Tesoro Anacortes refinery explosion: who should be held accountable?

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

By

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March 19, 2021

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.

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INTRODUCTION

On April 2nd, 2010, a heat exchanger at the Tesoro petroleum refinery in Anacortes, Washington catastrophically ruptured, causing a severe explosion that fatally injured seven employees working in the area. It was later determined that the cause of the rupture was a phenomenon known as high temperature hydrogen attack (HTHA), in which hydrogen reacted with carbon atoms present in the carbon steel of the heat exchanger to weaken the structure (Aldridge et al., 2014). Independent investigations into the incident have fully identified root causes of the rupture, and blame has been placed on Tesoro through an inconclusive federal prosecution (Stayton, 2014). Although the causal nature of the incident has been well defined, there has been no attempt at a systematic approach of determining how the hazard was able to develop or who should be held morally accountable. Terminating at root cause analysis and pointing fingers fails to justifiably assign any moral accountability for the incident, removes an opportunity for closure of the affected families, and fails to consider any deep-seated safety problems within the refining industry.

I argue that The American Petroleum Institute (API) should be held morally accountable for the Tesoro Anacortes refinery incident over Tesoro because only they satisfy all of Van de Poel's responsibility criteria, which are wrong-doing, causal contribution, foreseeability, and freedom of action (van de Poel & Royakkers, 2011). While analyzing a comprehensive investigation report from the Chemical Safety Board (CSB), I will draw upon Actor-Network Theory to characterize the Tesoro Anacortes refinery network. I will then systematically analyze both the API's and Tesoro's contributions to the incident under the lens of the responsibility criteria to show who is morally responsible.

BACKGROUND

The Anacortes refinery was originally built in 1955 by the Shell Oil company until it was purchased by the Tesoro Refining and Marketing Company in 1998 (*A Short History of Tesoro's Anacortes Refinery*, 2014). To effectively recycle heat at the plant, the heat exchangers at the refinery's Naphtha Hydrotreater Unit (NHT) use hot reactor effluent from the hydrotreater to preheat a combined liquid naphtha and hydrogen rich vapor feed. These heat exchangers were composed of carbon steel prior to the incident. High temperature hydrogen attack (HTHA) is a phenomenon by which hydrogen diffuses into structural steels to react with carbon, which produces large methane vapor bubbles that become trapped in the metal. As more methane is produced, the bubbles grow larger to form "blisters", then "microcracks", and finally, cracks that greatly weaken the steel. Structural steels are particularly susceptible to HTHA at high operating temperatures and hydrogen partial pressures (Aldridge et al., 2014). Included in a recommended practice by the American Petroleum Institute known as API RP 941 *Steels for Hydrogen Service at Elevated Temperatures and Pressures in Petroleum Refineries and Petrochemical Plants* is a graph containing Nelson curves that help inform industry of operating conditions that are considered safe against HTHA for steel alloys (*API RP 941, 8th Edition*, 2016). The Nelson curves were developed in 1949 based solely off of industry experience with HTHA incidents (Silfies et al., 2016). Tesoro also follows a risk based process safety program heavily influenced by *API RP 581 Risk Based Inspection Technology* (Aldridge et al., 2014; *API RP 581, 3rd Edition*, 2016).

LITERATURE REVIEW

Many scholars have analyzed the root causes of the Anacortes incident to show where process safety programs need improvement and where process safety program development frameworks have utility. These analyses ultimately aim to improve process safety programs by suggesting alterations to the way that companies think about their process safety programs. These arguments still fail to consider the development of root causes and do not adequately discuss which parties to the incident should be held accountable.

In *The Pitfalls of Risk Based Inspection: an Insurer's View of the Chevron Richmond and Tesoro Anacortes Incidents,* Clarke begins by highlighting the importance of risk based inspection (RBI) programs for process safety. Clarke continues to address some of the common challenges with RBI programs in the context of both the Anacortes incident and the Chevron Richmond refinery incident, stating that in both incidents "decisions were made that the risks were acceptable when in fact they were not." Clarke then draws upon the Anacortes incident to make recommendations regarding the basis for sound RBI programs. He states that low risk plant areas must be assessed more frequently, and that RBI processes need to be constantly improved when new safety information comes to light. Clarke takes no systematic approach to assign responsibility for the incident, opting to simply highlight Tesoro's process safety failures and to suggest that "standards were partially to blame" (Clarke, 2016).

In *Analysis of Safety Culture Weaknesses in Chemical Safety Board Investigation Reports*, Uno builds upon the work of Clarke by organizing the RBI challenges he described into deficiencies of Risk Based Process Safety (RBPS) guidelines. Uno starts by explaining the background behind six different major process safety incidents investigated by the Chemical

Safety Board (CSB), including the Tesoro Anacortes explosion. Uno continues to mention that the CSB began identifying deficiencies in safety culture after their 2007 report on the BP Texas City refinery explosion. During the same year, an organization known as the Center for Chemical Process Safety (CCPS) included safety culture in their newly published RBPS guidelines. Uno presents the RBPS guidelines falling under categories such as to “maintain a dependable practice” and to “develop and implement a sound culture.” Uno continues to classify organizational root-causes for the Anacortes incident into deficiencies of the RBPS guidelines, including “establish and enforce high standards of performance”, “maintain a sense of vulnerability”, and “provide timely response to process safety issues and concerns” (Uno, 2021). Uno only aims to show the utility of RBPS guidelines for development of adequate process safety programs and again fails to comment on the moral responsibility of Tesoro or any other parties to the incident. While building off of root-cause analysis to make recommendations for risk based safety programs and to show the utility of process safety frameworks aims to prevent similar incidents from occurring, there is also value in systematically attempting to assign moral accountability for the incident.

CONCEPTUAL FRAMEWORK

Before I question the moral accountability of pertinent groups involved in the Anacortes incident, I will draw upon Actor-Network theory to understand the interplay between these groups, their respective contributions to the incident, and the technical conditions that enabled the incident. This will allow me to systematically apply Van de Poel’s responsibility criteria in an informed way to Tesoro and the API to determine which of the groups can be held morally accountable for the incident. According to John Law, an Actor-Network is “a combination of social and technical engineering in an environment filled with indifferent or overtly hostile physical and social actors (Law, 1987)." Consequently, Actor-Network Theory (ANT) seeks to identify and characterize a network builder who recruits both non-human and human actors to accomplish a specific goal.

The process by which actors are assembled to form and stabilize a network is known as translation. ANT stipulates that actors only have meaning in relation to one another, and that any actor within a network can be broken into its own sub-network. Actors can be both allies or adversaries in the network, and it is entirely possible that actors originally recruited to achieve the network goal later become "rogue actors" that destabilize and potentially dissolve the network (Cressman, 2009).

Van de Poel's discussion of responsibility in engineering highlights the difficulty of assigning responsibility for the outcomes of an engineering project to specific individuals in the event of collective participation. This challenge is known as the problem of many hands, where if the collective were considered a single entity, they could reasonably be held accountable for the outcome unlike any individuals that make up that collective. Van de Poel also postulates that there are four criteria that can be evaluated to determine if an individual is morally responsible for an outcome: (1) wrong-doing; (2) causal contribution; (3) foreseeability; (4) freedom of action. In order for an individual to be held accountable for an outcome, they must satisfy all four of these criteria. Van de Poel further stipulates that given the problem of many hands, these criteria can also be applied to the collective and sub-groups within the collective to identify where moral responsibility lies (van de Poel & Royakkers, 2011). In the following analysis, Actor-Network Theory will be used to describe how the Anacortes refinery network was "translated". Following, van de Poel's responsibility criteria will be applied systematically to evidence from the CSB investigation report along with ANT characterization of rogue actors.

ANALYSIS

Actor-Network Theory Translation

In the context of Actor-Network Theory (ANT), the "builder" of the Tesoro Anacortes refinery is the Tesoro Refining and Marketing Company, who developed the network to achieve their goal of refining petroleum into profitable products with low cost and risk. Tesoro senior leaders recruited multiple non-human and human actors to accomplish this goal. An example of a non-human actor would be the physical equipment of the Anacortes refinery, which was previously owned by the Shell Oil Company, such as the Naphtha Hydrotreater Unit (NHT). Tesoro also brought their own safety culture to the network, a risk-based process safety program, and recruited human actors to serve as managers, operators, and other site-personnel. To ensure the stability of the Tesoro Anacortes refinery network from a safety standpoint, Tesoro recruited Shell Oil's previous process hazard analyses (PHAs), external subject matter experts, PSM specialists from the Washington State Department of Labor and Industries (L&I), and recommended practices (RP) from the American Petroleum Institute (API) (Aldridge et al., 2014).

Wrong-doing:

Van de Poel's wrong-doing criterion is satisfied when an individual, subgroup, or overall group does something that is considered wrong and violates norms (van de Poel & Royakkers, 2011). I argue that both Tesoro and the API engaged in multiple "wrong" behaviors that satisfy this criterion, moving them a step closer to responsibility. The Chemical Safety Board's (CSB) investigation found that Tesoro did not opt to substitute the dated carbon steel heat exchanger left behind by Shell Oil with inherently safer materials of construction or use post-weld heat treatment (PWHT) even though this was known to make steels more resistant to HTHA. A 2009 incident report cited that during start up, the heat exchangers at the NHT unit "leaked substantially" to the point where the leaks became "steady streams". The incident was not treated as a severe process safety incident, and these dangerous leakages became a normalized occurrence. Tesoro failed to address these leakages during their regular process hazard analyses (PHA) – instead, they relied on additional operators to mitigate the leakages with steam lances (Aldridge et al., 2014).

These facts show that Tesoro violated a norm in the sense that management had an insufficient commitment to process safety and valued inexpensive and easy solutions to plant issues. Additionally, startup of the heat exchangers is considered a non-routine hazardous operation (Aldridge et al., 2014). According to the Center for Chemical Process Safety (CCPS) , from 1970 to 1989 60-75% of all major accidents in continuous processes like refining occurred during non-routine operation (*Guidelines for Hazard Evaluation Procedures, 3rd Edition*, 2008). Tesoro management's willingness to station additional operators by the heat exchangers during this non-routine operation without addressing additional risk constitutes moral wrong-doing that endangered human lives.

According to the CSB, Tesoro's corrosion PHA's from 2001 and 2006 did not challenge the improper assumptions of Shell Oil's previous 1996 corrosion PHA, and in their 2006 PHA, Tesoro opted to remove a mechanical integrity checklist because it was "not a legal requirement" (Aldridge et al., 2014). This is morally wrong in the sense that Tesoro opted to do only what was legally required of them rather than what maximized the safety of its employees. Something to note is that van de Poel's responsibility criteria do not stipulate that the wrong-doing itself *must* have been deliberate (van de Poel & Royakkers, 2011). Rather than monitoring the internal temperatures and partial pressures of the heat exchangers, which would assist with HTHA identification, Tesoro relied only on measurements of the inlet and outlet stream conditions because this was not a definitive recommendation under API RP 581 (Aldridge et al., 2014; *API RP 581, 3rd Edition*, 2016). The CSB found that damage mechanism hazard reviews (DMHRs) conducted over 20 years had wrongly assumed that HTHA-inhibiting stainless steel cladding was present in all sections of the heat exchanger (Aldridge et al., 2014) when only one section was covered. This evidence highlights unintentional wrong-doing that if avoided could have led to Tesoro performing more adequate evaluation of HTHA hazards.

The American Petroleum Institute also satisfies the wrong-doing criteria in multiple ways. As previously mentioned, the refining industry relies on API RP 941 for choosing materials of construction and operating conditions where HTHA is a possibility. At the time of the incident, API RP 941 contained no minimum requirements for HTHA susceptibility evaluations, no requirements for the use of inherently safer materials, and no requirement for industry to verify actual process operating conditions. Furthermore, the Nelson curves of API RP 941 are based off of self-reported data from industry where HTHA was observed. For submittance of this data, the API only requested average and maximum process temperature and a single value of hydrogen partial pressure, which does not adequately characterize the conditions under which HTHA occurred. The CSB found that the API provided inadequate instructions for reporting HTHA damage, that the reports did not need to consider equipment age, and that the data in the reports may not have been representative of the true operating conditions of failed equipment. Additionally, consequences of HTHA incidents were not required to be reported, which overlooked the severity of previous HTHA incidents (Aldridge et al., 2014). This evidence shows that the API either formulated API RP 941 with negligence or that they downplayed the importance of the recommended practice and the potential consequences of HTHA, which violates safety norms.

API Technical Report (TR) 941 even acknowledged that the API found it "difficult to obtain accurate operating data and material damage assessments" and goes on to state that "we are still far from being able to make quantitative predictions about the behavior of steels subject to HTHA" (*API TR 941-A*, 2008). HTHA susceptibility has a more complex dependence on process variables, and the Nelson curves do not account for the role that variables such as weld type, stress, and asset lifetime play (Aldridge et al., 2014). This implies violation of norms from API on the account that they published and updated API RP 941 without an adequate understanding of how to predict HTHA susceptibility and made little to no effort to develop accurate experimental data, instead relying on 61 years of self-reported industry incidents. Additionally, API RP 581, which informed risk based inspection programs, failed to state that risk should be based upon actual process conditions rather than design conditions (Aldridge et al., 2014).

These factors combined led to an inaccurate Nelson curve and Tesoro's assumption that the heat exchanger was of low susceptibility to HTHA (Aldridge et al., 2014). According to Silfies et al., there were several cases of HTHA occurring in non-PWHT steel below the carbon steel Nelson curve that had been reported beginning 2008, prior to the Anacortes incident in 2010 (Silfies et al., 2016). The CSB found that similar HTHA damage in non-PWHT steel had occurred at the Exxon Mobil, Valero, Shell Oil, and ConocoPhillips refineries (Aldridge et al., 2014). The API failed to act upon this knowledge in time, releasing an industry wide alert on the matter in 2011 and later updating the Nelson curves for non-PWHT carbon steel in the 8th edition of API RP 941 in 2016 (Aldridge et al., 2014; Silfies et al., 2016). This implies that the API violated societal norms by underestimating the underlying severity of the issue of these HTHA incidents. Overall, Tesoro's inadequate PHAs and lack of safety culture and the API's negligent approach to formulating and updating important HTHA data in API RP 941 and 581 constitute wrong-doing in line with van de Poel's philosophy on moral responsibility.

<u>Causal Contribution</u>

Van de Poel's causal contribution criterion is satisfied when an individual, subgroup, or overall group's wrong-doing was necessary for the incident to occur (van de Poel & Royakkers, 2011). Using ANT for utility, I will show how both Tesoro and the API satisfy this criterion such that they are closer to moral responsibility. Multiple actors from both Tesoro and the API that were originally recruited to the Tesoro Anacortes refinery network later became adversarial – these so called "rogue" actors are directly responsible for the destabilization of the Tesoro Anacortes refinery network attributed with the heat exchanger explosion. Most noticeably, the network was destabilized due to the carbon steel construction of heat exchanger E - Tesoro's choice to continue the use of cheap carbon steel for the heat exchanger unknowingly allowed for HTHA to occur and most directly lead to the rupture and explosion. Additionally, heat exchanger E was constructed using non-PWHT welds, which lead to high stress within the carbon steel that assisted with HTHA (Aldridge et al., 2014).

Tesoro also relied on the Nelson curves of API RP 941 to justify that their process was of low HTHA risk and based their risk based inspection program on API RP 581. Because of the aforementioned problems with the API recommended practices, Tesoro believed that they were running their heat exchangers under safe operating conditions and consequently, did little to inspect for HTHA or consider the phenomenon during PHAs. This allowed HTHA to slip through the cracks of Tesoro's risk based safety program, which enabled the eventual rupture of heat exchanger E. A less obvious rogue actor that caused the incident to be more catastrophic was Tesoro's normalization of leaks and fires from the heat exchanger. While utilizing extra operators to mitigate seemingly insignificant deviations was easy and inexpensive, this led to additional operators being present at heat exchanger E when it ruptured, leading to more fatalities (Aldridge et al., 2014). In summary, there is a clear causal relationship between the wrong-doings of both Tesoro and the API and the Tesoro Anacortes refinery explosion.

Foreseeability

The foreseeability criterion of Van de Poel is satisfied when an individual, subgroup, or overall group was aware of both the problems that lead to an incident and the potential consequences (van de Poel & Royakkers, 2011). This is where I believe Tesoro and the API differ; Tesoro could not have feasibly known about the HTHA problems in their heat exchanger while they API could have, ultimately lending to the moral responsibility of the API for the incident. First, Tesoro could not have known that their operating conditions were unsafe because they were relying on the inaccurate industry standard API RP 941. According to simulations from the CSB, the portion of heat exchanger E that ruptured never operated above the carbon steel Nelson curve, so even if Tesoro had appropriate temperature and pressure sensing equipment along the heat exchanger, they would not have had a reason to suspect HTHA to occur. Next, the CSB cites that it is very difficult to inspect for HTHA because damage might not be detected before an incident. This is because "(the damage) can be microscopic and may be present only in small, localized areas of the equipment." The CSB notes that HTHA identification is highly dependent on the skill of the inspector and that at the time, there were few with the necessary expertise (Aldridge et al., 2014). This fact means that it would have been extremely difficult for Tesoro to know of the HTHA problem before the incident occurred, excusing them from satisfaction of the foreseeability criteria.

According to the API, their standards represent "the industry's collective wisdom on everything from drill bits to environmental protection and embrace proven, sound engineering, operating practices, and safe interchangeable equipment and materials (*About API*, n.d.)." However, in light of HTHA incidents occurring in non-PWHT steel that were reported before the Anacortes incident, the API failed to warn of the issue. It is my belief that this fact satisfies the portion of the foreseeability criteria related to knowledge of the problem. Because the API understood the mechanism of HTHA and its potential to severely weaken structural steels, I also find it likely that at least one member of the experienced API subcommittees had the imagination to envision a fatal loss of containment (LOC) incident caused by HTHA. Other fatal refining accidents that happened before Anacortes, like the Texas City Refinery explosion that left 180 injured and 15 dead, resulted from LOC of flammable hydrocarbons, and while the mechanisms may have been different, the consequences were similar (*Investigation Report - Refinery Explosion and Fire*, 2007). Consequently, I believe that the API as a collective feasibly knew of the HTHA problem and the potential consequences, thus satisfying Van de Poel's foreseeability criteria.

<u>Freedom of Action</u>

The freedom of action criterion of Van de Poel is satisfied when an individual, subgroup, or overall group was able to act without compulsion (van de Poel & Royakkers, 2011). Tesoro influences the safety of its own refineries through the employees it hires, equipment it chooses, and the standards and regulations it adheres to. It follows that even with the possibility of internal disagreement regarding process safety and safety culture, Tesoro as a collective was did not negatively influence this incident out of compulsion. The API influences safety in the refining industry by publishing, editing, and advocating for its recommended practices. Because the API had sufficiently enhanced safety in the refining industry prior to the incident, and because ensuring the safety of the refining industry is arguably the API's top priority, I believe that the API subcommittees as a collective were not forced to act out of compulsion. Accordingly, I believe that Tesoro and the API both satisfy the freedom of action criteria. Because the API is the only group that satisfied all four criteria, they can be held morally accountable according to van de Poel (van de Poel & Royakkers, 2011).

Tesoro and the API were both able to influence the safety of the Anacortes refinery freely because of their respective power as large organizations. Because API standards are developed by "subcommittees and task groups comprised of industry experts", one might argue that the subcommittees responsible for the development of API RP 941 and 581 could have been split on deciding how to deal with the knowledge of HTHA incidents in non-PWHT carbon steel (*Standards Committees*, n.d.). This would imply that the subcommittees responsible were actually unable to act without compulsion because there was not total agreement on what to do in light of new HTHA reports. According to van de Poel, this becomes a problem of many hands; individuals who may have lacked the ability to act freely because they were overruled by a majority viewpoint may not satisfy the freedom of action criteria, but the committees as collectives do satisfy the criteria (van de Poel & Royakkers, 2011).

CONCLUSION

By analyzing the role each group played and systematically applying the responsibility criteria, I found that the American Petroleum Institute (API) satisfies the criteria of wrong-doing, causal contribution, foreseeability, and freedom of action, whereas Tesoro fails to satisfy the foreseeability criteria. Because of this, I believe that the API, not Tesoro, should be held accountable for this tragic incident. This research is important because it shows the utility of using moral responsibility frameworks to assign responsibility for engineering disasters, gives a greater insight into why the Anacortes incident occurred, and offers a definitive opinion on who should be held accountable so that the industry can move a step closer to providing closure for the victims of the incident.

Word Count: 3960

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