

Name:

Enrolment No:



UNIVERSITY WITH A PURPOSE

**UNIVERSITY OF PETROLEUM & ENERGY STUDIES**

**End Semester Examination (Online) – July, 2020**

**Program: MBA (OG) & MBA (ET)**

**Subject/Course: Energy & Utilities (Program Elective)**

**Course Code: OGET 7006**

**Semester: 2<sup>nd</sup>**

**Max. Marks: 100**

**Duration: 3 Hours**

**IMPORTANT INSTRUCTIONS**

1. The student must write his/her name and enrolment no. in the space designated above.
2. The questions have to be answered in this MS Word document.
3. After attempting the questions in this document, the student has to upload this MS Word document on Blackboard.

		Marks	COs
Q.1	(a) Provide a comparative analysis of Pipeline and Tanker Trucks as mode of transport for petroleum products while clearly highlighting the advantages of Pipelines	10	CO2,3
	(b) Home Area Networks create big savings for its stakeholders. Analyze the Savings for a Utility as a Stakeholder to HAN.	10	CO1,2
Q.2	A CGD network supplies natural gas for domestic, Industrial, commercial PNG and CNG for Transport use. In this regard, discuss the potential benefits of Natural gas usage through CGD Network.	20	CO3,4
Refer the case of McKee Refinery's Propane Deasphalting Unit and answer the following questions:			
Q.3	(a) What was the main cause of the fire at McKee Refinery's Propane Deasphalting Unit?	10	CO1,2,3,4
	(b) Conduct a HAZOP Study on the PDA Unit of the refinery.	10	
Q.4	"Fireproofing would have given firefighters more time to respond before the fire grew out of control." Comment on the lack of adequate firefighting protection at the McKee Refinery.	20	
Q.5	(a) Explain any three HAZOP and HAZID lessons learnt from the McKee Refinery PDA accident.	10	
	(b) Could the fire be avoided if HAZID was done? If yes, how?	10	

**ANSWERS**

## **Case of McKee Refinery's Propane Deasphalting Unit**

February 16, 2007: Propane gas leaked from the McKee Refinery's Propane Deasphalting Unit in Sunray, Texas. As winds carried the vapor cloud, a spark ignited the propane and the entire cloud burst into flames. The fire spread quickly, forcing an evacuation of the refinery as firefighters battled the blaze. Three workers suffered serious burns and the refinery was shut down for two months. Gas prices increased 9 cents per gallon in the west.

### **BACKGROUND**

#### **Industrial Overview**

Shamrock Oil and Gas built the McKee Refinery outside Sunray, Texas in 1933. The refinery underwent major modifications in the 1950s and 1990s. Valero acquired the refinery in 2001 and further upgraded it in 2004. By 2005, Valero was the largest refiner in North America, with eighteen refineries producing 3.3 million barrels per day. The McKee Refinery contributed about 170,000 barrels per day to Valero's overall production

#### **PROPANE DEASPHALTING (PDA) UNIT**

One part of the refinery is the Propane Deasphalting (PDA) Unit, where high-pressure propane serves as a solvent to recover fuel and asphalt from crude oil residues. In 1992, the refinery shut down a control station in the PDA unit. Rather than remove the idle subsection, or isolate it with slip blinds, the refinery simply closed the six-inch valves around this section. This configuration created a "dead-leg" of pipes that had nothing flowing through them. Normally, these pipes would be empty. However, a foreign object blocked one of the valve seats, preventing it from sealing completely. Over the fifteen years that the control station was out of service, water entrained in the propane passed through the jammed valve and settled in the low point of the supposedly empty dead-leg. Unlike piping that was in use, the dead-leg was not insulated or heat-traced to prevent freezing, leaving it vulnerable to low temperatures.

#### **WHAT HAPPENED?**

In February 2007, a four-day cold front froze the water in the dead-leg pipe, causing it to expand, and crack the pipe. Ice blocked the crack and prevented any propane from exiting. When the ice thawed, propane could escape through the crack. On February 16, the cold front passed and the ice began to melt. As the ice melted, propane began spewing from the cracked pipe at approximately 4,500 pounds per minute.

Workers reported hearing a pop and noticed a vapor cloud spewing from the PDA unit. They initially thought a steam line had ruptured but soon realized the potential for significant danger. Wind carried the propane cloud toward a boiler house, where it likely found the spark that ignited the entire cloud. Immediately, flames shot back to the source of the propane leak in the PDA unit. The fire alarm sounded as flames attacked nearby piping and, as the pipes carrying liquid propane failed, the fire ferociously consumed their contents. A high-pressure jet of flaming propane launched itself at a steel column supporting a pipe rack filled with petroleum products. This steel column did not have fireproofing and it collapsed under the flames within minutes. The pipes broke and the fire intensified as it fed more propane.

Firefighters tried to combat the fire from the South, but the wind blew and shifted, forcing the firefighters to find another attack position. The fire blocked access to manual valves that could help isolate flames, and operators could not isolate propane flow remotely because prescribed remotely operated shut-off valves (ROSOV's) had not been installed. Emergency managers ordered a total refinery evacuation 15 minutes after the fire ignited. Too many pressurized pipes had ruptured, and responders actually worked near vessels containing liquid propane that were engulfed in flames and at risk of failing. They sounded the evacuation alarm and shut down the refinery as responders isolated the main feeds and gas supplies.

Later, emergency response teams reentered the refinery to isolate fuel sources and gradually control the fire. Valero planned to reenter and extinguish the fire the next day, but chlorine and sulfuric acid leaks prevented them and it was not until February 17, a day later, that Valero personnel finally extinguished the fire.

### **PROXIMATE CAUSE**

Freezing water cracked a pipe that had been unused for fifteen years. Propane gas leaked through the crack, forming a vapor cloud. A single spark, probably from the boiler room, ignited the gas and the fire flashed back through the propane cloud.

### **UNDERLYING ISSUES**

#### **DEAD-LEG NOT DISCOVERED**

There was no record that the refinery conducted a formal management of change review when the control station was taken out of service. The change consisted of shutting the valves surrounding the control station. Operators did not remove the idle portion or isolate it with slip blinds. When Valero acquired the refinery in 2001, the dead-leg had been in place for almost ten years. Without a formal written program to identify, review and freeze-protect dead-legs and other infrequently used piping, Valero personnel did not recognize the presence of a dead-leg in the control station and never addressed the freezing hazard. The pipes remained unused, without freeze protection, and imperfectly isolated from the functioning unit.

#### **PROCESS HAZARD ANALYSIS (PHA)**

##### **FINDING ERRONEOUSLY CLOSED BEFORE COMPLETION**

Refinery operators could not cut off the fuel for the fire because remotely operable shutoff valves (ROSOVs) had not been installed. The fire prevented them from reaching the shutoff valves in the unit itself. A 1996 Process Hazard Analysis (PHA) by the previous owner identified the need for ROSOVs in the PDA. Although the valves were never installed, the action item was checked complete. The 2006 Valero PHA revalidation did not revisit earlier findings or apply Valero's ROSOV standard, so the revalidation did not uncover the missing valves.

The refinery did not violate any official standards, but the missing valves violated Valero's requirements. While the American Petroleum Institute (API) does not offer specific guidance for ROSOV design or location, Valero's corporate policy requires ROSOVs for installations such as the PDA.

#### **INADEQUATE FIRE PROTECTION STANDARDS**

Valero covered steel supports within thirty feet of potential fire sources with fire-resistant insulation to keep the steel cool and delay structural failure. The columns within a thirty foot radius of the PDA unit that had been fireproofed remained standing after the fire, but an unprotected pipe bridge 77 feet away collapsed. Even though the pipe bridge was outside the radius for required fireproofing, a loss-prevention report listed the rack as a “top priority” for the fireproofing program. Unfortunately, the rack had not been fireproofed by February 2007. Fireproofing would have given firefighters more time to respond before the fire grew out of control. The McKee Refinery fireproofed beyond both the American Petroleum Institute’s recommendations and Valero’s corporate policies, but the fire’s size exceeded industry expectations. The mishap investigation found that neither API’s recommendations nor Valero’s fireproofing standards specified sufficient protective distances.

### **AFTERMATH**

Three workers at the refinery suffered serious burns; one member of the fire brigade suffered minor burns. Ten people were treated for minor injuries. The refinery was shut down for approximately two months and operated at reduced capacity for one year. The losses were greater than fifty million dollars and Valero received three OSHA citations