Thermal Sciences

Exponent®

Investigation of the December 22, 2018 MHF Unloading Incident at the Torrance Refinery

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Prepared for

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Contents

Acronyms and Abbreviations

AES	Acid Evacuation System
AHO	Alkylation Unit Head Operator
API	American Petroleum Institute
DMR	Damage Mechanism Review
HazMat	Hazardous Materials
HCA	Hierarchy of Hazard Control Analysis
HF	Hydrofluoric Acid
MHF	Modified Hydrofluoric Acid
MOC	Management of Change
LAC	Los Angeles County
LOPC	Loss of Primary Containment
P&ID	Piping and Instrumentation Diagram
PHA	Process Hazard Analysis
PMI	Positive Material Investigation
PSM	Process Safety Management
SSA	Shift Safety Advisor
SPA	Safeguard Protection Analysis
TFB	Torrance Fire Brigade
TFD	Torrance Fire Department
TORC	Torrance Refining Company LLC

1 Limitations

At the request of Torrance Refining Company LLC (TORC), Exponent, with the assistance of TORC personnel, conducted an investigation of the December 22, 2018 unloading incident where a small quantity of MHF was released shortly after the MHF unloading process was initiated. There were no offsite or onsite effects.

The scope of services performed during this investigation may not adequately address the needs of other users of this report, and any re-use of this report or its findings, conclusions, or recommendations presented herein are at the sole risk of the user. The opinions and comments formulated during this assessment are based on observations and information available at the time of the investigation. No guarantee or warranty as to future life or performance of any reviewed condition is expressed or implied.

2 Background

2.1 Introduction

Approximately four to six times per month, TORC's MHF Alkylation Unit receives a Modified Hydrofluoric Acid (MHF) delivery from a Honeywell tanker truck. The MHF is transferred from the Honeywell tanker truck to the MHF Alkylation Unit's storage vessel 5C-31, which is located behind a reinforced concrete blast wall in the Acid Evacuation System (AES) area. The MHF is transferred by pressurizing the delivery tanker truck with nitrogen. Unless unloading is taking place, the unloading header is unpressurized and filled with nitrogen.

On December 22, 2018, TORC received an MHF delivery from Honeywell. After completing pre-unloading checks and shortly after initiating the unloading from the Honeywell tanker truck to the unloading header, at approximately 8:00 AM, the Alkylation Unit Head Operator (AHO) observed a dripping release occurring from the bottom portion of the MHF unloading header. As soon as the AHO observed the release, the AHO directed the Honeywell drivers to stop the unloading process from the tanker trunk, and applied water mitigation using a firehose. Due to the positioning of the AHO at the start of the truck unloading, he did not initially observe the MHF release at the bottom portion of the unloading header. Review of refinery video indicates that the time between the MHF release beginning and the isolation of the unloading header and application of water mitigation was approximately 24 seconds.

While continuing water mitigation, the AHO attempted to stop the release through use of the valves on the unloading header. When these attempts were unsuccessful, the Shift Safety Advisor (SSA) was notified. The SSA then immediately notified Torrance Fire Department (TFD), and began assembling Torrance Refinery Fire Brigade (TFB) personnel. While this was occurring, the AHO was directing additional water mitigation from elevated and ground-level water cannons. The MHF release was stopped shortly after 11:00 AM. There were no injuries, personnel exposure, or onsite or offsite impacts, other than a delay in the MHF delivery.

2.2 Investigation Team

The incident investigation was initiated by TORC on December 23, 2018 at approximately 5:00 PM.

Exponent was retained by TORC to assist in the investigation into the incident as a third party. With specific focus into the Process Safety Management (Title 8 California Code of Regulations (CCR) §5189.1, CalPSM) and California Accidental Release Prevention Program 4 regulations (Title 19 CCR §§ 2762.0.1 et seq., CalARP Program 4) of the incident, and the quantity released.

The investigation team consisted of both Exponent and TORC members. For Exponent, the team members included engineers with specialization in mechanical engineering, fluid mechanics, process safety, and metallurgy. For TORC, the team included the PSM Supervisor, USW Representatives, a Process Safety Representative, a Materials and Corrosion Engineer, and a member of the refinery's Joint Health and Safety Committee.

2.3 Root Cause Methodology

The investigation team applied the ABS Consulting SOURCE incident investigation techniques (ABS methodology), which is the methodology that TORC uses for incident investigations. The basic steps of the ABS methodology are:

(1) Gathering all data relevant to the investigation;
(2) Developing causal factors using a systematic method based on the data;
(3) Determining root cause of each causal factor; and
(4) Developing recommendations directly relating to causal factors and the incident sequence.

2.4 Materials Reviewed, Inspections, Analyses, and Testing

The Process Hazard Analysis (PHA) for the MHF Alkylation Unit (Unit 5 PHA December 22, 2017) was reviewed as part of the incident investigation. However, the only potentially relevant recommendation related to the incident from the PHA was that a Damage Mechanism Review

(DMR) be completed for the unit. At the time of incident, the DMR for the unit had not yet been completed.[1]

With respect to Safeguard Protection Analyses (SPAs) and Hierarchy of Hazard Control Analysis (HCAs), the SPA and HCA that were conducted as part of the MHF Alkylation Unit PHA were reviewed by the incident investigation and determined not to be relevant to the incident.

In addition to conducting an inspection of the MHF unloading header and area, Exponent reviewed information listed in Attachment A, including P&IDs, Inspection Reports, Operating and Emergency procedures for MHF truck offloading, video and audio recordings of the incident. In addition, Exponent also performed laboratory examination and testing of the subject 1" nipple, flange, and valve.

[1] The DMR for the Alkylation Unit was completed on April 23, 2019. Note that the P&ID error discussed further below would not have been identified and/or corrected through the DMR process. The intent of the DMR is not to review P&IDs in detail, but to identify potential damage mechanisms to piping and vessels based on equipment operations and process materials.

3 Incident Overview and Timeline

On December 22, 2018, shortly after initiating the unloading of Modified Hydrofluoric Acid (MHF) from a Honeywell tanker truck into the Torrance Refinery's MHF Alkylation Unit's MHF unloading header, there was a Loss of Primary Containment (LOPC) and a small release of MHF occurred from a 1" nipple on the unloading header.

Within seconds of the release beginning, it was observed by the Alkylation Unit Head Operator (AHO). The Alkylation Unit Head Operator (AHO) stopped the MHF unloading from the tanker truck and began to apply water mitigation. During the incident, an estimated 1.27 gallons of MHF (10.8 lb.) was released from a 1" nipple on the bottom portion of MHF unloading header and mitigated with water.

There were no injuries or personnel exposure associated with this incident, no offsite impacts, and no onsite effects or impacts other than a delay in unloading the MHF from the tanker truck. The release of 10.8 lb. of MHF is below the API RP 754 threshold for a Tier 2 event.

Substance and Quantity Released:

A conservative upper-bound estimate on the quantity of MHF released during the incident is 10.8 pounds, between 08:02:10 AM and 11:15:06 AM. This release was mitigated through the use of water, and there were no readings that indicated that MHF left the refinery.

Agency Notification and Response:

- Torrance Fire Department (TFD)
- Los Angeles County Hazardous Materials (LAC HazMat) Unit
- South Coast Air Quality Management District

Incident Timeline[2]:

- 8:02:10 AM – MHF release began
- 8:02:20AM to 8:02:50 AM – AHO notices MHF release from bottom portion on the MHF unloading header, tanker truck isolated, and water mitigation applied to release
- 8:15 AM –AHO asks for a TFB response; TFD notified
- 8:16 AM – Additional water mitigation applied to MHF release
- 8:21 AM – TFD arrives
- 11:15 AM – MHF release stopped
- 11:22 AM – Water mitigation stopped; Draeger sample confirms no MHF reading from 1" nipple
- 11:24 AM – All clear announced
- 11:26 AM – LAC Health HazMat arrives

Emergency Response Actions:

The AHO immediately isolated the tanker truck from the MHF unloading header and began to apply water mitigation. During the release, additional water mitigation was applied, and TFB was notified. TFB notified TFD and began to assemble TORC Emergency Response personnel. TFD responded, notified LAC HazMat and AQMD, and set up perimeter monitoring including LAC HazMat[3]. TORC Emergency Response personnel suited up in HazMat Level A Suits, ensured secondary isolation of the MHF unloading header, and evacuated the header.

Meteorological Conditions Recorded at Torrance Refinery:

- At 8:00 AM, ToRC recorded: 51.8ºF, 99% rH, and calm winds
- At 8:02 AM, ToRC recorded: 51.8ºF, 100% rH, winds of 1.5 mph from 285 degrees
- At 9:00 AM, ToRC recorded: 53.5ºF, 99% rH, winds of 4.1 mph from 360 degrees

[2] Based on personnel interviews and review of video and radio recordings.

[3] Neither TFD nor LAC HazMat detected any airborne HF either at the command post at 4th and Trapper in the refinery or along Crenshaw between 190th Street and Del Amo Boulevard. In addition TFD and LAC Hazmat tested the pH of the mitigation water (impounded onsite) and found a neutral pH..

- At 10:00 AM, ToRC recorded: 56.2ºF, 100% rH, winds of 2.6 mph from 360 degrees
- At 11:00 AM, ToRC recorded: 60.7ºF, 82% rH, winds of 4.3 mph from 245 degrees

Meteorological Conditions Recorded at Torrance Airport:

- At 7:50 AM, Torrance Airport recorded: 51.8ºF, 100% rH, and calm winds.
- At 10:55 AM, Torrance Airport recorded: 57.8ºF, 93% rH, and calm winds.

Injuries or Illnesses:

None.

Offsite Impact:

None.

Onsite Effects:

Delay in unloading MHF tanker.

4 Root Cause Analysis

4.1 Overview

The direct cause of the release was corrosion at the threads of a carbon steel 1" nipple located at the bottom portion on the MHF unloading header. Between no later than 2009 and early 2016, the 1" nipple had been made of Monel. However, the P&ID indicated that the 1" nipple should be carbon steel, and a carbon steel nipple was ordered and installed by ExxonMobil when the nipple was replaced between late 2015 and early 2016[4]. Because the nipple ordered was consistent with the P&ID, and therefore was believed to be a like-for-like replacement, no Management of Change (MOC) was issued for using a carbon steel nipple.

The investigation team determined that if the 1" nipple had replaced with the correct alloy (Monel) at this time, this incident would likely not have occurred because Monel does not corrode at the same rate as carbon steel in MHF service. The root cause was an undetected discrepancy between the documents generally used for MHF unloading header inspection and maintenance and the "controlled" governing document (the P&ID). This inaccuracy in the P&ID resulted in a carbon steel nipple being used instead of Monel.

4.2 Discrepancy Between P&ID and Inspection Documents

ExxonMobil's Retro-Positive Materials Inspection (PMI) documents indicate that the 1" nipple was composed of Monel in 2009. Current TORC inspection and engineering documents for the MHF unloading header indicate that the 1" nipple should be composed of Monel. However, since at least 2009, the controlling document, the P&ID, has indicated that the 1" nipple on the upstream side of the valve is of a carbon steel composition. As a result of this inaccuracy in the controlling document (P&ID), ExxonMobil replaced the Monel nipple on the upstream side of the valve with one made from carbon steel when the header piping was replaced between late 2015 and early 2016.

[4] TORC took control of the Torrance Refinery from ExxonMobil on July 1, 2016.

4.3 Root Cause

Using the ABS methodology, one causal factor was identified:

Causal Factor #	Description
CF-1	The ExxonMobil processes and procedures in place from 2009 or earlier through early 2016 did not ensure that an error in the MHF unloading header P&ID, the controlling document, was detected and corrected.

The root cause of the release was the failure under ExxonMobil to ensure that the MHF unloading header P&ID, the controlled document, was consistent with inspection and engineering documents used to identify the proper materials in the field. This resulted in a pipe nipple of carbon steel being ordered and installed between late 2015 and early 2016 where Monel had been used previously.

If ExxonMobil had had a system in place to check the inspection and engineering documents against the controlling P&ID when generated, and to require discrepancies be resolved with input from engineers and metallurgists, then the incorrect designation on the P&ID would have been discovered no later than 2009.

The root cause and its mapping using the ABS methodology is presented below:

Casual Factors	Root Causes and Path Through Root Cause Map	Recommendations
CF#1 – The ExxonMobil processes and procedures in place from 2009 or earlier through early 2016 did not ensure that an error in the MHF unloading header P&ID, the controlling document, was detected and corrected. Background In 2009, under ExxonMobil, a retro-PMI was completed on the MHF Alkylation Unit. The inspection identified that the 1" nipple which had the release on December 22, 2018 was composed of Monel at that time. The controlled P&ID, however, indicated that this small section of piping was composed of carbon steel. This discrepancy was not detected or corrected by ExxonMobil. This created an undetected discrepancy, and when the 1" nipple was replaced in early 2016, A106 carbon steel consistent with the controlled P&ID was used.	Root Cause 1-1 Issue: The 1" nipple that corroded through at the threads was carbon steel as identified on the controlled and controlling P&ID. However, there were other inspection and engineering documents which identified the 1" nipple as Monel. 2: Equipment/Software Issue 7: Process/Manufacturing Equipment Issue 18: Design Issue 19: Design Input Issue 21: Design Input Data Issue 225: Company SPAC Issue 226: No SPAC or Issue Not Addressed in SPAC Reference: Even though inspection and engineering documentation (drawings) existed that identified the proper material for the1" nipple; those documents were not routinely referenced and evaluated against the P&ID. The controlled P&ID used to order the 1" nipple in 2016 had the incorrect materials specification break highlighted on the P&ID. The inspection and engineering documentation for the 1" nipple was inconsistent with the P&ID, but correct.	1.1 Replace failed 1" carbon steel nipple with a Monel 1" nipple 1.2 Update P&ID #05A0141D01 to reflect what is in the field for this section of piping. 1.3 TORC to review all material specification breaks on the MHF Alkylation Unit inspection documents and these specification breaks should be checked against the MHF Alkylation Unit P&IDs' specification breaks and corrected, as necessary 1.4 TORC to develop a standard to provide consistency between Process Safety Information such as P&IDs and material specifications.

5 Conclusions

For this incident, the TORC/Exponent investigation team have determined that:

- The root cause of the LOPC was the failure under ExxonMobil to ensure consistency between the P&ID (controlling document) and the inspection and engineering documents.

- This resulted in the installation of a carbon steel 1" nipple where Monel had previously been used.

- The LOPC occurred due to corrosion of the carbon steel 1" nipple.

- According to the controlled P&ID, since at least 2009, the 1" nipple was supposed to be carbon steel.

- ExxonMobil inspection (Isometrics and PMI) and engineering documents indicated that the 1" nipple had been Monel in the past, at least as early as 2009.

- In early 2016, the 1" nipple, fabricated from A106 carbon steel, was installed in the MHF unloading header, between the main header and a valve to the evacuation system.

- The maximum quantity of MHF released through the 1" nipple was approximately 10.8 pounds. This amount does not consider any credit for water mitigation applied during the incident.

- The effectiveness of water mitigation applied during the incident assisted in preventing any offsite or onsite impacts.

- There were no injuries or personnel exposure.

5.1 Hierarchy of Hazard Control Analysis (HCA)

Pursuant to the Cal PSM and CalARP Program 4 regulations for a major incident, the investigation team also conducted an HCA on recommendations identified in Section 4.3 above. The results of the HCA are presented below:

Final Recommendation				
#	**Recommendation**	**Anticipated Date of Completion**	**Root Cause**	**ISS/HCA Level Strategy**
1	Replace the 1" carbon steel nipple with a 1" Monel nipple.	Completed	1	**Level:** 2nd Order Inherent Safety **Strategy:** Minimize
2	TORC to update P&ID #05A0141D01 to reflect what is in the field for this section of piping.	6/7/2019	1	**Level:** Procedural
3	TORC to review all material specification breaks on the MHF Alkylation Unit inspection documents, check against specification breaks on the MHF Alkylation Unit P&IDs, and correct as necessary.	Walkdown completed. Documentation to be updated by 12/7/2019	1	**Level:** Procedural
4	TORC to develop a standard to provide consistency between Process Safety Information such as P&IDs and material specifications.	11/1/2020	1	**Level:** Procedural

ATTACHMENT A: Materials Reviewed

Interviews

Head Operator	December 27, 2018
Head Operator	January 14, 2019
Assistant Operator 1	January 14, 2019
Assistant Operator 2	January 14, 2019
Console Operator	December 27, 2018
Shift Safety Advisor	December 27, 2018
Truck Driver 1	January 9, 2019
Truck Driver 2	January 9, 2019
Maintenance Personnel 1	December 27, 2018
Maintenance Personnel 2	December 27, 2018

Video Reviewed

Camera 3	5:00 AM to 5:00 PM
Camera 7	5:00 AM to 5:00 PM
Camera 8	5:00 AM to 5:00 PM

Audio Reviewed

Channel 13	6:00 AM to 12:00 PM
Channel 14	6:00 AM to 12:00 PM

Documents Reviewed

MHF Unloading to 5C-31 SOP OP05-005, Rev 25	Revised November 2, 2018
P&ID Unit 05 – Drawing 05A0141D01	Revised October 24, 2017
Basic Alkylation Materials Guideline MM-005-H50, Rev 2	Revised May 5, 2017
Unit 5 PHA and associated SPA and HCA	December 22, 2017
Inspection Isometric Drawings	Various Dates
Positive Material Identification Documents	Various Dates
Torrance Fire Department Incident Report 18-0014853	December 22, 2018