# AC 2011-884: GULF COAST OIL SPILL INSTRUCTION AT TUSKEGEE UNIVERSITY

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# Gulf Coast Oil Spill Instruction at Tuskegee University


## Abstract

On April 20, 2010 one of the greatest natural disasters in America began. An offshore drilling rig, the Deepwater Horizon, exploded and began to release an estimated 200,000 gallons per day of oil into the Gulf of Mexico. A disaster of this magnitude necessitates classroom emphasis in order to educate engineering students in the areas of safety and the environment. In response to this educational exigency, Tuskegee University College of Engineering and Physical Sciences incorporated content from the oil spill into an introductory chemical engineering course required for all chemical engineering students and an engineering ethics course required for all engineering students. Based on anecdotal and statistical evidence, both activities increased student awareness of the safety and environmental issues associated with the spill.


## Introduction

The 2010 Gulf Coast oil spill was one of the worst environmental disasters in American history. The incident began with an offshore drilling rig, the Deepwater Horizon. According to Transocean's website[1], the Deepwater Horizon was built in 2001 in South Korea and was designed to operate in water up to 8,000 feet deep, drill 5 ½ miles down, and accommodate a crew of 130. It floated on pontoons and was moored to the sea floor by several large anchors. The rig, which was under contract to the oil giant BP, was doing exploratory drilling but was not in production. At the time of the accident, seventy-nine Transocean workers, six BP employees and 41 contract workers were aboard.

During March and early April, several platform workers and supervisors expressed concerns with well control. On April 20, 2010, high pressure methane gas from the well ignited and exploded. Most of the workers were evacuated by lifeboats or were airlifted out by helicopter, but eleven workers died in the explosion. Efforts by multiple ships to douse the flames were unsuccessful. After burning for approximately 36 hours, the *Deepwater Horizon* sank on the morning of April 22, 2010[2]. The explosion killed 11 platform workers, injured 17 others and began a devastating oil spill into the Gulf of Mexico.

On July 15, the leak was stopped by capping the gushing wellhead after releasing approximately 4.9 million barrels of crude oil. It was estimated that 53,000 barrels per day escaped from the well just before it was capped. It is believed that the daily flow rate diminished over time, starting at about 62,000 barrels per day and decreasing as the reservoir of hydrocarbons feeding the gusher was gradually depleted. On September 19, the relief well process was successfully completed and the federal government declared the well "effectively dead." An estimated 140 million gallons, approximately 4.9 million barrels, were dispersed into the Gulf of Mexico.

Throughout the summer of 2010, the oil spill was a topic of discussion within the Tuskegee University (TU) College of Engineering and Physical Sciences (CEPS). At the

start of the fall semester, it was concluded that content related to the oil spill would be developed for relevant engineering courses. Two courses were identified to include oil spill content for fall 2010: Introduction to Chemical Engineering (CENG 0110) a freshman level course and Engineering, Ethics and Society (AENG 0390, CENG 0390, EENG 0390 and MENG 0390) a sophomore/junior level course.

## Introduction to Chemical Engineering Activity

The department of chemical engineering at TU offers an introductory course (CENG 0110) to freshman. It is a one credit hour course offered once per week for two hours. The purpose of the course is to introduce chemical engineering students to the profession early in their academic careers. The course includes content ranging from information about chemical engineering career opportunities to simple chemical engineering calculations. One component of the multi-faceted course is the discussion of pertinent current events. The Gulf Coast Oil Spill was deemed the highest priority current event and discussed during the Fall 2010 semester. It is also planned to be discussed during the Spring 2011 semester.

For the oil spill assignment, CENG 0110 students were asked to develop a three minute presentation focused on one of the following six topics: timeline, root causes, methods for control/containment, environmental impact, economic impact and chemical engineers' roles in the oil spill. All students were provided with one article to aid with understanding the root causes for the spill.[3] Eighteen students were enrolled in the course, thus three students presented on each of the six topics. It is the professor's opinion that the students performed exceptionally to be freshman. They used appropriate sources for information and had a good command of Microsoft Powerpoint for preparing presentations.

All the students and the professor evaluated each student presentation. The students were instructed to grade each other on a scale of 0 to 10, but to try to keep the first few presentations within the range of 4 to 7 because the scores could ultimately be scaled by the professor if the best or worst presentations came first. The average raw score for the presentations was $6.5 \pm 1.2$ ($2\sigma$). The students with the highest scores presented on the environmental impact (7.5), methods for control/containment (7.2) and economic impact (7.1). Based on anecdotal evidence alone (i.e. the professor's perception), the students struggled with "identifying chemical engineers' roles" and were not excited about discussing the timeline. However, the average scores for the six topics given in Table 1 suggest that "root causes" may have been the most difficult topic.

In addition to the evaluation of their presentations, CENG 0110 students were administered a pre-activity assessment to determine their knowledge of the Gulf Coast oil spill. They were given the same assessment after the activity to determine if their scores improved. The questions asked are given in Appendix A. For the eighteen students assessed, the average pre-activity score was 2.8/7.0 and the average post activity score was 4.5/7.0. Based on a paired sample t test analysis,[4] the increase was significant at the 0.025 level.

**Table 1: Average Student Presentation Scores per Topic**

| Topic | Average Student Score (0 to 10) |
|---|---|
| Timeline | 6.8 |
| Root Causes | 6.3 |
| Methods for Control/Containment | 6.7 |
| Environmental Impact | 6.8 |
| Economic Impact | 6.7 |
| Chemical Engineers' Roles | 6.5 |

## Engineering Ethics Activity

The College of Engineering and Physical Sciences at Tuskegee University offers a course entitled "Engineering, Ethics and Society". This is a three credit course that is offered once a week for three hours every semester and is a required course for all engineering students (chemical, aerospace science, electrical and mechanical engineering). This course acquaints students with (1) the nature of engineering ethics; (2) engineering activities in a societal context; and (3) contemporary issues in the engineering profession. Moral complexities in the engineering profession are highlighted through exposure to historical development, ethical reasoning, risk assessment, effects on the environment and global issues. Workplace responsibilities and professional codes of ethics are also discussed. The course is taught through a series of presentations by experts from industry (engineers, attorneys and businessmen), faculty from engineering disciplines and other programs on campus. The course content is divided into two parts: principles of engineering ethics and real world case studies.

Topics under the principles of engineering ethics include:

1. Engineering and moral complexity
2. Moral reasoning, technology, values and society
3. Commitment to safety, risk and product reliability
4. Engineering as a social experiment
5. Workplace rights and responsibilities
6. Environmental ethics

In the second part of the course real world case studies are discussed. Typical cases related to chemical engineering that have been studied in the past include:

1. The chemical disaster at Bhopal India
2. Dow Corning breast implants
3. Environmental clean-up and problems with the superfund

The Deepwater Horizon disaster on April 20, 2010 is an interesting case for an ethics course. It was included for the fall 2010 semester and is planned to be included for the spring 2011 semester. The case study includes the description of the accident and the sequence of events that caused the explosion, a brief history of safety violations at BP

and other companies involved, and the role of government. This case is presented in Appendix B.

For the assignment, students were required to study the case and determine the main reason(s) for the Deep Water Horizon disaster. Students were provided with the following potential list:

- Company's greed (BP)
- Lack of oversight from government
- Company's work environment
- Not paying attention to heath and safety regulations
- Lobbying efforts by the company
- Transocean company
- Halliburton company

The results from the students in the first semester were mixed.

- Most students cited BP as the company responsible for the disaster. They argued that the safety records of BP show that the company does not care about the environment or the health and safety of workers. They argued that greed was the root cause for the disaster.
- Some of the students cited that all three companies (BP, Transocean and Halliburton) were equally responsible for the accident. They argued that Transocean provided the drilling rig, *Deepwater Horizon*, and the personnel to operate it. Transocean was solely responsible for operation of the drilling rig and for operations safety. Halliburton was responsible for and provided technical advice as to the design, modeling, placement and testing of the cement that was pumped into place behind the casing string and in the shoe track to isolate the hydrocarbon.
- A few students indicated that the government's lack of oversight was the main cause of the accident. They argued that government officials were too friendly with the companies involved and simply rubber stamped all the activities of the companies.

## Summary

Educational content related to the Gulf Coast oil spill was included in both the introduction to chemical engineering course and the engineering ethics course in the College of Engineering and Physical Sciences at Tuskegee University. In the chemical engineering course, students investigated a particular topic related to the oil spill and presented findings individually in class. Pre and post activity assessments revealed that the students' knowledge of the oil spill increased significantly as a result of the activity. In the engineering ethics course, students reviewed the facts related to the oil spill and identified the root causes for the disaster. Although most students identified BP as the root cause, some felt that all three companies involved and the government held equal responsibility.

## References


1. Transocean's Website http://www.deepwater.com

2. The Encyclopedia of Earth Website http://eoearth.org/article/Deepwater_Horizon_oil_spill

3. "Failure of Rig's Last Line of Defense Tied to Myriad Factors," *The New York Times*, June 20, 2010.

4. R. A. Johnson, *Miller and Freund's Probability and Statistics for Engineers*, 5th Edition, Prentice Hall, Englewood Cliffs, New Jersey, 1994, pp. 259-260.

5. United States Department of Labor, OSHA website, http://osha.gov/dep/bp/pb.html

# Appendix A - BP Oil Spill Assessment for CENG 0110

**Instructions: Circle the correct answer**

1. Approximately when did the BP oil spill start?
    a. February 2010
    b. March 2010
    c. April 2010
    d. May 2010
    e. June 2010
    f. July 2010
    g. August 2010
2. What body of water was most affected by the oil spill?
    a. The Pacific Ocean
    b. The Gulf of Mexico
    c. The Mississippi River
    d. The Atlantic Ocean
    e. The Great Lakes
3. What was the last line of defense to make sure that oil never leaked from the well in case of an emergency?
    a. An underwater pump
    b. a cap over the well
    c. cement in the well
    d. the blind shear ram
    e. a turbo rail
4. What do the letters "BP" stand for?
    a. Better Petroleum
    b. Brigham Petroleum
    c. British Petroleum
    d. Bradford Petroleum
    e. Brash Petroleum
5. When was the oil spill stopped?
    a. March 2010
    b. April 2010
    c. May 2010
    d. June 2010
    e. July 2010
    f. August 2010
    g. September 2010
6. Approximately how much oil spilled per day?
    a. 5,000 gal

b. 10,000 gal
c. 50, 000 gal
d. 100,000 gal
e. <u>200,000 gal</u>
f. 1,000,000 gal
g. 2,000,000 gal

7. What is the initial amount for the oil spill fund?
   a. $20M
   b. $200M
   c. $2 Billion
   d. <u>$20 Billion</u>
   e. $200 Billion
   f. $2 Trillion

8. List 2 methods used to control/contain the oil spill.
   a. _____
   b. _____

❖ The correct answer is underlined. For question 5, two answers are underlined because, after administration, the professor deemed the question subject to interpretation. It could not be re-worded for the post-test because it would compromise the pre/post test comparison.

# Appendix B - Background Information for the Engineering Ethics Case Study

## 1. Safety Records of BP [5]

### 1.1- Refinery Explosion in Texas City

After a 2005 BP refinery explosion in Texas City, Texas that killed 15 people and injured 180, a Justice Department investigation found that the explosion was caused by "improperly released vapor and liquid." Several procedures required by the Clean Air Act to reduce the possibility of just such an explosion either were not followed or had not been established in the first place

### 1.2- Four additional fatalities at Texas City Refinery

There have been four additional fatal incidents at the Texas City refinery since the 2005 explosion. One worker was crushed between a lift and a pipe rack, another was electrocuted while working on a light circuit, a third was killed when the top blew off a pressure vessel, and a fourth was hit by a front-end loader.

### 1.3- Incidents at Alaska Operations

The 2000 Prudhoe Bay pipeline spill was blamed on a corroded pipeline.

### 1.4- Storage Tank in California

In 2002 the firm was found to be falsifying inspections of fuel storage tanks in California. They settled a lawsuit by the South Coast Air Quality Management District for $100 million.

### 1.5- Toledo Refinery

OSHA safety fines levied on the Toledo refinery in 2005

### 1.6- Environmental Laws

In the last five years, investigators found BP has admitted to breaking U.S. environmental and safety laws and committing outright fraud. BP paid $373 million in fines to avoid prosecution.

## 2. Working Environment at BP

- Fear of reprisal
- A pattern of the company intimidating workers who raised safety or environmental concerns

- Managers shaved maintenance costs by using aging equipment for as long as possible
- Many managers are penalized for too many incident reports being filed, creating pressure on them and their workers to not report.

## 3. Spill flow rate

In their permit to drill the well, BP estimated the worst case flow at 162,000 barrels per day (25,800 $m^3$/d). Immediately after the explosion BP and the United States Coast Guard did not estimate any oil leaking from the sunken rig or from the well. On April 24, the Coast Guard announced that a damaged wellhead was indeed leaking. It was stated that "the leak was a new discovery but could have begun when the offshore platform sank two days after the initial explosion. Initial estimates by the Coast Guard and BP officials, based on remotely operated vehicles as well as the oil slick size, indicated the leak was as much as 1,000 barrels per day (160 $m^3$/d). Outside scientists quickly produced higher estimates, which presaged later increases in official numbers. Official estimates increased from 1,000 to 5,000 barrels per day (160 to 790 $m^3$/d) on April 29, to 12,000 to 19,000 barrels per day (1,900 to 3,000 $m^3$/d) on May 27, to 25,000 to 30,000 barrels per day (4,000 to 4,800 $m^3$/d) on June 10, and to between 35,000 and 60,000 barrels per day (5,600 and 9,500 $m^3$/d), on June 15. Internal BP documents, released by Congress, estimated the flow could be as much as 100,000 barrels per day (16,000 $m^3$/d), if the blowout preventer and wellhead were removed and if restrictions were incorrectly modeled.

## 4. Causes of Explosion

Attention has focused on the cementing procedure and the blowout preventer, which failed to fully engage.

- There was a leak in the hydraulic system that provides power to the shear rams
- The blowout preventer schematic drawings, provided by Transocean to BP, do not correspond to the structure that is on the ocean bottom.
- A leak was spotted on a crucial piece of equipment in the oil rig's blowout preventer weeks before the accident, and Transocean and BP were contacted about it.
- Managers misread pressure data and gave their approval for rig workers to replace drilling fluid in the well with seawater, which was not heavy enough to prevent gas that had been leaking into the well from firing up the pipe to the rig, causing the explosion.
- An engineer with BP, team leader overseeing the project, ignored warnings about weaknesses in cement outside the well which could have prevented the gas from escaping.

## 5. Consequences

- Environmental Damage - Oil Spills Damage Beaches, Marshlands and Fragile Marine Ecosystems
- Oil Spills Kill Birds
- Oil Spills Kill Marine Mammals
- Oil Spills Kill Fish
- Oil Spills Destroy Wildlife Habitat and Breeding Grounds
- Health consequences

## 6. Role of Government

- The Interior Department exempted BP's drilling operation from a detailed environmental impact analysis last year, according to government documents, after three reviews of the area concluded that a massive oil spill was unlikely.

- The Interior Department never did an analysis that took into account what turns out to be the very real possibility of a serious spill.

- In one assessment, the agency estimated that "a large oil spill" from a platform would not exceed a total of 1,500 barrels and that a "deepwater spill," occurring "offshore of the inner Continental shelf," would not reach the coast.

- In another assessment, it defined the most likely large spill as totalling 4,600 barrels and forecast that it would largely dissipate within 10 days and would be unlikely to make landfall.

- The agency's oversight role has devolved to little more than rubber-stamping British Petroleum's drilling plans.

## 7. Role of Halliburton

The blow out occurred shortly after Halliburton completed an operation to reinforce drilling hole casing with concrete slurry. This is a sensitive process that, according to government experts, can trigger catastrophic blowouts if not performed attentively. According to the Minerals Management Service, 18 of 39 blowouts in the Gulf of Mexico since 1996 were attributed to poor workmanship injecting cement around the metal pipe. Halliburton is currently under investigation by the Australian government for a massive blowout in the Timor Sea in 2005 caused by its faulty application of concrete casing.

## 8. Role of Transocean

A key instrument failed during the well blowout, causing the worst oil spill in U.S. history. One Transocean employee said Transocean failed to comply with recertification maintenance rules for the Deepwater Horizon's blowout preventer: According to his testimony, the rig's blowout preventer, designed to shut off the well in case of an emergency, was four years overdue for major maintenance. When the accident occurred, the blowout preventer failed to work, which led directly to the massive oil spill.

Transocean claims the Deepwater Horizon's blowout preventer underwent extensive inspections and maintenance on a regular basis, including an inspection that morning. But a BP executive told the panel the blowout preventer had been modified in 2004 and 2005, which made early efforts to shut the well down ineffective, because its plumbing was different from what the response team had on its books, an assertion Transocean refutes.