Fire Boom Performance Evaluation

Controlled Burning During the Deepwater Horizon Spill

Operational Period

April 28th to July 19th, 2010

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1. Background and Introduction - Controlled Burning

This report focuses on the practical aspects and lessons learned from working with fire boom on offshore waters during the Deepwater Horizon (DWH) spill response effort. The report takes into account burn data logs initially collected and prepared by DWH responders, first hand observations from BP personnel, on-site fire boom manufacturer representatives, Obrien's Response Group team members, United States Coast Guard (USCG) supervisors, shrimp boat vessel captains and aerial surveillance spotter and guidance personnel.

This report also addresses the different types of fire booms used, their durability, characteristics and overall performance. Throughout the spill response, fire boom was widely requested from manufacturers and Oil Spill Response Organizations' (OSRO's) stock to meet the tactical needs of the burning operations.

As burns became more frequent, new tactics were developed to make burns even more effective. Officials from BP, USCG and Elastec/American Marine, Inc. formed large burn teams allowing for multiple consecutive burns. Offshore burning was demonstrated to be a very safe and effective way to quickly remove significant amounts of spilled oil from the water surface. By the time the well was capped approximately 400 burns were conducted, with some burns lasting several hours in duration. Although some burns were of such short duration and/or had marginal data recorded on size and duration they were eliminated from the volume estimation calculations. 376 well-documented burns are estimated to have eliminated between 220,500 and 310,400 barrels[1]. These burns were accomplished during the operational period from April 28th to July 19th, 2010, using five different types of fire boom. These different types of boom are listed below.

- American Marine – Elastec/American Marine, Inc. (formerly known as 3M)
- Oil Stop – AMPOL, Oil Stop Division
- PyroBoom - Applied Fabrics Technologies, Inc.
- Hydro-FireBoom - Elastec/American Marine, Inc.
- Kepner Fire Boom – Kepner Plastics

The estimated burn volume achieved during this operational period is provided in Figure 1.

[1] This range of barrels burned is simply an estimate. The range of oil burned in each controlled burn event is estimated by (1) multiplying the area occupied by the fire (itself an estimate) by the duration of the burn, and (2) multiplying the result by a minimum burn rate, and then a maximum burn rate, respectively. The maximum and minimum burn rate were selected based on a review of the existing burn rate literature, an understanding of the levels of emulsion encountered during the burns and the expertise of the DWH responders involved in the controlled burn group. The burn rates selected represent (educated) estimates.

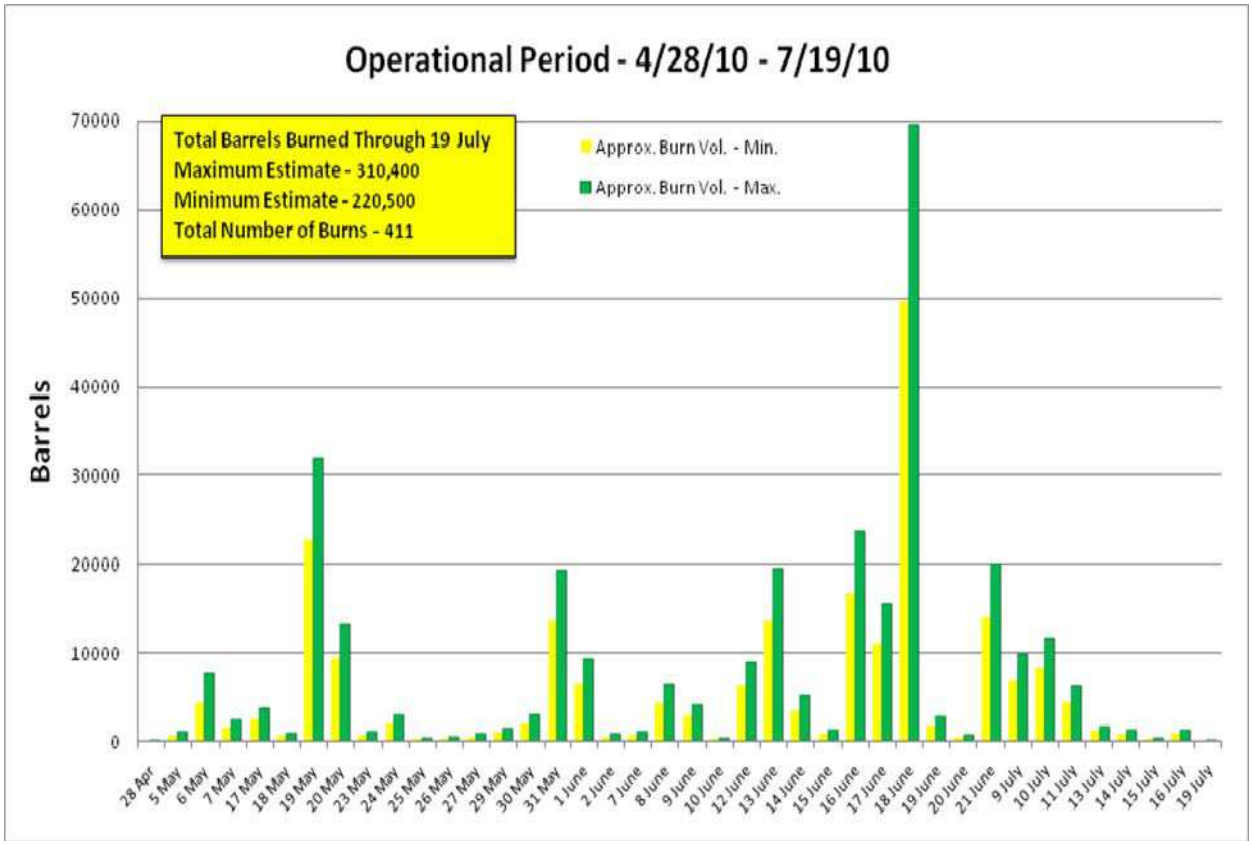


Figure 1.

In the beginning, burns would typically last in the range of one hour. However, as more burns occurred, the technique was refined. On June 16th, a burn of 11 hours and 48 minutes in duration became the longest continuous burn time recorded. Collectively, the burns made it possible to efficiently remove significant amounts of oil from the marine environment (an estimated 220,500 to 310,400 barrels).

What is significant during this operation was the sheer number of controlled burns conducted - providing a unique opportunity to repeatedly test and evaluate fire boom equipment. These fires were of a much greater intensity and size than can be generated in any test facility.

2. Development of Fire booms

In the mid 1980's some of the first commercial fire booms became available with a limited capability of containing burning oil. Several tests were conducted subsequently in field trials - Spitsbergen, Norway (1988), Newfoundland, Canada (1993), United Kingdom Southampton (1996). During the 1989 Exxon Valdez

spill in Prince William Sound, Alaska, a single controlled test burn was conducted, (Subsequent burns could not be conducted because of a storm that spread and emulsified the oil to a non-combustible condition.)

The oil industry and government agencies continued to fund research and tests of fire booms over a 25-year period. This research greatly assisted in making it possible to successfully conduct this first large-scale, controlled, offshore burn operation in the Gulf of Mexico.

Numerous research papers can be accessed via the MMS, (BOEMRE) Website: http://www.boemre.gov And the ASTM Committee F20 has developed general guidelines for the burning of oil, including F1788 (Standard Guide for In-Situ Burning of Oil Spills on Water) and F2152 (Standard Guide for In-Situ Burning of Spilled Oil; Fire Resistant Boom).

In the F2152 Guide, fire boom is described, inter alia, as follows:

" 4.1 To be effective, the fire-resistant boom shall contain oil floating on water before, during and after exposure to in-situ burning of oil"

"4.3 If a boom is defined as reusable, a procedure for cleaning, decontamination, salvage and restoration shall be provided to the user by the manufacturer "

"5.5.2 The fire-resistant boom shall withstand oil fires and contain oil in various conditions that include both calm water and waves with significant wave height of up to 1m and period of 3 to 4 seconds."

The performance of fire booms deployed during this spill was based on these and other guidelines. It should be noted that all of the fire boom systems used during this spill were used repeatedly until significant repair or replacement was required. Some fire booms performed better than others and some were more "user friendly". Some were easier to deploy, recover and repair, while others were difficult to handle and showed significant damage after only a short exposure to fire.

Some fire booms did better at oil retention and wave performance than others. Fire boom performance was not only affected by fire intensity, but also by fatigue stress on boom components and connectors while deployed in varying sea states. For convenience, time saving, and for some booms to minimize damage, booms remained at tow behind vessels throughout the night until operations began the next day. A gentle, straight-line tow throughout the night was generally less stressful on the fire booms. Those booms that became brittle during their burns, usually suffered additional damage whether towed through the night or recovered on deck.

One purpose of this report is to feature fire boom performance using the parameters listed below while taking into account the observations made by personnel on site during the controlled burning activity.

Parameters

A. Burn duration & number of systems used
B. Visual observations of oil retention / wave performance
C. Repair & durability
D. Handling & Operational observations
    - Logistics, shipping (air lift capability)
E. Burn Volumes accomplished per system type

3. Types of Fire boom

The two basic types of fire boom are non- water-cooled and water-cooled. Non-water-cooled boom has a permanent, solid flotation in the form of metallic or ceramic floats covered or attached to a fire resistant fabric. Water-cooled booms incorporate inflatable buoyancy chambers allowing them to be stored and recovered onto powered reels. These booms have pumping systems to distribute sea water to an outer fabric, saturating and cooling the boom during a burn.

Fire Boom: Hydro-Fire Boom (water-cooled)
Manufacturer: Elastec/American Marine, Inc.

Hydro-Fire Boom systems feature a sectional inflatable boom covered in a fire blanket that is continually soaked with sea water during burning and is mounted on a powered reel for both deployment and recovery. This system is readily transportable by C-130 aircraft. (Several systems, for example, were shipped from Brazil to the Gulf of Mexico in one aircraft during the response.) As seen in Figure 2, the boom features a stainless steel top tension cable and a series of individually inflated segments that are insulated by the water-cooled blanket. Five 100-foot boom sections make up a single fire boom system. As shown in *Figure 3*, the Hydro-Fire Boom is deployed Apex first so two sides of the boom are inflated at the same time. Pumps on each of the boom-towing vessels provide cooling seawater to the boom's outer fabric.

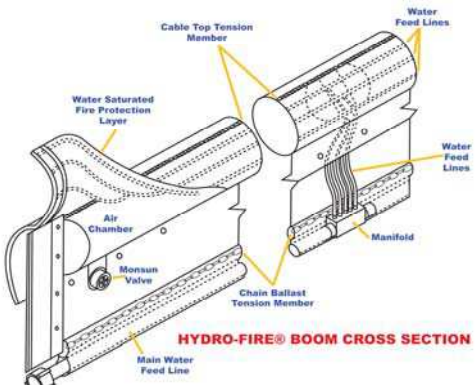


Figure 2.
Source: Elastec/American Marine, Inc.

Figure 3.
Source: MC252 Photo Log

With the series of inflatable segment design, should a failure occur in any one of the segments, the boom does not lose its entire flotation integrity.

* *Hydro Fire Boom Specifications;*
A system is comprised of 5 sections of 100ft (30m) Fire Boom each with 14" flotation and 18" skirt; 1 Boom Reel with Brake and air inflation system; 2 high-flow water pumps with flow meters, filters, and pressure gauges. Weight 8 lbs/ft. (12 kg/m)

Fire Boom: **American Marine** - Non- Water-Cooled (formerly known as 3M)
Manufacturer: **Elastec/American Marine, Inc.**

As shown in Figures 4 & 5, this is a non-water-cooled, ceramic fire boom with a high-temperature solid flotation core. The high temperature core is surrounded by stainless steel mesh and ceramic fabric components to withstand 2000°F. A sacrificial outer cover provides protection and ease of handling during storage and deployment.

Figure 4.
Source: MC252 Photo Log

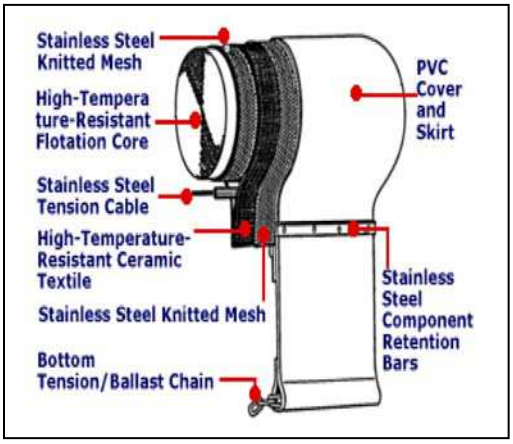


Figure 5.
Source: Elastec/American Marine, Inc.

The American Marine boom was originally developed to support offshore oil exploration activities in Alaska during the 1990's. During the DWH Spill many systems were shipped to the Gulf from Alaska. Two different sizes of this boom were utilized, one with 12" flotation and another with 18" flotation.

Specifications;
Overall size 30", flotation 12", skirt 21"
Overall size 32", flotation 18", skirt 24"

Fire Boom: **PyroBoom** – non water-cooled
Manufacturer: **Applied Fabrics Technologies, Inc.**

The typical Pyroboom "burn kit" consists of 500 ft (150m) of PyroBoom, a fence-type boom consisting of high temperature fabric and stainless steel flotation chambers bolted to its sides. During the first burning operations only 200ft were available from the manufacturer. During the DWH response, BP purchased boom from Africa and placed additional orders with the manufacturer, Applied Fabrics Technologies, Inc.

The PyroBoom construction is portrayed below in figure 6 featuring a silicone coated refractory barrier fabric and stainless steel float shells filled with glass foam. Boom components are assembled using ASTM connectors and off-the-shelf fasteners. The original booms provided during this response arrived with aluminum connectors, however, post-spill orders are being made with stainless steel connectors.

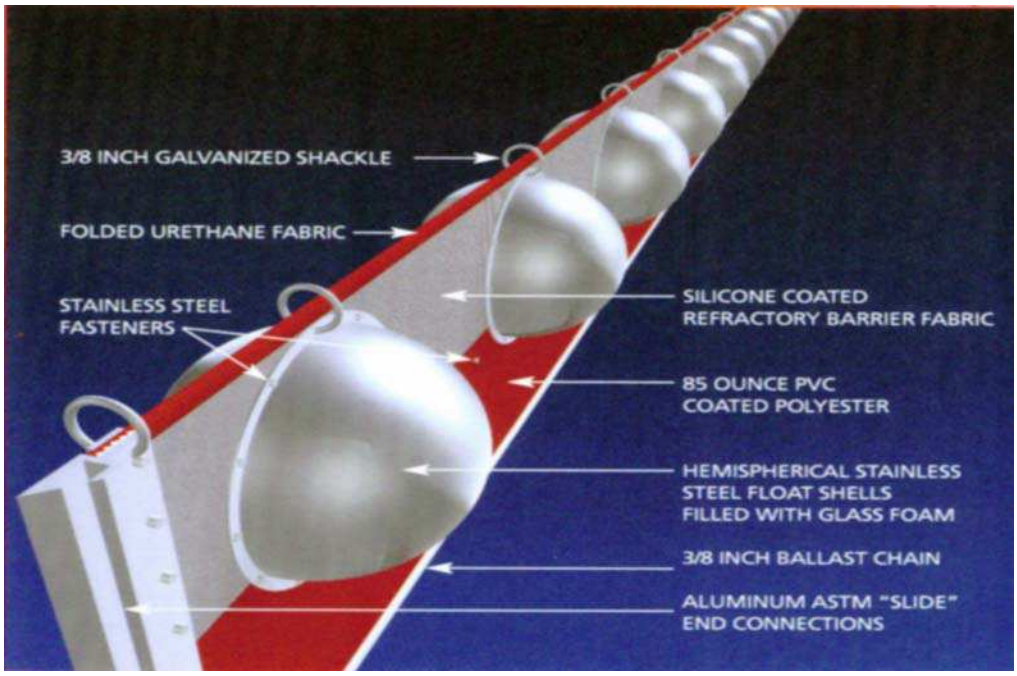


Figure 6.
Source: Applied Fabrics Technologies, Inc.

*Specifications; (PyroBoom)
Freeboard 11 inch, draft 19 inch. 8.9 lbs/ft (13.3 kg/M)

Fire Boom: Oil Stop Fire boom – non water-cooled
Company: Oil Stop L.L.C.

The Oil Stop fire boom has a multi-layer construction consisting of a high temperature inflatable membrane, covered by a ceramic insulation, encapsulated with a stainless steel screen. A sketch of the fire boom design is shown in Figure 7.

Specifications – Oil Stop Boom

Single-point inflation Harbor Model– approx: 8#/ft.

Single-point inflation Harbor Model – 12” X 18”

Reel with 500 ft. Harbor Fire Boom and 600 ft. single-point inflation guide boom – approx: 10’ X 7’ X 7.5’- 8,500#

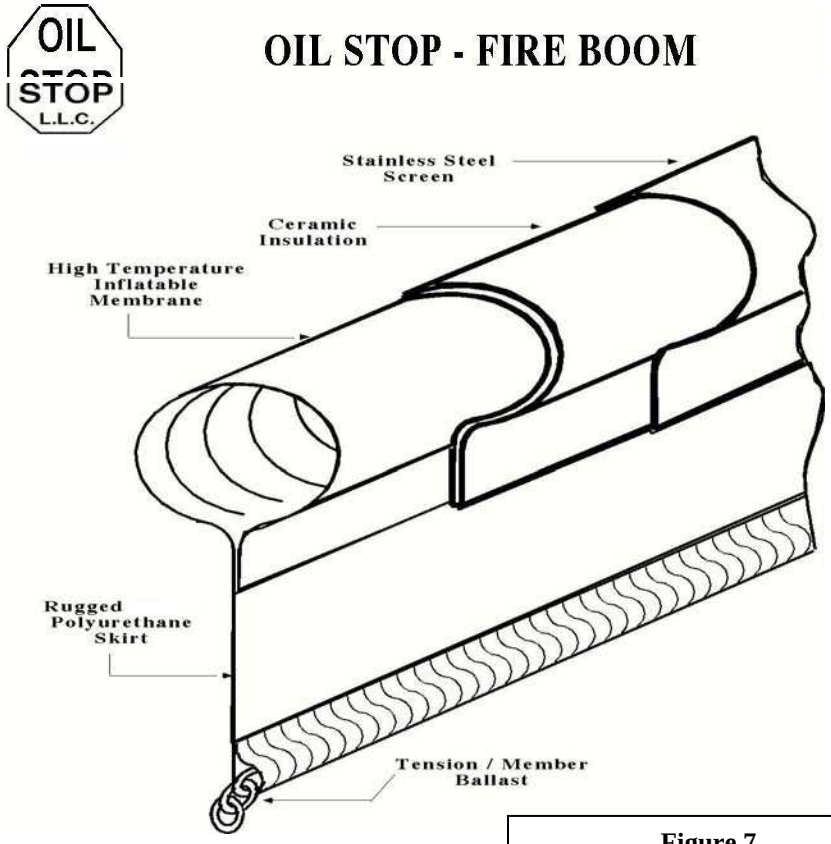


Figure 7.
Source: Oil Stop L.L.C.

Fire Boom: Kepner Fire boom

Manufacturer: Kepner Plastics Fabricators, Inc.

The Kepner fire boom design is a non-water-cooled type with the size specification listed below. The small number of Kepner fire boom systems used had been manufactured approximately 20 years ago.

Model #BTTB1115 FG FireGard Fire Containment Boom
Float Diameter: 11”
Skirt Length: 15”
Two, 250 ft section lengths per system[2]

[2] Technical data provided by the World Catalog of oil spill products

4. Fire Boom Performance

A. Burn Duration and Number of Systems Used

Table 1. below was developed to summarize the data in "Appendix A" by comparing the different fire boom types against the number of systems used, the longest reported continuous burns and the number of average barrels burned per fire boom system. Some fires within the fire boom had very short durations and would have to be restarted. The data captures only the durations for "continuous" burns occurring during the controlled burn operations.

Many factors came into play when achieving long duration burns. The sea state and winds had a major impact on the length of burns and the capability of keeping the oil contained in the fire boom. The oil properties encountered were also of concern as the water content (emulsion) varied considerably from day to day. Some days the oil was thick and relatively fresh, at times concentrated along natural convergence zones, and other times it was thin and spread out over larger areas.

Table 1. Burn Data Summary (refer to "Appendix A" for data source)

Factors	Hydro-Fireboom	American Marine / 3M	Pyroboom	Oil Stop	Kepner
No. of Systems Used	27	37	13	3	2
Longest Continuous Burn	11 hrs 48 min.	11 hrs 21 min.	3 hours 13 min	27 min.	43 min.
Average Max/Min Barrels Burned per System	5,173/ 3,775	3,916/ 2,800	1,750/ 1,238	28/ 11	296/ 211

B. Oil Retention & Wave Performance

The Hydro-Fire Boom systems maintained a high level of containment integrity for extended periods of time, and were able to repeatedly collect large amounts of oil. These systems endured some of the longest and largest burns experienced (see Appendix A).

In general, booms with ceramic floatation systems became less capable of retaining oil with each burn. But, an interesting observation was that the American Marine/3M boom developed a build-up of oil residue that would impregnate the fire resistant fabric. This would enhance the oil holding proprieties of the boom and increase the number of times it could be used. This probably extended its containment capability and allowed for more burning time. The more modern versions of the American Marine systems proved to be reliable as well and allow multiple burns. In general, non water-cooled or dry fabric booms suffered more than water-cooled booms when exposed to wave action following a burn. The more flexible American Marine boom faired better than others in this respect.

An attempt to use the three reel-mounted Oil Stop fire boom systems was made during May, 2010, but was unsuccessful. (It should be noted at the outset that the small amount of Oil Stop fire boom used on the response – obtained from local OSROs – was manufactured 12 to 14 years prior.) The first Oil Stop boom system deployed sank within a short time. The next boom system deployed accomplished a 27 minute burn, but after a couple of hours the boom experienced some flotation problems. After third system also experienced flotation problems, a field decision was made to discontinue use of this fire boom. Although, this generation of Oil Stop boom did not prove to be a viable way to contain oil for burning, Oil Stop's subsequent generations of fire boom systems may be.

As shown in Figure 8, Oil Stop systems used included 200 feet of guide boom on the leading edges connected to 300 feet of fire boom. Their guide boom is standard containment boom in 100 foot sections with 12 foot long segmented chambers (8/section). During the DWH response, it was found that it was generally best practice to use fire boom for the entire 500 feet in order to burn larger volumes of contained oil. A full configuration of fire-resistant boom is also desirable in order to allow for "full-boom" burns, and to handle shifts of burning oil within the U-configuration due to wind and/or back and forth movements of

towing vessels.

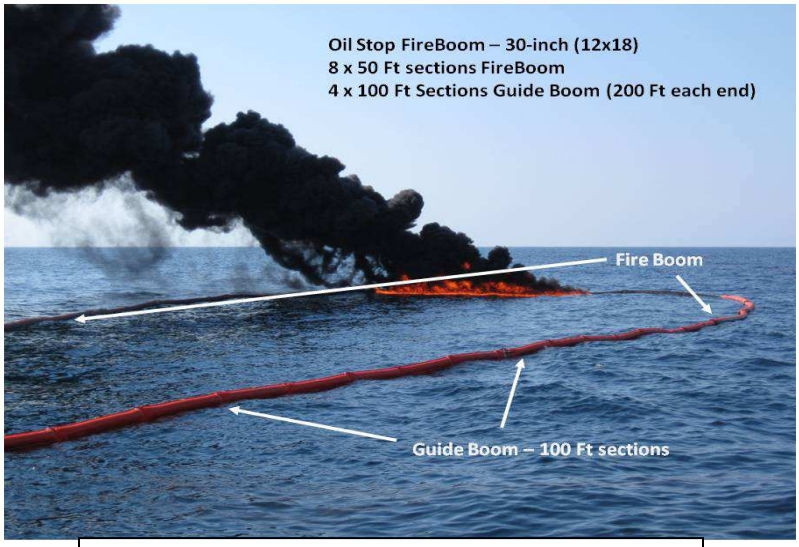


Figure 8.
Source: Oil Stop L.L. C.
Showing Controlled Burning inside its Fire Boom

Regarding oil retention and wave performance, the PyroBoom oil containment capability was compromised under certain wind and wave conditions. As shown in Figure 9, used PyroBoom would tend to suffer during towing as the fabric would tear easily. This was observed at times in both new boom and boom sections after burns.

As mentioned earlier, for fire boom to be effective, it has to contain oil floating on water before, during and after exposure to in-situ burning of the oil. The more rigid construction booms did not have as good wave response.

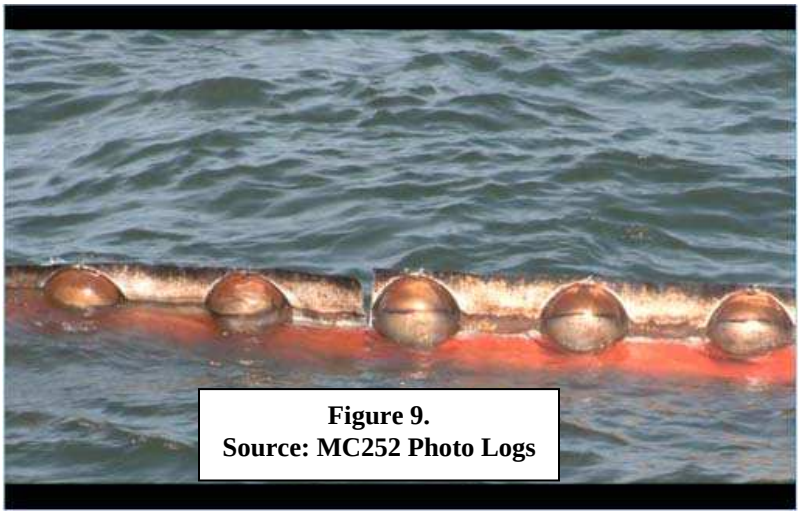


Figure 9.
Source: MC252 Photo Logs

This is mostly due to the boom construction and lower buoyancy to weight ratios as listed below.

Hydro-Fireboom	6.3:1
Pyroboom	3.3:1
American Marine (3m)	3.8:1

Two 500' systems of (older generation) Kepner fire boom were deployed during the response effort. Both systems failed after approximately 5 minutes due to intense heat of the fires. It appeared that the outer, fire proof cover did not protect the underlying foam flotation.

C. Burn fatigue / durability / repair

The Hydro-Fire boom maintained its integrity and had good fatigue resistance for extended periods. Field observers reported as many as 10 to 14 burns (often, large burns) with the Hydro-Fire Boom. After a fire boom's extended use, localized degradation can take place at the hottest down-wind portion (or apex) of the boom. The boom manufacturer of the water-cooled boom has already made modifications to improve its thermal protection. This has been accomplished by increasing the sea water flow rate to the boom and by enhancing the water distribution system within it. The boom was relatively quick to deploy and took from 30 to 40 minutes. The Hydro-Fire boom retrieval was assisted greatly by the powered boom reels. Having a water-cooled flexible cover, this boom is easily handled, recovered, or repaired while in the water. Typically the boom was left in the water over night, and towed by fishing vessels. The Hydro-Fire Boom did not show any signs of wear due to towing.

Repair ability – 100 foot sections were reused and the inflatable portion of the boom under the water cooled cover, was salvaged and re-blanketed.

Operators could extend the life of the Hydro-Fire Boom by adding foam flotation to any deflated areas or change deflated bladders. Hydro-Fire Boom seemed to have the longest life, even during the most intense burns. It exhibited good sea keeping abilities which extended the operating window when sea conditions deteriorated.

The two longest continuous burns recorded with the Hydro-boom were 11 hours 48 minutes and 10 hours 20 minutes.

Another good performer was the American Marine fire boom. Although perhaps not as durable as the water-cooled boom, it was available in quantity and contributed significantly to the burn operation. The PVC cover protected the boom during handling and deployment. Fabric failures were only seen after extended high-temperature exposures. No tears were witnessed in the newer American Marine boom, showing good thermal integrity. (There were, however, fewer burns per system than the Hydro-Fire Boom.) This boom is built like a traditional boom with fabric encasing the floats. Stainless end connectors were typically undamaged and were able to be changed with boom in the water. This boom also has a mid tension stainless steel cable.

The longest continuous burn recorded with the American Marine / 3M was 11 hours 21 minutes.

The Pyroboom is a fence type boom constructed with stainless steel hemispheres on each side and high temperature silicone-coated refractory fabric. The wind and wave conditions experienced during the DWH spill response occasionally impacted the PyroBoom's stability allowing oil to splash over. The structural integrity was subject to compromise after repeated burns, but could often be controlled by alternating the most intense portions of a burn to different sections of a U-configuration.

The PyroBoom aluminum end connectors were a problem as they would melt and weld together. This prevented the operators from easily taking out bad sections or rotating the boom's leading ends into the apex. Completing such repairs while deployed in the water was nearly impossible and recovering the boom on deck for such repairs often led to additional damage of the fabric.

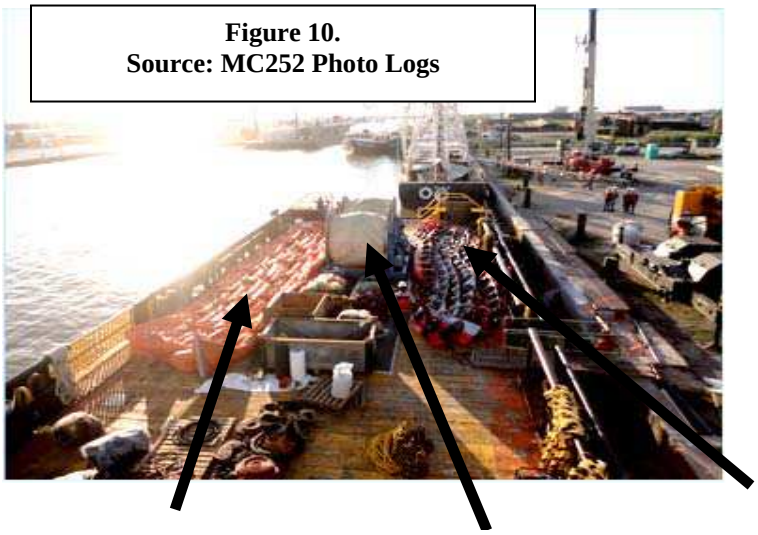
Post-spill orders of PyroBoom are being made with stainless steel end connectors. Small wire rope was sometimes retrofitted between spheres and connectors and sphere to sphere to extend boom life. The smooth spheres made the boom easy to deploy on smooth decks, but difficult over railings on some of the ships. The tensile strength of the upper fabric after several burns appeared weaker as evidenced by some fabric failures.

The longest recorded continuous burn with the Pyroboom systems was 3 hours 13 minutes.

D. Handling & Operational Observations

Regarding storage volume, the inflatable booms took significantly less space on deck. The boom system's storage volume has a significant impact on logistics, especially when considering air lift transport. Shipping and delivery to a port of call usually involves connexes and crate packaging. *Figure 10* portrays the three types of fire boom (as labeled) placed on the back deck of a supply vessel for offshore transport from Venice Dock to the burn region during the DWH response.

Figure 10.
Source: MC252 Photo Logs



Picture shows 1000 ft. of Hydro-boom, 1000 ft. of American Fireboom, and 400 ft. of Pyroboom. Photo was taken at Venice Dock after loading operations.

American Marine /3M 2 Reels of Hydro-Fireboom Pyroboom

Hydro-Fire Boom, provided on reels, offers speed, simplicity and stress reduction during deployment and recovery. PyroBoom which is non-water-cooled and non-inflated, provides simplicity of use and a range of options for storage and transport.

The fire boom volumes shown in *Figure 10* are listed below:

Hydro-Fire Boom	Reel size: 122" x 89" x 103" / 500ft	= 0.05 cu.ft../ft
Pyroboom	Overall size 30", freeboard 11"	= 1.135 cu.ft./ft
American Marine/3M	Overall size 31", freeboard 12"	= 1.01 cu.ft/ft

E. Burn Volume

"Appendix A" lists the burn number, burn date and the estimated minimum and maximum burn volumes sorted by the fire boom types, as summarized In Table 1 (page 10).

5. Conclusion

Over the last 20 years many manufacturers have tried to produce fire resistant booms. Using ASTM guidelines along with years of research by public and private sectors paid off and was a big factor in the success of the Gulf *Insitu* Controlled Burn Operations.

Hydro-Fire Boom systems collected the most oil and were responsible for the highest volume of oil burns per system. Other systems also contributed significantly. Dry type booms, while successful, lost their oil retention capabilities more quickly than the water-cooled boom. This data is summarized in *Table 1* of the report.

"Appendix A" speaks for itself, providing the burn data collected during the spill response. The data depicts the burn number, burn date and the maximum estimated burn volume for each individual burn by boom type. This report should make it clear that the success of a fire boom is not only determined by its capability to contain oil and maintain a large fire; it must also sustain its oil containment capability and endure the constant fatigue stresses imposed by the varying wind and wave action. Effective fire boom must also retain its structural and thermal integrity while deployed for burning, and while on the water, waiting for the next burn. Along with the massive scale of the DWH incident response, came the opportunity to try out a wide range of available fire boom designs. Some manufacturers are currently improving their designs based on lessons learned during this incident.

The overall collective fire boom performance during this unprecedented response effort expanded our understanding of controlled burn strategies and tactics. Preferred response options are highly situational and depend on different factors. Windows of opportunity and environmental tradeoffs need to be thoroughly understood and anticipated when considering response options. In any offshore oil spill, controlled burning should be considered seriously, under the right conditions, as a primary response tool.

APPENDIX A

BURN DATA

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
1	4/28/2010	77	108								
2	5/5/2010	512	716								
3	5/5/2010	10	13								
4	5/5/2010	1	2								
5	5/5/2010	147	364								
6	5/6/2010	1760	3285								
7	5/6/2010	1031	1925								
8	5/6/2010	1723	2413								
9	5/6/2010	41	131								
10	5/7/2010	371	519								
11	5/7/2010	25	35								
12	5/7/2010	113	158								
13	5/7/2010	170	237								
14	5/7/2010	1	2								
15	5/7/2010	994	1392								
16	5/17/2010	1851	2591								
17	5/17/2010	166	232								
18	5/17/2010	136	190								
19	5/17/2010	0	0								
20	5/17/2010	0	0								
21	5/17/2010	297	416								
22	5/17/2010	210	293								

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
23	5/18/2010	235	329								
24	5/18/2010	368	515								
25	5/18/2010	51	72								
26	5/18/2010	0	0								
27	5/19/2010	303	425								
28	5/19/2010	11700	16380								
29	5/19/2010	3800	3800								
30	5/19/2010	769	1076								
31	5/19/2010	1423	1992								
32	5/19/2010	4809	6733								
33	5/20/2010	2940	4116								
34	5/20/2010	678	950								
35	5/20/2010	864	1210								
36	5/20/2010	0	0								
37	5/20/2010	4783	6696								
38	5/20/2010	1	2								
39	5/20/2010	179	251								
40	5/23/2010			160	224						
41	5/23/2010			293	410						
42	5/23/2010							34	84		
43	5/23/2010	139	195								
44	5/23/2010	125	176								

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
45	5/23/2010			10	14						
46	5/23/2010					2	3				
47	5/23/2010	8	11								
48	5/24/2010	172	240								
49	5/24/2010			75	105						
50	5/24/2010					382	534				
51	5/24/2010	179	250								
52	5/24/2010					280	392				
53	5/24/2010	76					106				
54	5/24/2010			7	10						
55	5/24/2010					458	641				
56	5/24/2010					132	185				
57	5/24/2010					40	56				
58	5/24/2010					19	26				
59	5/24/2010					0	0				
60	5/24/2010			77	108						
61	5/24/2010					153	214				
62	5/24/2010					49	68				
63	5/24/2010			73	103						
64	5/24/2010					0	0				
65	5/24/2010					0	0				
66	5/24/2010					180	253				

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
67	5/24/2010	0	0								
68	5/26/2010					20	28				
69	5/26/2010	117	163								
70	5/26/2010	0	0								
71	5/26/2010					75	105				
72	5/26/2010					24	33				
73	5/26/2010	14	20								
74	5/26/2010					114	160				
75	5/27/2010	57	80								
76	5/27/2010					55	77				
77	5/27/2010					217	304				
78	5/27/2010					177	248				
79	5/27/2010					11	15				
80	5/27/2010	10	14								
81	5/27/2010					3	4				
82	5/27/2010	10	13								
83	5/27/2010					27	38				
84	5/27/2010	0	0								
85	5/27/2010					11	16				
86	5/27/2010					16	23				
87	5/27/2010					0	0				
88	5/28/2010					0	0				

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
89	5/29/2010					0	0				
90	5/29/2010					1	1				
91	5/29/2010					81	113				
92	5/29/2010					284	397				
93	5/29/2010					0	0				
94	5/29/2010					560	703				
95	5/29/2010					95	133				
96	5/30/2010					93	130				
97	5/30/2010					68	95				
98	5/30/2010					95	133				
99	5/30/2010					257	360				
100	5/30/2010					32	44				
101	5/30/2010					207	290				
102	5/30/2010					95	133				
103	5/30/2010					116	162				
104	5/30/2010					325	455				
105	5/31/2010					186	261				
106	5/31/2010					720	1008				
107	5/31/2010					0	0				
108	5/31/2010					59	83				
109	5/31/2010					187	262				
110	5/31/2010					501	702				

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
111	5/31/2010					9	12				
112	5/31/2010					73	102				
113	5/31/2010					97	136				
114	5/31/2010	424	594								
115	5/31/2010					513	719				
116	5/31/2010					144	202				
117	5/31/2010	8512	11916								
118	5/31/2010					101	142				
119	5/31/2010					750	1050				
120	5/31/2010					254	356				
121	5/31/2010					1248	1748				
122	6/1/2010	3849	5389								
123	6/1/2010					138	193				
124	6/1/2010	2451	3431								
125	6/1/2010					132	185				
126	6/2/2010	571	800								
127	6/7/2010					231	223				
128	6/7/2010					66	92				
129	6/7/2010					18	26				
130	6/7/2010					157	220				
131	6/7/2010					36	51				
132	6/7/2010					61	85				

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
133	6/7/2010					180	252				
134	6/8/2010					45	63				
135	6/8/2010					109	153				
136	6/8/2010					65	92				
137	6/8/2010					127	178				
138	6/8/2010					3	4				
139	6/8/2010					1621	2270				
140	6/8/2010	367	513								
141	6/8/2010					469	656				
142	6/8/2010					322	451				
143	6/8/2010					70	98				
144	6/8/2010					604	846				
145	6/8/2010					503	704				
146	6/8/2010					90	126				
147	6/8/2010					65	91				
148	6/8/2010					84	118				
149	6/9/2010					75	106				
150	6/9/2010					1156	1618				
151	6/9/2010					119	167				
152	6/9/2010					123	73				
153	6/9/2010	29	41								
154	6/9/2010					60	85				

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
155	6/9/2010					266	372				
156	6/9/2010	52	73								
157	6/9/2010	99	139								
158	6/9/2010	116	162								
159	6/9/2010					343	480				
160	6/9/2010					103	144				
161	6/9/2010					64	89				
162	6/9/2010					106	148				
163	6/9/2010					68	95				
164	6/9/2010					66	93				
165	6/9/2010	93	131								
166	6/10/2010	300	400								
167	6/12/2010	2	3								
168	6/12/2010					6	8				
169	6/12/2010					218	305				
170	6/12/2010					32	45				
171	6/12/2010					909	1272				
172	6/12/2010					255	357				
173	6/12/2010	14	20								
174	6/12/2010					19	27				
175	6/12/2010					33	46				
176	6/12/2010	4597	6436								

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
177	6/12/2010					85	120				
178	6/12/2010					19	26				
179	6/12/2010					31	44				
180	6/12/2010					55	77				
181	6/12/2010					5	7				
182	6/13/2010					4774	6683				
183	6/13/2010					15	21				
184	6/13/2010	888	1244								
185	6/13/2010					2283	3196				
186	6/13/2010					4692	6568				
187	6/13/2010					171	240				
188	6/13/2010					26	36				
189	6/13/2010					64	89				
190	6/13/2010	360	504								
191	6/13/2010					35	49				
192	6/13/2010					120	168				
193	6/13/2010					342	479				
194	6/13/2010					32	45				
195	6/13/2010					21	30				
196	6/14/2010	88	123								
197	6/14/2010					61	86				
198	6/14/2010					20	27				

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
199	6/14/2010					73	102				
200	6/14/2010					11	16				
201	6/14/2010					264	370				
202	6/14/2010					92	129				
203	6/14/2010					106	148				
204	6/14/2010					1133	1586				
205	6/14/2010	20	29								
206	6/14/2010	19	27								
207	6/14/2010					3	5				
208	6/14/2010					186	261				
209	6/14/2010					1	1				
210	6/14/2010					1041	1457				
211	6/14/2010					387	542				
212	6/14/2010					54	75				
213	6/14/2010					20	27				
214	6/15/2010	344	482								
215	6/15/2010					111	156				
216	6/15/2010					169	236				
217	6/15/2010					43	60				
218	6/15/2010					8	11				
219	6/15/2010	143	200								
220	6/15/2010					1	1				

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
221	6/15/2010					12	17				
222	6/15/2010					1	2				
223	6/15/2010	14	19								
224	6/16/2010	5956	8339								
225	6/16/2010					5	7				
226	6/16/2010					214	299				
227	6/16/2010					705	986				
228	6/16/2010					2508	3512				
229	6/16/2010					1014	1420				
230	6/16/2010					81	113				
231	6/16/2010					292	409				
232	6/16/2010					5968	8355				
233	6/16/2010					33	46				
234	6/16/2010					2237	3132				
235	6/16/2010	1251	1751								
236	6/16/2010	7492	10488								
237	6/16/2010	59	83								
238	6/16/2010					44	62				
239	6/18/2010	121	170								
240	6/18/2010					69	96				
241	6/18/2010	147	205								
242	6/18/2010	148	207								

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
243	6/18/2010					420	588				
244	6/18/2010					49	69				
245	6/18/2010					820	1148				
246	6/18/2010	4333	6066								
247	6/18/2010					255	357				
248	6/18/2010					842	1178				
249	6/18/2010					16097	22536				
250	6/18/2010					21932	30705				
251	6/18/2010					127	178				
252	6/18/2010					1705	2388				
253	6/18/2010					2133	2986				
254	6/18/2010					422	591				
255	6/19/2010					360	504				
256	6/19/2010					83	116				
257	6/19/2010					1226	1716				
258	6/19/2010					39	55				
259	6/19/2010					36	50				
260	6/19/2010					204	286				
261	6/20/2010					37	52				
262	6/20/2010			198	278						
263	6/20/2010	24	33								
264	6/20/2010					75	105				

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
265	6/20/2010					18	25				
266	6/20/2010					74	104				
267	6/20/2010					85	120				
268	6/21/2010					2975	4165				
269	6/21/2010					1350	1889				
270	6/21/2010			1139	1595						
271	6/21/2010	1550	2170								
272	6/21/2010					1237	1731				
273	6/21/2010	473		473	662						
274	6/21/2010	1141		1141	1597						
275	6/21/2010	468		468	655						
276	6/21/2010	292	409								
277	6/21/2010			160	224						
278	6/21/2010			51	71						
279	6/21/2010			54	76						
280	6/21/2010			0	0						
281	6/21/2010			41	57						
282	6/21/2010	395	553								
283	6/21/2010			774	1083						
284	6/21/2010	13	18								
285	6/21/2010			744	1041						
286	6/21/2010			625	876						

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
287	6/21/2010			638	893						
288	6/21/2010	78	110								
289	7/8/2010									0	0
290	7/9/2010			346	484						
291	7/9/2010	2067	2894								
292	7/9/2010			361	506						
293	7/9/2010			413	799						
294	7/9/2010			357	500						
295	7/9/2010			157	220						
296	7/9/2010			58	81						
297	7/9/2010					294	441				
298	7/9/2010			25	34						
299	7/9/2010			928	1299						
300	7/9/2010			277	387						
301	7/9/2010					25	36				
302	7/9/2010									422	591
303	7/9/2010			50	71						
304	7/9/2010			1150	1611						
305	7/10/2010					140	197				
306	7/10/2010	3794	5312								
307	7/10/2010			4	6						
308	7/10/2010	940	1316								

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
309	7/10/2010					311	436				
310	7/10/2010			61	86						
311	7/10/2010			2646	3705						
312	7/10/2010	176	246								
313	7/10/2010	76	106								
314	7/10/2010			59	83						
315	7/11/2010	46	65								
316	7/11/2010	578	810								
317	7/11/2010	61	85								
318	7/11/2010			72	101						
319	7/11/2010			660	924						
320	7/11/2010	0	0								
321	7/11/2010	1136	1590								
322	7/11/2010	550	771								
323	7/11/2010			50	70						
324	7/11/2010			66	92						
325	7/11/2010			81	114						
326	7/11/2010					772	1081				
327	7/11/2010			50	70						
328	7/11/2010			242	339						
329	7/11/2010			72	100						
330	7/13/2010					47	65				

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
331	7/13/2010	45	64								
332	7/13/2010	43	60								
333	7/13/2010	2	2								
334	7/13/2010	20	27								
335	7/13/2010	3	4								
336	7/13/2010	0	0								
337	7/13/2010	20	28								
338	7/13/2010	0	0								
339	7/13/2010	32	44								
340	7/13/2010	160	224								
341	7/13/2010					66	92				
342	7/13/2010	2	3								
343	7/13/2010	1	1								
344	7/13/2010			0	0						
345	7/13/2010					75	105				
346	7/13/2010			27	38						
347	7/13/2010	67	93								
348	7/13/2010			105	147						
349	7/13/2010	18	25								
350	7/13/2010			0	0						
351	7/13/2010					435	609				
352	7/14/2010	2	3								

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
353	7/14/2010					54	75				
354	7/14/2010	14	20								
355	7/14/2010					81	114				
356	7/14/2010	89	124								
357	7/14/2010					0	0				
358	7/14/2010					7	10				
359	7/14/2010			0	0						
360	7/14/2010	43	60								
361	7/14/2010	22	31								
362	7/14/2010	103	144								
363	7/14/2010	16	23								
364	7/14/2010			12	17						
365	7/14/2010	0	0								
366	7/14/2010	20	28								
367	7/14/2010	10	14								
368	7/14/2010	48	67								
369	7/14/2010	56	79								
370	7/14/2010	42	42								
371	7/14/2010	0	0								
372	7/14/2010	10	13								
373	7/14/2010			74	103						
374	7/14/2010	18	25								

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
375	7/14/2010			50	69						
376	7/14/2010			77	107						
377	7/14/2010			55	78						
378	7/15/2010			19	26						
379	7/15/2010			41	57						
380	7/15/2010			0	0						
381	7/15/2010			0	0						
382	7/15/2010			27	37						
383	7/15/2010			8	11						
384	7/15/2010			0	0						
385	7/15/2010			37	52						
386	7/15/2010			79	110						
387	7/15/2010			83	117						
388	7/15/2010	0	0								
389	7/16/2010	0	0								
390	7/16/2010	7	10								
391	7/16/2010	473	662								
392	7/16/2010	56	79								
393	7/16/2010	32	44								
394	7/16/2010					21	30				
395	7/16/2010	11	16								
396	7/16/2010	0	0								

Burn #	Burn Date	Hydro-Fire Est. Min Volume (Barrels)	Hydro-Fire Est. Max Volume (Barrels)	Pyro-Boom Est. Min Volume (Barrels)	Pyro-Boom Est. Max Volume (Barrels)	AMI / 3M Est. Min Volume (Barrels)	AMI / 3M Est. Max Volume (Barrels)	Oil Stop Est. Min Volume (Barrels)	Oil Stop Est. Max Volume (Barrels)	Kepner Est. Min Volume (Barrels)	Kepner Est. Max Volume (Barrels)
397	7/16/2010	11	15								
398	7/16/2010	1	1								
399	7/16/2010	16	23								
400	7/16/2010					63	89				
401	7/16/2010			0	0						
402	7/16/2010			0	0						
403	7/16/2010	82	115								
404	7/16/2010	55	78								
405	7/16/2010			0	0						
406	7/16/2010	13	18								
407	7/16/2010			8	12						
408	7/16/2010					50	70				
409	7/17/2010			0	0						
410	7/19/2010	106	148								
411	7/19/2010			0	0						
Total		101932	139661	16088	22745	103591	144890	34	84	422	591
Systems Deployed		**27**	**27**	**13**	**13**	**37**	**37**	**3**	**3**	**2**	**2**
Barrels/ System		**3,775**	**5,173**	**1,238**	**1,750**	**2,800**	**3,916**	**11**	**28**	**211**	**296**

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