent over the course of testing. The nominal viscosity of Hydrocal is 200 cP at 20.0°C, with specific gravity of 0.903, and interfacial tension of 20.6 dynes per cm at 25.5°C. The Hydrocal was dyed red for better visibility.

2.3 Slick Thickness

To achieve the nominal slick thickness of 25-mm (1-inch) for the oil recovery systems to encounter the required 102,000 L (27,000 gal), oil was dispensed on the surface of the tank. A VisiScreen device was used to measure and document the slick thicknesses at multiple locations in the test basin prior to each test.

2.4 Oil Distribution and Sampling

76,000 L (20,000 gal) calibrated frac tanks were used to store the 303,000 L (80,000 gal) of test oil. As test oil was transferred from the frac tanks to the test basin, the oil levels in the frac tanks were carefully measured to ensure the proper amount of oil was transferred to create the 25-mm thick (1-inch) slick. As oil was dispensed into the test tank, samples were obtained and analyzed to confirm initial oil properties. Multiple oil surface samples were obtained and analyzed for initial properties prior to each official test.

2.5 Oil Recovery

Two banks of four-cell calibrated recovery tanks, located on Ohmsett's Auxiliary Bridge, were used during the test (Figure 2). Each of the eight recovery tanks had a capacity of approximately 2,300 L (600 gal) and for sounding purposes, equates to 1.8 L/mm (11.8 gal/in). Fluid depth was measured with a 1.2 m (4 ft) aluminum ruler, and readings were accurate to within 3 mm (1/8 in).

Figure 2 Recovery Tanks on the Auxiliary Bridge

The skimmer's discharge line was connected to Ohmsett's manifold system via a 254-mm (10-inch) flange. A wye downstream of the flange split the flow into two 254-mm (10-inch) pipes, and recovered fluid traveled 4.5 m (15 ft) vertically up to a 203-mm (8-inch) 3-way valve located at each recovery tank. Each manually operated 3-way valve either diverted flow to bypass mode or to collect mode. As each skimmer was allowed to reach to steady state conditions, fluid flow was diverted to bypass mode where the fluid traveled through the manifold and returned to the basin surface. Once the timed collection period started, flow was diverted to the recovery tanks. Prior to test end, flow was redirected to bypass and the collection period ended.

The volume of oil recovered was determined in the following manner. At test end, fluid soundings of each recovery tank cell were obtained to determine total volume of fluid recovered. Following a 30-minute period in which gravity separation took place, free water was decanted from the bottom of each recovery tank cell. A second set of fluid soundings were obtained from which the gross oil volume was calculated. The remaining fluid was stirred and a representative sample was obtained and sent to Ohmsett's on-site lab for water content analysis per ASTM D-1796 (ASTM, 2011). After deducting the free and entrained water from the total fluid recovered, the volume of (pure) oil recovered was determined. Valves located at the bottom of each recovery tank cell allowed for visual decanting of free water.

3 Test Procedure

This was an advancing skimmer test and the methodology was developed based on guidelines from ASTM's F-2709, *Standard Test Method for Determining Nameplate Recovery Rate of Stationary Oil Skimmer Systems* (ASTM 2008a) and ASTM F-631, *Standard Guide for Collecting Skimmer Performance Data in Controlled Environments* (ASTM, 2008b).

3.1 Preliminary Tests

The ASTM F-2709 standard suggests a minimum measurement period of 30 seconds (ASTM, 2008a). The minimum 30 second test period would be waived only if the system filled all eight recovery tanks (18,000 L (4800 gallons)) within 30 seconds. Other applicable data collection, measurement and sampling techniques were integrated into the protocol based on ASTM standards.

Prior to official testing, each manufacturer was allowed one day of practice runs to adjust equipment settings and operational speeds to optimize their system and determine the best tow speeds for calm and wave conditions.

3.2 Performance Tests

The measurement period for each test began when:

- The skimmer system was at its proper tow speed;
- The skimming system was adjusted to its optimum setting;
- The oil recovery and discharge flow appeared to be at steady state;
- The team signaled they were ready to begin the measurement period.

When the above conditions were met, the 3-way valve on each bank of recovery tanks was swung to divert the flow from bypass mode to collect mode and timing started.

The test could end in three possible ways: typically the team leader signaled to end the test period; the tanks were full; or the end of the test distance was reached. At test end flow was redirected to bypass mode and timing ceased. All measurements were taken and the skimmer system was repositioned to start the next test.

3.3 Calculation of Performance Measurements/Oil Recovery Rate and Oil Recovery Efficiency

The two performance measurements are:

Oil Recovery Rate (ORR): Total volume of oil recovered per unit time.

$$ORR = \frac{V_{oil}}{t} \qquad (1)$$

Where: ORR = Oil Recovery Rate, L/min (gpm)
V_{oil} = Volume of oil recovered, L (gal) (decanted and lab corrected)
t = Elapsed time of recovery, minutes

and: Recovery Efficiency (RE): The ratio of the volume of oil recovered to the volume of total fluid recovered.

$$RE = \frac{V_{oil}}{V_{total\ fluid}} \times 100 \qquad (2)$$

Where: RE = Recovery Efficiency, %
$V_{total\ fluid}$ = Volume of total fluid (water and oil) recovered

WENDY SCHMIDT
OIL CLEANUP X CHALLENGE

11 October 2011

Dear Dag,

Congratulations to you and NOFI for completing your testing at Ohmsett during the Wendy Schmidt Oil Cleanup X CHALLENGE this past summer. All of us, including Judge Gene Johnson as well as the personnel at the Ohmsett facility, were pleased to see your system operating in the test basin in pursuit of this X CHALLENGE. Your team spirit and camaraderie were appreciated by all.

In this binder, you will find your team's test results, associated data, pictures, and video from Ohmsett.

Below, we have included a summary of your team's mean Oil Recovery Rate (ORR) and mean Oil Recovery Efficiency (ORE) as calculated by the Judging Panel and the X PRIZE Foundation in accordance with the Competition Guidelines and Field Testing Procedures. In addition, we have provided a summary of which of your Official Test Runs were used to compute your official score in the competition.

Combined MEAN ORR	Combined MEAN ORE	CALM MEAN ORR	CALM MEAN ORE	Run 1 CALM Ohmsett #83			Run 2 CALM Ohmsett #84		
				ORR	% from mean	ORE	ORR	% from mean	ORE
2712	83.0	2958	91.9	2865	3.1%	90.1	2553	N/A	71.1
				Run 3 CALM Ohmsett #85			Run 4 CALM Ohmsett #90		
				ORR	% from mean	ORE	ORR	% from mean	ORE
				2860	3.3%	91	3149	6.5%	94.7
		WAVE MEAN ORR	WAVE MEAN ORE	Run 1 WAVE Ohmsett #86			Run 2 WAVE Ohmsett #87		
				ORR	% from mean	ORE	ORR	% from mean	ORE
		2466	74.0	2573	4.3%	78.5	2419	1.9%	72.3
				Run 3 WAVE Ohmsett #88			Run 4 WAVE Ohmsett #89		
				ORR	% from mean	ORE	ORR	% from mean	ORE
				2399	N/A	72.2	2406	2.4%	71.3

= Official Test Run used for calculation

= Official Test Run not used for calculation

xxx = individual test run results meet or exceed competition criteria

xxx = individual test run results less than competition criteria

Again, congratulations for completing this enormous effort and we wish you all the best in your future endeavors!

Sincerely,

The Wendy Schmidt Oil Cleanup X CHALLENGE Team and the X PRIZE Foundation


WENDY SCHMIDT
OIL CLEANUP
CHALLENGE
Date October 11, 2011
Pay to the Order of NOFI
$ 300,000.00
Three Hundred Thousand 00/100
Dollars


CHALLENGE
OIL CLEANUP

NOFI CURRENT BUSTER 6 WITH
NORMAR INTEGRATED PUMP SYSTEM

RECOVERY EFFICIENCY
X
PUMP CAPACITY

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INTRODUCTION

In any oil spill situation, the focus on recovery efficiency should be the top priority as it gives the best cost- and environmental benefit for the operator. The NOFI Current Buster 6 is primarily designed for operation in demanding conditions and higher speeds through the water, with the aim of collecting, separating and hold the oil.

By introducing the NorMar Integrated Pump System (IPS), especially designed for the NOFI Current Buster technology, we have managed to develop a system that increases the recovery efficiency to above 70%. Due to the technology of the NorMar IPS and the favorable design of the NOFI Current Buster, the system has proven its high recovery efficiency in various types of oil and pump capacities.

OBJECTIVE

Clarify the influence of the pump capacity on the NOFI Current Buster recovery efficiency, based on the characteristics of the technology and tests performed with different pumps.

RECOVERY EFFICIENCY X PUMP CAPACITY

According to The International Tanker Owners Pollution Federation (ITOPF) in the Use of Skimmers in Oil Pollution Reponse, a determining factor in the overall performance of a system is the recovery efficiency, which measures the "selectivity" of the system by collecting oil rather than water. The recovery efficiency is expressed as the ratio of the amount of oil collected to the amount of oil and water collected.

The high recovery efficiency of the NOFI Current Buster Technology is due to its unique ability to separate the oil from water by settling, concentrating the oil in a temporary storage before the pump is activated to transfer it to the vessel’s tank. The system can have more than 1 meter oil layer concentrated on the surface, as observed in physical measurements carried out during the Macondo Blow-out in 2010.

Therefore, since the oil is already concentrated by the NOFI Current Buster, the pump capacity will not have any significant influence on the recovery efficiency of the system. It will only ensure a faster discharge of the system’s temporary storage.

The structure that supports the pump is more relevant in this analysis than the capacity of the pump itself, since it must ensure stability and right floatability for the pump, in order to enable the oil concentrated on the surface to be pumped to vessel’s tank, reducing to a minimum the pumping of water. The NorMar Integrated Pump was developed and intensively tested internally and offshore in order to achieve the perfect tool to fit the NOFI Current Buster, ensuring a recovery efficiency higher than 70%.

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The NOFI Current Buster has been tested both in controlled environmental conditions and offshore using pumps with different capacities and it was not observed any reduction of the recovery efficiency of the system. In both situations the recovery efficiency was higher than 70%.

A PROVEN TECHNOLOGY

In order to illustrate the information presented above, we would like to present the results of two tests: The Wendy Schmidt Oil Cleanup X CHALLENGE and Oil on Water Exercise 2015.

WENDY SCHMIDT OIL CLEANUP XCHALLENGE

The Wendy Schmidt Oil Cleanup X CHALLENGE was a competition designed to inspire a new generation of innovative solutions that will speed up the pace of cleaning up seawater surface oil resulting from spillage from ocean platforms, tankers, and other sources. The one-year competition culminated in the fall of 2011, with competitive demonstrations taking place at OHMSETT, the National Oil Spill Response Research & Renewable Energy Test Facility.

The aim of the test was to analyze the ability to recover oil from the water's surface at the highest oil recovery rate (ORR) at oil recovery efficiency (ORE) of more than 70%.

Oil Recovery Rate (ORR): Total volume of oil recovered per unit time.

$$ORR = \frac{V_{oil}}{t} \qquad (1)$$

Where: ORR = Oil Recovery Rate, L/min (gpm)
V_{oil} = Volume of oil recovered, L (gal) (decanted and lab corrected)
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and: Recovery Efficiency (RE): The ratio of the volume of oil recovered to the volume of total fluid recovered.

$$RE = \frac{V_{oil}}{V_{total\ fluid}} X\ 100 \qquad (2)$$

Where: RE = Recovery Efficiency, %
$V_{total\ fluid}$ = Volume of total fluid (water and oil) recovered

Ref: MAR Incorporated/ Ohmsett Test Facility, High Capacity Advancing Oil Recovery System Performance Testing at Ohmsett for the Wendy Schmidt Oil Cleanup X CHALLENGE, Atlantic Highlands, NJ, USA.

Recovery efficiency:

The NOFI Current Buster with an integrated pump was tested with a pump capacity over 350m3/hr both in calm water and in wave conditions and the recovery efficiency of the system varied between 71,1% and 94,7%.

Combined MEAN ORR	Combined MEAN ORE	CALM MEAN ORR	CALM MEAN ORE	WAVE MEAN ORR	WAVE MEAN ORE
2712	83.0	2958	91.9	2466	74.0

Run	ORR	% from mean	ORE
Run 1 CALM Ohmsett #83	2865	3.1%	90.1
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= Official Test Run used for calculation

= Official Test Run not used for calculation

xxx = individual test run results meet or exceed competition criteria

xxx = individual test run results less than competition criteria

OIL ON WARTER EXERCISE 2015

The NOFO (Norwegian Clean Seas Association for Operating Companies) and the Norwegian Coastal Administration organize annually an offshore exercise which consists of releasing oil at sea to test the efficiency of oil spill response technologies. In 2015, the exercise was held at Frigg Field, located in the North Sea, Norway.

In the full report issued participants of Oil on Water Exercise 2015, the result of tests carried out by an outsourced laboratory demonstrated the amount of water and oil collected by the participating systems during the operation.

Recovery efficiency:

The official results proved again the unique capability of the NOFI Current Buster technology in separating oil from seawater effectively, filling storage tanks with as little water as possible. In this test carried out offshore, the NOFI Current Buster 6 with the NorMar Integrated Pump System was operated with a 30m3/h pump and the recovery efficiency was also higher than 70%.

Tested system	Recovery efficiency oil/ water	Total volum pumped to the vessel (*)	Recovered emulsion (*)	Recovered water (*)
NOFI Current Buster 6 with NorMar Integrated Pump System	77,8 %	18 m^3	14 m^3	4 m^3

(*) - ref. NOFO report

Analyzing the data of the table above, it is observed that the NOFI Current Buster 6 collected only 4m3 of water and 14m3 of emulsion, presenting a recovery efficiency of 77.8%.

CONCLUSION

The system has been tested in different conditions: on tanks and offshore, with different types of oil and pumps, without any significant variation on its recovery efficiency. That proves that the capacity of the pump does not influence on its performance and efficiency.

REFERENCES

ITOPF, The International Tanker Owners Pollution Federation: Use of Skimmers in Oil Pollution Response, London, United Kingdom, p. 7 e 8.

NOFO, Norwegian Clean Seas Association for Operating Companies, Report NOFO Oil-On-Water Exercise 2015. Sandnes- Norway

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