The BP Texas City Refinery Explosion: An Actor-Network Theory Based Analysis of the Effects of the BP and Amoco Merger in 1998

STS Research Paper
Presented to the Faculty of the
School of Engineering and Applied Science
University of Virginia

By

Madison Stone

April 10, 2024

On my honor as a university student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

ADVISOR

Benjamin J. Laugelli, Assistant Professor, Department of Engineering and Society

Introduction

Risk Based Process Safety (RBPS) is a management system created by the Center for Chemical Process Safety (CCPS) in 2007, aiming to support process safety by improving upon past CCPS and OSHA process safety management (PSM) systems (Center for Chemical Process Safety, 2022). While it is not regulatory, RBPS inherently shares all the elements of the U.S. OSHA PSM system, including incident investigation or learning from experience (Center for Chemical Process Safety, 2022). The vapor cloud explosion at the BP Texas City refinery on March 23, 2005, is a heavily analyzed process safety incident due to the involvement of several kinds of issues, with most authors accrediting the incident to a combination of human error, technical inadequacies, and safety culture issues. However, the incident is also unique in that the Texas City refinery was owned by Amoco just a few years before the incident occurred, prior to the BP and Amoco merger in 1998 (U.S. Chemical Safety and Hazard Investigation Board, 2007). Many of the current analyses on the BP Texas City refinery incident do not focus on the important influence of the effects of the change in refinery ownership. Thus, throughout this paper, I will show how the company merger directly weakened the role of several, already damaged parts of the Texas City refinery. I will focus my analysis on the culminating effects of the economic decisions made by BP executives following the BP and Amoco merger and how they all led to the refinery's failure. I will examine the company merger through the process of translation, as defined by the Science, Technology, and Society (STS) framework, Actor-Network Theory (ANT), and how the BP executives failed at a specific stage in the process. ANT is particularly useful for this case, as it distinguishes itself from other sociotechnical approaches by considering both human and non-human elements equally as actors within a network (Cressman, 2009).

Background

The massive explosion at the BP Texas City refinery occurred on March 23, 2005, resulting in 15 fatalities, 180 injuries, and it being classified it as one of the most catastrophic industrial accidents in U.S. history (Lees, 2012). The disaster involved the restarting of the refinery's ISOM process unit after turnaround maintenance (Lees, 2012). The ISOM unit, which aims to provide higher octane components for unleaded gasoline, consists of several individual pieces of equipment, and the incident began as the raffinate splitter was overfilled with liquid hydrocarbons during the startup (U.S. Chemical Safety and Hazard Investigation Board, 2007, Lees, 2012). The tower was overfilled due to the blocked flow of liquid leaving the tower, where the automatic control valve was left closed for several hours (U.S. Chemical Safety and Hazard Investigation Board, 2007). Operators eventually became concerned with the lack of flow out of the tower and opened the control valve a total of five times, however, the level inside the tower continued to rise due to the rapid heating of the column (Lees, 2012). The liquid swelled until it flowed into the overhead vapor line, activating three safety relief valves which were designed to prevent column overpressure by directing flow of primarily vapor to a blowdown drum and stack (U.S. Chemical Safety and Hazard Investigation Board, 2007). Approximately 196,000 L of liquid overfilled the blowdown drum, resulting in a huge flammable vapor cloud that soon found an ignition source (Lees, 2012).

Literature Review

There exists a plethora of academic publications that examine the incident at the BP refinery in Texas City. These sources generally settle on several factors contributing to the incident, including human error and safety culture issues. While the BP Texas City incident is

almost never explained by just one key issue, the influence of BP's acquisition of Amoco prior to the incident is often left out or vaguely mentioned during the discussion of other factors.

In "Human factors analysis of the BP Texas City refinery explosion," Cheryl MacKenzie and others identify several pre-existing latent conditions that affected unit operators' decisions on the day of the incident. In one example, the authors carry out a thorough depiction of the insufficient staffing during start up, a process condition that requires significantly more manual control and therefore increases the operator's workload. The staff budget cuts made in years prior are highlighted, however it was left ambiguous why such cuts were made. In other words, the impact of BP's acquisition of Amoco is once again alluded to through the discussion of other initiating factors.

The authors of "Texas City refinery accident: Case study in breakdown of defense-in-depth and violation of the safety-diagnosability principle in design" identify other important "accident pathogens," or pre-existing adverse conditions at the Texas City refinery, in addition to human actors. Such conditions include design flaws and maintenance shortcomings, trailer siting, and poor safety practices. Combining the aforementioned issues, Joseph Saleh and others conclude that at the time of the incident the Texas City refinery violated the safety-diagnosability principle, an idea that requires various features be put in place to monitor for a breach of any safety barrier. In other words, the paper solely relates a weak safety culture to the plant's technical issues, failing to consider how the change in refinery ownership may have assisted a weak safety culture in causing the incident.

While the papers described above certainly add meaningful analyses to the library of publications on the BP Texas City explosion, they both fail to consider the role that BP's acquisition of the Texas City refinery, and Amoco more generally, played in the event. In the

coming sections, I will describe how the BP and Amoco merger lead to the Texas City explosion through social issues that arose due to the acquisition and inherited technical issues associated with the plant.

Conceptual Framework

The science, technology, and society (STS) framework that will be utilized to analyze the explosion at the BP Texas City refinery is Actor-Network Theory (ANT). ANT is especially useful in this case, as exemplified through the literature review above. More specifically, ANT distinguishes itself from other sociotechnical approaches by considering both human and non-human elements equally as actors within a network (Cressman, 2009). Large-scale technological innovations, such as the Texas City refinery, are the function of the interaction of heterogeneous elements, or actors, as such elements are shaped and assimilated into a network (Law, 1987). To that end, Michel Callon, one of the first writers to use the term "Actor-Network Theory," attests that an actor network is "simultaneously an actor whose activity is networking heterogenous elements and a network that is able to redefine and transform what it is made of."

The process of forming and maintaining an actor network is explained through the ANT concept of "translation." Overall, translation is the process by which the identity of actors, the possibility of interaction, and the margins of maneuver are negotiated and delimited (Callon, 1984). Callon further describes the translation process as occurring in four steps, including problematization, interessement, enrolment, and mobilization. Focusing on just the first three steps, a network builder first identifies a problem or goal and the heterogenous actors needed to solve it. The network builder also establishes itself as an obligatory passage point (OPP), rendering them indispensable in the network (Haiza Muhammad Zawawi, 2018). However, the OPP is not achieved until all actors are convinced that the alliance can satisfy their needs (Haiza

Muhammad Zawawi, 2018). Thus, the next step, interessement, involves recruitment, where the network builder attempts to impose and stabilize the identity of the relevant actors through its problematization (Callon, 1984). Indeed, actors may "refuse the transaction by defining its identity (…) in another manner" (Callon, 1984). The network builder must successfully translate the interests of the actors to serve those of the network. After interessement is enrolment, where the network builder assigns an official set of interrelated roles to the chosen actors, and the actors accept them (Callon, 1984). The network builder assigns roles such that all actors are successfully associated together and the network functions well (Callon, 1984).

The explosion at the BP refinery in Texas City is an excellent illustration of how an actor network that was once considered to be a "black box" became vulnerable over time and eventually failed. In the following sections, I will show that the BP and Amoco merger can be viewed through the ANT concept of translation, thus attributing the failure of the Texas City refinery actor network to decisions made at certain steps in the translation process.

Analysis

The Texas City Refinery as an Actor Network

Upon the BP and Amoco merger, BP executives overtook their Amoco counterparts as the network builders of the Texas City refinery with a general goal of operating the plant in a profitable manner. BP executives thus had to undergo the process of translation, ensuring that all the relevant actors were recruited, assigned roles, and associated together such that the goal of the overall network was reached. With the refinery already well established, it can be assumed that to some extent, all the relevant actors were already recruited by the former owners of the refinery. Therefore, BP executives started the translation process at the enrolment stage, where the BP executives were responsible for assigning roles to actors and ensuring that roles allowed

for each actor to be successfully associated together. Such an idea has already been realized by Jack Philley in "Potential impacts to process safety management from mergers, acquisitions, downsizing, and re-engineering," where he writes, "If company A acquires an older plant from company B that has higher risk levels, it will take some time to upgrade the old plant up to the standards of the new owner."

Figure 1 depicts a general visualization of the Texas City actor network, with not all actors being represented. The network is organized in such a way that the BP executives act as an OPP as defined above. With each "tier" giving purpose to the actors below it, BP executives are indispensable, where the eventual goal, to make product, cannot ever be achieved if they were to be removed from the network. In effect, the actors in each "tier" in Figure 1 must work together to perform the roles that were assigned to them by the network builders. For example, plant managers must work alongside the ideas that come from the safety culture and regulatory agencies to ensure that operations work with the materials needed in a safe, productive, and legal manner. Furthermore, as network builders, the BP executives were responsible for assigning official roles and relationships such that the network is successful. Figure 1 illustrates the direct connections formed, where the transactions work downward. In other words, the BP executives exemplify a safety-oriented culture, hire plant managers, and show compliance with regulatory agencies, such as OSHA and the EPA. Then, the ideas associated with safety culture are

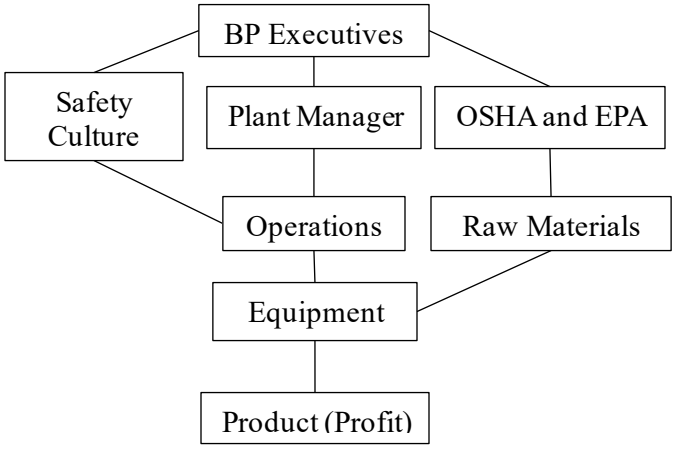

Figure 1. An example of the BP Texas City refinery actor network

represented and performed by operations staff, who are also hired by the plant manager, and OSHA and the EPA pass regulations concerning refinery materials. With each line, the overall goal of the BP executives as network builders is enforced, representing the final stage of translation (Callon, 1984). However, BP executives failed to fully perform their role as network builders and successfully associate all the actors in the network through certain economic decisions. More specifically, in 1999, BP cut all fixed costs by 25%, resulting in plant-wide staffing reductions and a decrease in maintenance expenditures, among other things (U.S. Chemical Safety and Hazard Investigation Board, 2007). Overall, in their final investigation report, the U.S. Chemical Safety and Hazard Identification Board (CSB) found that "BP audits, reviews, and correspondence shows that budget-cutting and inadequate spending had impacted process safety at the Texas City refinery." The remainder of this paper will aim to illustrate that the preference of BP's executives towards profitability following the BP and Amoco merger lead the Texas City refinery actor network to fail by progressively weakening the relationships between other important actors.

Profit Valued over Operations

An assessment made in January 2005, just two months before the incident, informed BP management that at the production level, plant personnel felt that one major cause of accidents at the Texas City facility was understaffing (U.S. Chemical Safety and Hazard Investigation Board, 2007). Indeed, on the day of the explosion at the Texas City refinery, the ISOM unit was understaffed for the task of unit startup, with one board operator in charge of monitoring three process units, including the startup of the ISOM raffinate section (U.S. Chemical Safety and Hazard Investigation Board, 2007). In addition to a startup being an abnormal process condition that requires significantly more manual control, an action item in the years preceding the incident

stated, “Extend the requirement to have two board operators for any planed startup or shutdown activities (…)” (U.S. Chemical Safety and Hazard Investigation Board, 2007). The 25% cut in fixed costs in 1999 was the first of many budget cuts that ignored requests for increased staffing. Thus, as BP executives took over as network builders, they valued profit over operations, assigning profit a more important role than operations. However, actors only have meaning in the context of networks, and importance is a function of the strength of the bonds among all actors in a network (Law, 1987). Through the perpetual budget cuts, BP executives decreased the purpose of operations in the network, harming their direct connections which are a symbol of their primary role in the network. Indeed, the Day Board Operator, who was monitoring the ISOM unit when the incident occurred, had worked 12-hour shifts for 29 consecutive days, likely resulting in fatigue, acute sleep loss, and cumulative sleep debt (U.S. Chemical Safety and Hazard Investigation Board, 2007). The CSB used a methodology to assess operator fatigue in accidents and concluded that fatigue was a likely contributing factor (U.S. Chemical Safety and Hazard Investigation Board, 2007).

While the progressive weakening of operations’ role in the BP Texas City refinery actor network did have a significant role in the incident, the state of operations was already vulnerable before the BP and Amoco merger, and BP executives failed to utilize such knowledge when assigning operations’ official role in the network during enrolment. Indeed, in their final investigation report, the CSB identified a 1996 Amoco staffing assessment of all units in the refinery that stated, “Personnel are concerned that under a minimum staffing scenario they would be unable to manage historic upsets.” Therefore, BP executives failed to realize the damaged nature of operations and upon assignment in the network, they hindered the importance of operations until the network collapsed. The influence of the economic decisions made by BP

executives during the enrolment stage of translation are shown in Figure 2. "Product and profit" is outlined in green because they were given influence by BP executives, and "operations" is outlined in red because it was negatively impacted by the preference for profit. Furthermore, Figure 2 shows the propagation of the weakening of the operations' purpose though dashed connections.

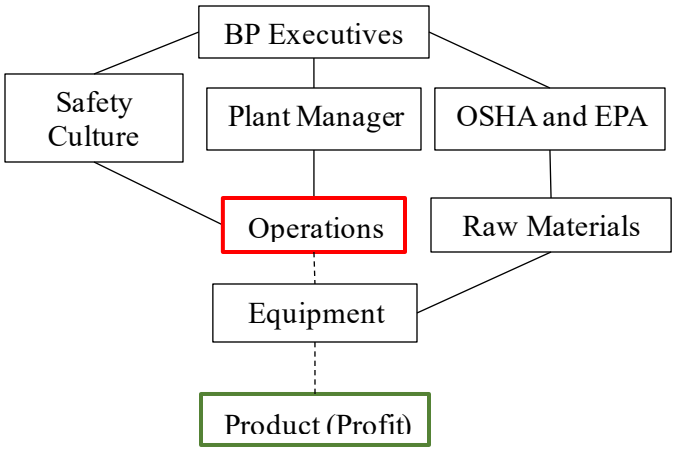

Figure 2. The effects of the power of product over operations in the Texas City refinery actor network

Profit Valued over Equipment

Assisting the understaffed, fatigued members of operations in the failure of the network was the weakened role of equipment assigned by the BP executives after repeated cuts in maintenance expenditures, among other equipment-related costs (U.S. Chemical Safety and Hazard Investigation Board, 2007). In 2002, a senior BP executive warned that ageing infrastructure at Texas City was "in complete decline," with the CSB identifying that budget cuts impairing process safety performance at the Texas City refinery was one of the root causes of its failure (Clark, 2007). During the startup on the day of the incident, the lack of attention to the state of equipment was culminated into a series of technical issues, including the level transmitter indicating that the liquid level in the tower was gradually declining, even though it was actually rising, leading to the eventual release of material and explosion (U.S. Chemical Safety and Hazard Investigation Board, 2007). Overall, it is seen that BP executives contributed

to the decline of process equipment at the Texas City refinery by forcing continuous cuts in capital and maintenance costs (U.S. Chemical Safety and Hazard Investigation Board, 2007).

Furthermore, the BP executives failed to realize how susceptible certain equipment was to failure upon becoming the network builders. More specifically, the design of the blowdown system was unsafe, leading to at least eight serious incidents from 1994 to 2004 (Lees, 2012). Despite the 15 years of proposals to remove blowdown stacks that vent directly to the atmosphere at the Texas City refinery, no changes were made due to cost considerations (U.S. Chemical Safety and Hazard Investigation Board, 2007). Thus, the failure of the network was sealed when BP executives assigned the official role and purpose of equipment as an actor. The BP executives inadequately evaluated the state of the refinery's technical components upon becoming the network builders, and continually weakened its purpose until the eventual collapse of the network.

I have shown that through the power instilled into the idea of profitability by the BP executives as network builders, the purpose and relationships of various actors weakened, leading to the failure of the Texas City refinery actor network. However, the literature review presented before highlights that there are many who analyze the BP Texas City refinery incident and accredit it to a weak safety culture present at all levels in BP. The infamous "Baker Panel" provided recommendations to "improve BP's corporate safety culture (…)" after the incident, including a call on BP's executive management to provide effective leadership on and establish appropriate goals for process safety (Baker et. al, 2007). While this paper does not aim to discount the influence of the lack of consideration towards safety present within the entire company, it does attempt to illustrate how the safety culture, or lack thereof, instituted by the BP executives as network builders was just one factor that led to the incident in Texas City. More

specifically, the ideas of the BP executives are materialized through the relationships of each actor in the network, and if safety is given a role of less importance, then the purposes of the subsequent actors will be less influenced by it. For example, it has been well documented that operations personnel often deviated from procedure, and did so on the day of the incident by initially filling the drum above the procedural level, showing a lack of respect for the hazards and the procedures put in place to protect personnel from such hazards (U.S. Chemical Safety and Hazard Investigation Board, 2007). Thus, BP executives displayed an incompetent safety culture, and its influence upon operations worked in conjunction with the relationships already weakened by the BP and Amoco merger to eventually cause the actor network to collapse.

Conclusion

Overall, I have argued that the explosion at the BP Texas City refinery was influenced by failures of the BP executives as network builders by framing the 1998 BP and Amoco merger in terms of the Actor-Network Theory concept of translation. More specifically, I provided evidence that showed how the continuous budget cuts made by BP executives soon after the acquisition of Amoco progressively weakened the purpose of other actors, ultimately leading to the actor network's failure. Furthermore, I utilized evidence from when Amoco owned the Texas City refinery to show that there were already vulnerabilities within the actor network, and BP executives failed to account for them when assigning official roles in the network. Thus, I have shown how the company merger directly weakened the role of several, already damaged parts of the Texas City refinery by examining the implications of the decisions of the BP executives upon becoming network builders. This analysis highlights for readers the shift in risk that can occur during mergers, especially how policy changes such as cost-cutting strategies can have severe safety implications (Philley, 2002).

References

Callon, M. (1984). Some elements of a sociology of translation: Domestication of the scallops and the fishermen of St Brieuc Bay. *The Sociological Review*, *32*(1), 196-233. Sage Journals. https://doi.org/10.1111/j.1467-954X.1984.tb00113.x

Center for Chemical Process Safety. (2022). Risk based process safety. In *Process safety for engineers: An introduction* (2nd ed., pp. 15-35). John Wiley & Sons, Incorporated.

Clark, A. (2007, March 20). *US safety report slams BP over Texas City disaster*. The Guardian. Retrieved March 3, 2024, from https://www.theguardian.com/business/2007/mar/20/oilandpetrol.news

Cressman, D. (2009). *A brief overview of Actor-Network Theory: Punctualization, heterogeneous engineering & translation*. ACT Lab/Centre for Policy Research on Science & Technology (CPROST), School of Communication, Simon Fraser University. https://summit.sfu.ca/item/13593

Haiza Muhammad Zawawi, N. (2018). Actor-Network Theory and inter-organizational management control. *International Journal of Business and Society*, *19*, 219-234. https://www.ijbs.unimas.my/images/repository/pdf/Vol19-S2-paper3.pdf

Law, J. (1987). On the social expansion of technical change: The case of the Portuguese maritime expansion. *Technology and Culture*, *28*(2), 227-252. http://www.jstor.org/stable/3105566?origin=JSTOR-pdf

Lees, F. (2012). BP America refinery explosion, Texas City, Texas, USA. In *Lees' loss prevention in the process industries: Hazard identification, assessment and control* (4th ed., pp. 3079-3086). Elsevier Science.

MacKenzie, C., Holmstrom, D., & Kaszniak, M. (2007). Human factors analysis of the BP Texas City refinery explosion. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *51*(20), 1444-1448. https://doi.org/10.1177/154193120705102015

Philley, J. (2002). Potential impacts to process safety management from mergers, acquisitions, downsizing, and re-engineering. *Process Safety Progress*, *21*(2), 151-160. https://doi.org/10.1002/prs.680210212

Saleh, J. H., Haga, R. A., Favaro, F. M., & Bakolas, E. (2014). Texas City refinery accident: Case study in breakdown of defense-in-depth and violation of the safety-diagnosability principle in design. *Engineering Failure Analysis*, *36*, 121-133. ScienceDirect. https://doi.org/10.1016/j.engfailanal.2013.09.014

Baker III, J. A., Bowman, F. L., Erwin, G., Gorton, S., Hendershot, D., Leveson, N., Priest, S., Rosenthal, I., Tebo, P., Wiegmann, D., & Wilson, L. D. (2007). *Baker Panel Report*. The BP U.S. Refineries Independent Safety Review Panel. https://www.csb.gov/assets/1/20/Baker_panel_report1.pdf?13842

U.S. Chemical Safety and Hazard Identification Board. (2007). *BP Texas City: Final investigation report*. https://www.csb.gov/file.aspx?DocumentId=5596