January 16, 2018

Setting the Record Straight

The Truth About Torrance Refinery MHF

Purpose of This Presentation

- **To set the record straight by telling the truth about Torrance Refinery's use of an alkylation catalyst called modified hydrofluoric acid (MHF), which is the newest, commercially viable alkylation technology available**

- **Present facts based on testing, modeling, and research by qualified experts**
  - Correct misinformation in these presentations by the grassroots organization Torrance Refinery Action Alliance - TRAA
    - "The Case Against MHF, -ARF-SRI-and Barriers-" (Jan. 4, 2017)
    - TRAA's feedback to Torrance Fire Department (Feb. 28, 2017)
  - Provide correct information for use in South Coast Air Quality Management District (SCAQMD) 1410 rulemaking process
  - Address community concerns generated by misinformation

- **Provide insights regarding issues raised at public meetings and hearings**

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Chapter 1: Refinery Statement & Background Information

We recognize we have to continue to earn the right to operate in the communities that host us.

Since acquiring the refinery on July 1, 2016 PBF Energy has been investing in our people, processes, equipment and procedures to improve refinery operations.

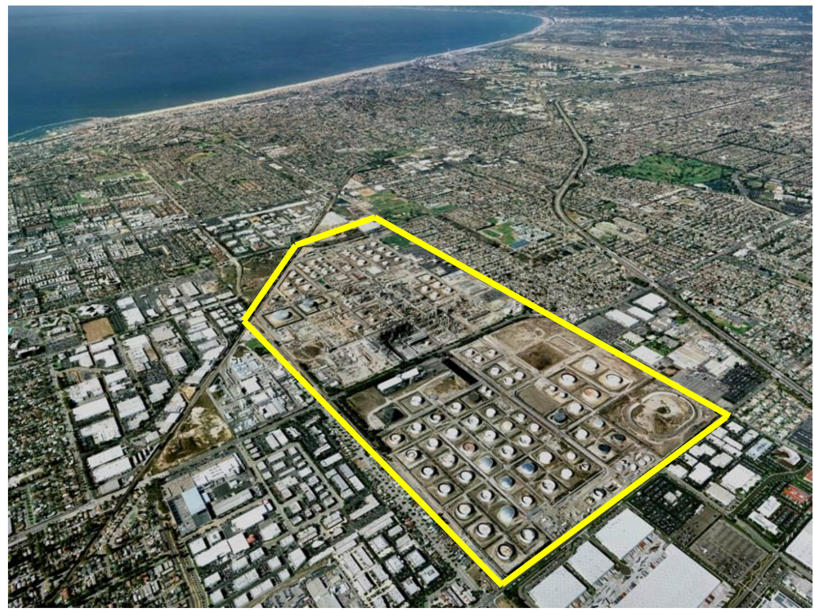
Everyone who works at the Torrance Refinery today is committed to safe, reliable, and environmentally responsible operations.

The Alkylation Unit with its MHF catalyst are critical to the refinery's future - this Additive represents the most recent proven alkylation technology.

Our goal is to operate the best refinery in the State of California and the world…we're working smartly and diligently on achieving this goal!

Torrance Refinery

- **Economic cornerstone for the City of Torrance**
  - Continuous operation on 750 acres since 1929
- **585+ employees / 320+ contractors**
  - ~300 families with ties to Torrance
  - Turnarounds require additional contractors
    - Spring 2017: ~1875 contractors at peak
- **~150,000 barrels per day (bpd) crude capacity**
  - Processes crude oils primarily from California
  - Makes gasoline, jet fuel, diesel, other products
- **Supplies ~20% of SoCal's gasoline demand**
  - ~10% of California's overall gasoline demand
  - Also supplies gasoline to Nevada & Arizona
  - Supplies ~25% of LAX jet fuel demand
  - Supplies ~65% of marine fuel to ports of L.A./LB
- **Uses MHF to make "alkylate" to blend gasoline**
  - Needed to make all grades of CARB gasoline



Key Priorities

- **Protect our workers, the community, and environment through safe work practices and procedures**
- **Refinery workers are accountable, responsible, and have authority**
  - To stop work for any safety concern
  - To shut equipment down for any safety concern
- **Continue improving our operational reliability to achieve safe, environmentally responsible operations**
  - A safe and reliable refinery will also keep the community safe
- **Earning the right to operate in this community**
  - Torrance Refinery meets with community groups frequently
  - We continue to work cooperatively with city officials and regulatory agencies
  - We have renewed efforts to explain to the community what we do, our safe practices and the refinery's local and regional socioeconomic contributions

Chapter 2: MHF Alkylation & How MHF Works

- **Alkylate: critical, "clean" gasoline blending component also increases octane**
  - Required for making all grades of CARB gasoline
- **Refineries use chemical catalysts to make Alkylate from low-value liquid petroleum gases - LPGs**
- **Catalysts used to make Alkylate**
  - Anhydrous hydrofluoric acid (**AHF**)
  - Modified hydrofluoric acid (**MHF**)
  - Sulfuric Acid
- **Each type of catalyst is safely used around the world but has unique risks**
  - HF & MHF (M/HF) are used in over 50% of U.S. Alkylation Units as well as globally
    - Benefit: M/HF is reused in the process
    - Sulfuric Acid requires additional processing for reuse
  - Refining configurations, feed type and product slate determine catalyst type
  - Globally, refining alkylation represents ~2% of HF end use

Use of MHF Alkylation Technology at Torrance

- **Torrance Refinery's MHF Alkylation Unit is necessary to produce alkylate, a critical component of California's CARB gasoline - the cleanest in the world**

- **Highly-qualified engineers and research scientists developed MHF in the 1990s**

- **Under the City of Torrance Consent Decree, following a rigorous review of the MHF testing and modeling data, the independent Court-appointed Safety Advisor, an LA County Superior Court Judge determined that MHF**
  - "would not form an aerosol or dense vapor cloud upon release" and MHF "(including mitigation) presents no greater risk than sulfuric acid alkylation plant producing a comparable amount of alkylate"

- **Torrance Refinery has never had an offsite M/HF release since start-up in 1966**
  - HF: used from 1966 until 1997
    - Survived 6.5+ magnitude Sylmar (1971) and Northridge (1994) earthquakes
  - MHF in use since 1997 court approval and permit from SCAQMD

Use of MHF Alkylation Technology at Torrance

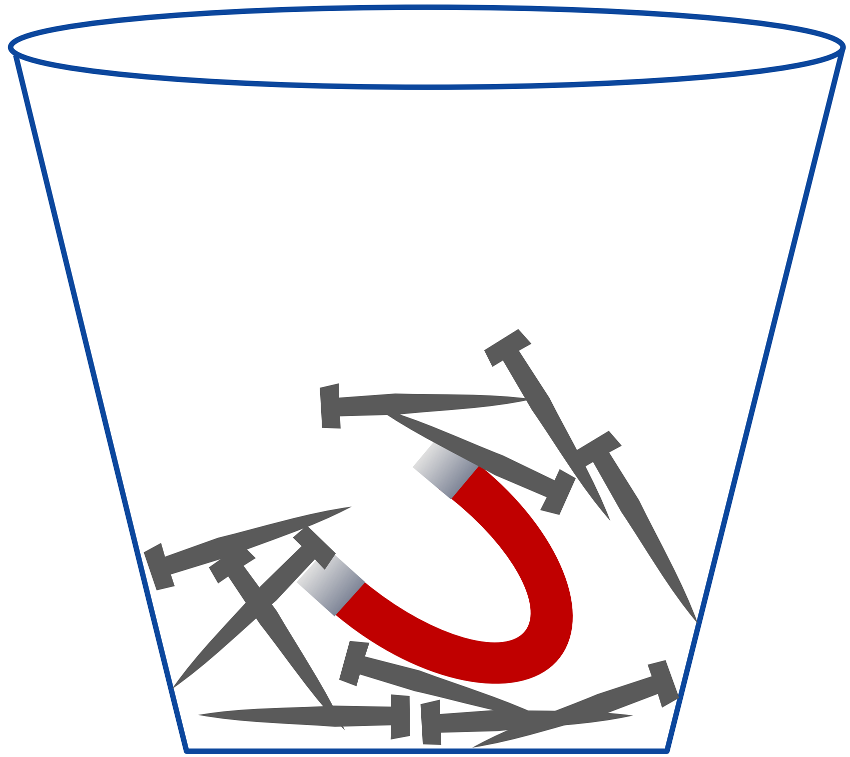
- **Excerpt AQMD: "Addendum, Mitigated Negative Declaration, Mobil Modified Hydrogen Fluoride Conversion Project", p. 2 - July 9, 1997**
  - "The experimental testing indicated that the addition of the Mobil additive to HF was an effective method for reducing or elimination the amount of aerosol formed during a release.
  - "In summary, after review of available test data and performing release/dispersion modeling, under similar release conditions the addition of the Mobil additive to an HF Alkylation unit was determined to result in a reduction of HF hazard zones for equivalent releases.
  - "In all cases, addition of the additive of the Alkylation unit will reduce the distance traveled by HF in the event of a release. At any concentration of the additive, the vapor pressure of HF will be reduced, thus reducing the potential for public exposure to HF."

MHF Works: Proven by Testing

- **HF and MHF have different characteristics and “behaviors”**
  - MHF is a different type of mixture from AHF
- **MHF works through Hydrogen Bonding**
  - Additive forms hydrogen bonds to AHF to hold MHF in Liquid Phase
  - Water also contributes to bonding AHF
- **MHF used at Torrance Refinery does not flash atomize because of hydrogen bonding**
- **Experiments in 1992 and 1994 showed the presence of the additive in AHF eliminates Flash Atomization of the release**
  - Testing proved no Flash Atomization was observed for MHF compositions containing as much as 85 wt% HF up to 140°F
- **AQMD Quote - “Alkylation Improvement Project, Final EIR”, Chapter 2, p. 2-7 - SCH #20030536, certified 12/16/04 regarding Valero’s MHF project**
  - “The modified HF catalyst reduces acid vapor pressure sufficiently to suppress the usual flash atomization process of hydrofluoric acid, causing most of the acid to fall to the ground as an easily controlled liquid and reduces the potential for off-site consequences of an accidental HF release.”

Example of Hydrogen Bonding: Nails in a Bucket

- Visualize the nails as HF molecules
- Visualize the strong magnet as the MHF Additive
- Put the nails and strong magnet in a pail
- Shake the pail to move the contents around
- The nails - HF molecules - attach or "bond" to the magnet - Additive
- Additive size and strength induces further attraction between HF molecules
- HF molecules are attracted to the Additive and each other and bond together



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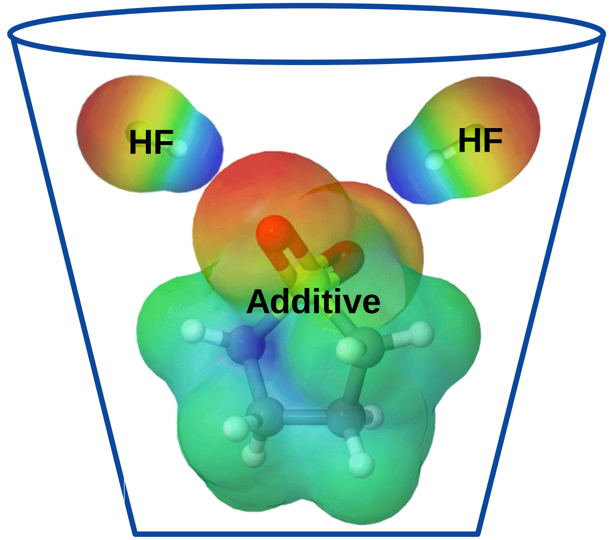
HF Bonding

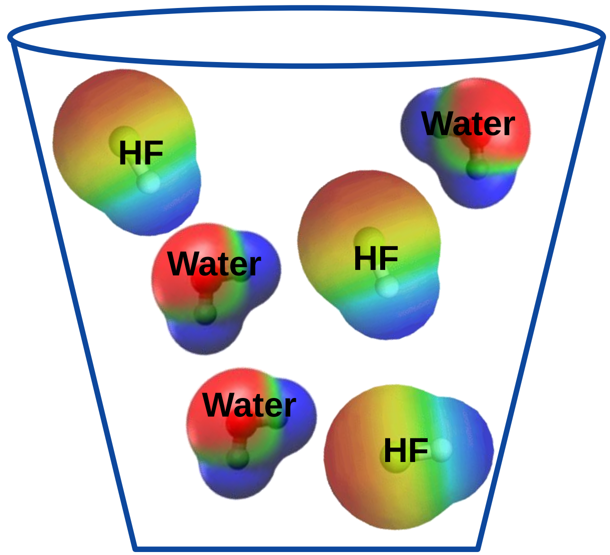
HF + Additive

- **Liquid HF chains already bond among themselves**
  - Typically five or six HF molecules per chain
- **MHF Additive acts like a strong magnet to bond HF chains**
- **Charge also distributed to surrounding HF chains**
  - Causes the chains to bond with each other
  - Reduces HF volatility over a much greater volume than just a single Additive molecule
- **A little Additive goes a long way**



HF + Water

- **On a pound for pound basis, water is an even stronger HF magnet than the MHF Additive**
- **One pound of water is roughly three times more effective at holding HF than one pound of Additive**



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Chapter 3: Torrance Refinery Action Alliance - TRAA

- **Torrance Refinery Action Alliance (TRAA): Small, grassroots organization that has been trying to selectively ban the use of MHF in two South Bay refineries**
  - 1/4/17 TRAA's "Science Advisory Panel" released a presentation "The Case Against MHF, -ARF-SRI-and Barriers-"
  - 2/28/17 TRAA presented "The Case Against MHF, ARF-SRI-Barriers" to Torrance City Council & the public at City Hall; submitted comments refuting Torrance Fire Department's (TFD) presentation on MHF

- **Torrance Refining plus independent global HF Alkylation authorities reviewed / analyzed TRAA presentations, sources and methodologies**
  - Identified "Myths:" Incorrect, misleading, altered data and information taken out of context
  - Response: "Setting the Record Straight - The Truth About Torrance Refinery MHF"
    - Compares and corrects TRAA "Myths" with "Facts"
    - Glossary of Terms included as an Addendum for reference

MYTH - TRAA Claims: PBF has no concern for the safety and well-being of the community

TRAA Comments on Torrance Fire Department's Presentation at Torrance City Council Torrance Refinery Workshop - February 28, 2017

AGENDA

TRAA Comments

- PBF's agenda is to convince the public MHF is safe by dazzling us with technobabble and wowing us with the authority of the Consent Decree.

Protecting the Public?

TRAA Comments

- MHF conversion was done just to make things safer for the Community? That should worry you. When does the refinery put safety before profits?
- MHF is a proprietary product, never independently tested or verified. Its sole virtue is a PUBLIC IMAGE of SAFETY, but it hinders alkylation.

FACT: We recognize we have to earn the right to operate in this community

- **We want everyone inside and outside the Torrance Refinery to be safe and feel confident the refinery is in excellent hands**
- **Safe, reliable, environmentally responsible operations are core values**
- **We put safety before profits, otherwise we would be unprofitable and unsuccessful**
- **Safety of all employees and contractors working in the refinery is our utmost priority**
  - They work in safe conditions
- **PBF met with community groups and public officials before acquiring Torrance**
  - Including TRAA, Homeowners, Associations, business groups, etc.
- **<u>ALL</u> refinery workers know they are accountable, responsible and have the authority to:**
  - Stop work for any safety concern
  - Shut equipment down for any safety concern
- **We expect and want our employees to leave work in the same condition they arrived and feeling positive that they made solid contributions to the refinery**
- **A safe and reliable refinery will also keep the community safe**
  - About 300 families in Torrance have ties to the refinery

MYTH: TRAA Science Advisory Panel is knowledgeable about MHF and refining

"We performed an independent assessment of MHF using what's called proprietary data that's readily available online and there is no absence of information; there's no vacuum. We have the information we need from the industry itself - online from Honeywell, from Valero, which uses MHF and so forth … Incidentally, we've heard that TORC has dismissed our science panel as aerospace engineers with no refinery experience. ***We prefer to think of ourselves as rocket scientists. Luckily, knowledge of chemistry and gas dynamics is more pertinent than refinery experience in this matter, so we feel we are qualified to do the assessment."***

– TRAA Sally Hayati, SCAQMD Hearing April 1, 2017

Torrance Refinery Action Alliance
February 20 ·

JOIN US TONIGHT AT TRAA's MEETING, 6pm, Torrance Sizzler, 2880 Sepulveda, to celebrate the successful rally/march and prepare for this:

MHF WORKSHOP 2/28, 7pm Torrance City Hall.

The city will pour MHF safety claims straight from the refinery into the public. WE ALL NEED TO GO. Come tonight so you will understand this attempt to bedazzle us with technobabble. TRAA's Science Advisory Panel has met with city and refinery. We've revealed decades-long deception and scientific errors in MHF safety claims. This is not rocket science. 90% HF is NOT safe. Yet, we've got rocket scientists working on it—and they still won't listen (http://bit.ly/2lo3xZr).

On 2/28, tell Torrance elected representatives and public servants to detach themselves from the refinery's embrace, listen to the public, independent experts, and AQMD (http://bit.ly/2k05JEB) and support a MHF/ HF ban.

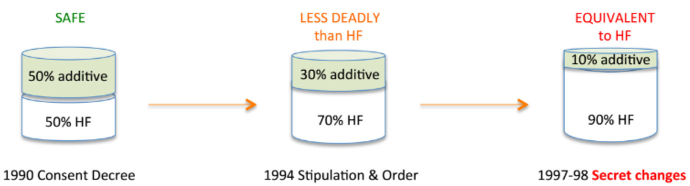
Please like/comment/share/tag to get the word out and Thank You!

Source: TRAA Facebook Page Post (Feb. 20, 2017)

MHF: Wolf in Sheep's Clothing

-False safety claims have been made for two decades-

Those claims date back to broken promises in '90, '94 for Torrance-Mobil Consent Decree



Hayati's MHF assessment is based on industry data in patents, EIRs, Safety Advisor reports, etc., with the assistance and verification of experts, including:

- Dr. Ron Koopman, HF expert, Test Director of both HF Release tests 1986 (Goldfish) & 1988 (Hawk)
- Dr. Rafael Moure-Eraso, Chemical Engineer, former Chair U.S. Chemical Safety Board (CSB)
- Dr. George Harpole, Chemical Engineer, Chief Engineer at Northrup Grumman in Redondo Beach [Harpole, 2016, "HF and MHF – Equivalent Ground Hugging Fog Hazards." <http://bit.ly/2ck2l8G>.]

Sally Hayati, TRAA 6

Source: TRAA Presentation "Modified Hydrofluoric Acid (MHF) – Wolf in Sheep's Clothing" (Nov. 16, 2016)

Torrance Refining Company

****Note: Purple boxes added to original image/text to highlight specific points referenced/discussed***

FACT: TRAA Science Advisory Panel members have no training or experience in Refining or Alkylation

- **Although TRAA Science Advisory Panel members may have earned advanced degrees, most have aerospace backgrounds**
  - Knowledge in this field is irrelevant to Refining or Alkylation
  - Ms. Hayati's degree is in Computer Science – not a "Rocket Scientist"
- **TRAA's "Case Against MHF" presents misinformation related to MHF Alkylation**
  - Understanding this complex field requires first-hand operational knowledge, experience, actual testing and/or modeling of alkylation technologies, particularly on efficacy of MHF
  - TRAA findings are based merely on internet searches, patent reviews, & news articles
    - Because these are insufficient to challenge the science behind MHF, TRAA resorts to filling in data gaps and / or presents predetermined outcomes/conclusions
    - Manipulating and / or altering data, particularly on patents
  - TRAA conclusions have not been tested or validated by third party
- **Contrast: Mobil, Phillips and Quest used highly QUALIFIED industry experts**
  - Experienced in the science of refining, alkylation, and dispersion modeling
    - Had in-depth technical knowledge of the chemistry and release phenomenology necessary to properly characterize MHF release behavior
    - Applied scientific rigor in testing the efficacy of MHF
  - MHF technology resulted from field and laboratory testing, and pilot plant studies

References
- *TRAA "The Case Against MHF, -ARF-SRI- and Barriers-" January 4, 2017*
- *TRAA Comments on Torrance Fire Department's February 28, 2017 Presentation at Torrance City Council Torrance Refinery Workshop*

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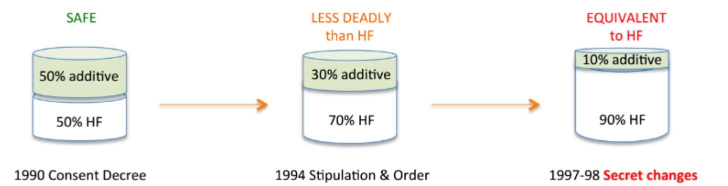

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Source: TRAA Presentation "Modified Hydrofluoric Acid (MHF) – Wolf in Sheep's Clothing" (Nov. 16, 2016)

Torrance Refining Company

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FACT: TRAA evaluations and conclusions appear to be based on patents and publicly available papers and include many incorrect assumptions

- **Patents are ideas - <u>NOT</u> final products developed from the ideas**
  - A final product or installation often varies significantly from the original patent
  - Many patents have **<u>NEVER</u>** been developed into a commercial product

- **When MHF was being developed, every reasonable idea generated a patent**
  - Only some ideas were advanced to a final installation
  - Many patents (ideas) were further developed with testing into a final product that was different from the patent

- **Ms. Hayati misrepresents the Additive concentrations in the depicted barrels**
  - 50% Additive was **<u>NEVER</u>** considered an option for MHF Alkylation
  - All of the patents TRAA references indicate that 50% Additive does not work as the alkylate production quality will reduce significantly

- **TRAA misinterpreted or changed some of the data they found in publicly available papers**

<u>References</u>

- *Cited throughout presentation*

Chapter 4: MHF has Distinguishing Behaviors

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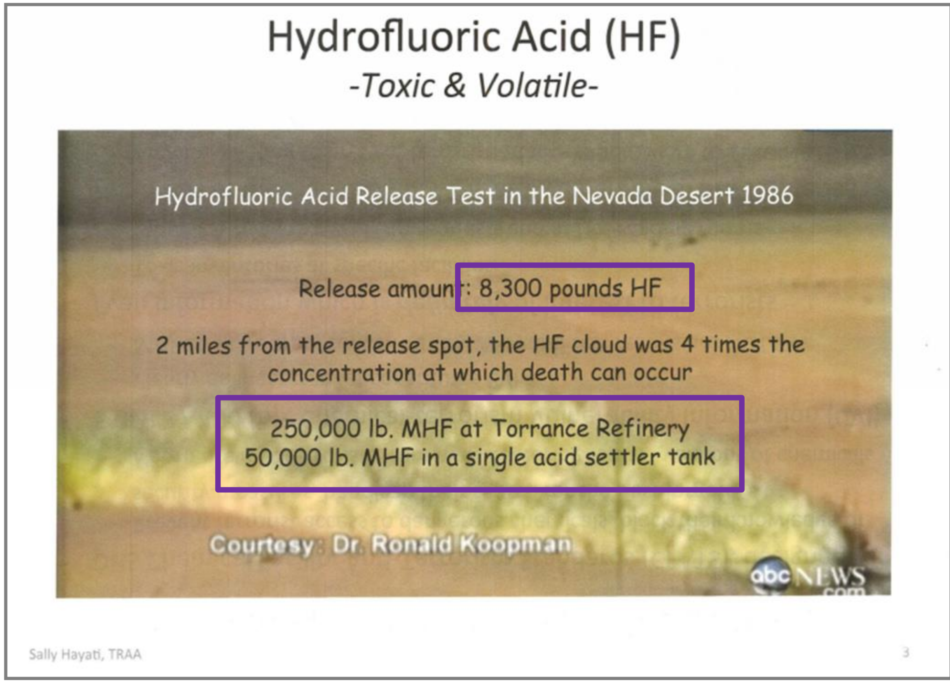
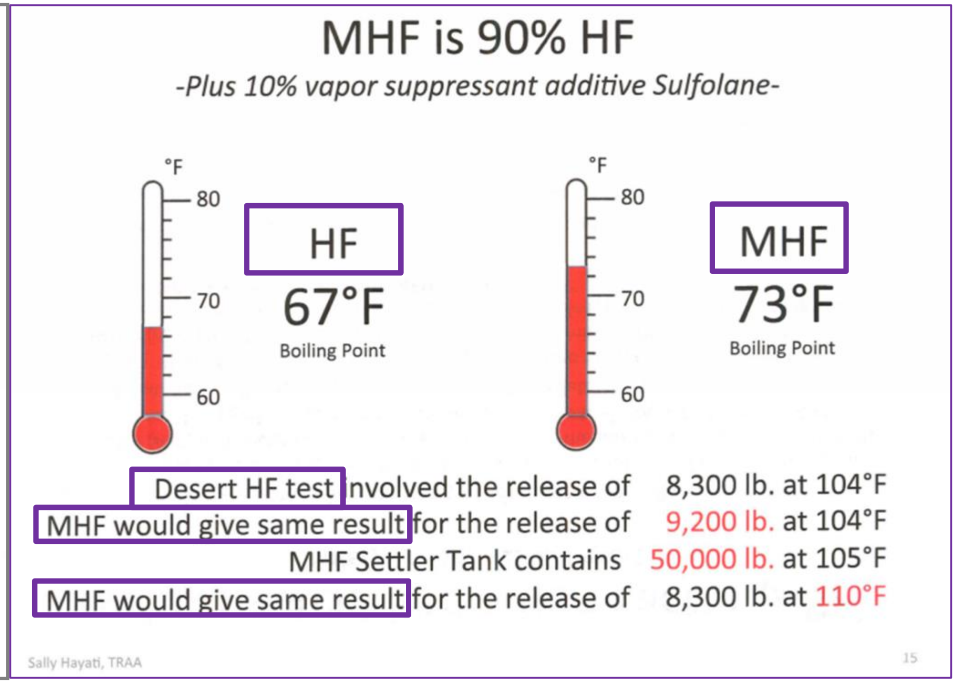
MYTH - TRAA Slides 3 & 15:
All types of HF acid behave the same

TRAA "Case Against MHF" Jan 4, 2017 – Slide 3



TRAA "Case Against MHF" Jan 4, 2017 – Slide 15



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FACT: Actual lab and field testing of these types of HF Acid prove each acid behaves differently

- **Hydrofluoric Acid (HF) type determines whether Flash Atomization occurs**
  - Flash Atomization: The occurrence of a substance disintegrating into extremely small droplets when a pressurized liquid is released into the atmosphere
- **Anhydrous Hydrofluoric Acid (AHF): 99.995 wt% HF – generic used in industry**
  - **Full Flash Atomization readily observed**
  - 1986 Desert Testing of AHF shown on TRAA Slide 3 was pre-MHF technology
  - HF has different characteristics - **CANNOT** be compared to MHF
- **HF-Alky Unit Acid (HF-AUA): 90-92 wt% HF – used by most refineries**
  - **Partial Flash Atomization readily observed**
- **Delivered MHF to the Torrance Refinery: 85 wt% HF, 15 wt% Additive**
  - **Flash Atomization is not observed**
- **MHF-AUA: ~80 wt% HF, ~7 wt% Additive, ~3 wt% Water, ~3 wt% ASO ~7 wt% Hydrocarbon – used by Torrance Refinery**
  - **Flash Atomization is not observed**

References

- *December 2016 ARF email submission to Torrance Fire Department*
- *DAN 95M-0874 - MHF Airborne HF Reduction estimates*

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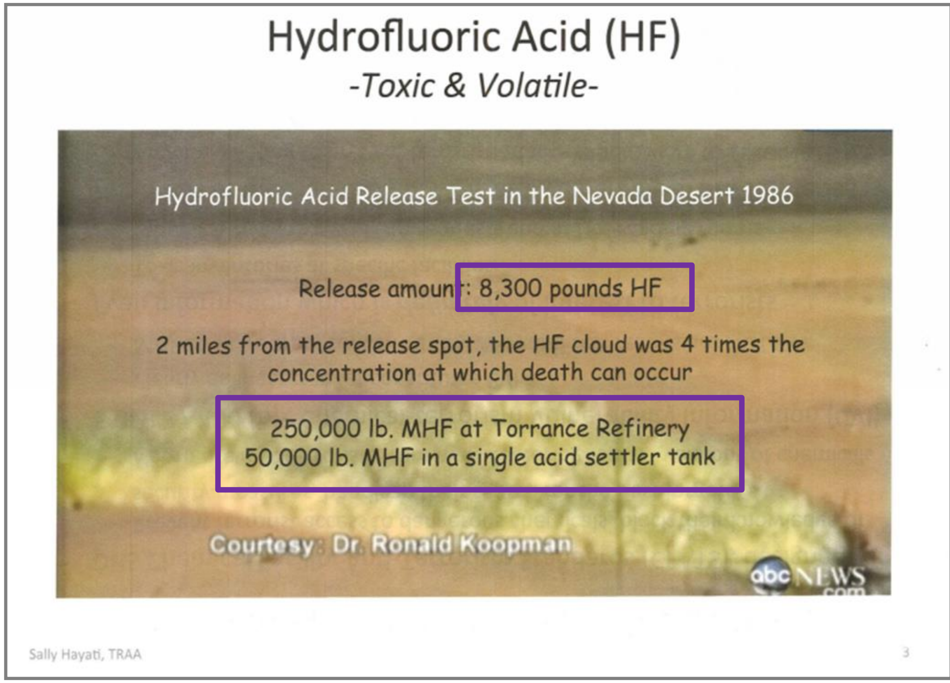
MYTH - TRAA Slides 3 & 15:
All types of HF acid behave the same

TRAA "Case Against MHF" Jan 4, 2017 – Slide 3



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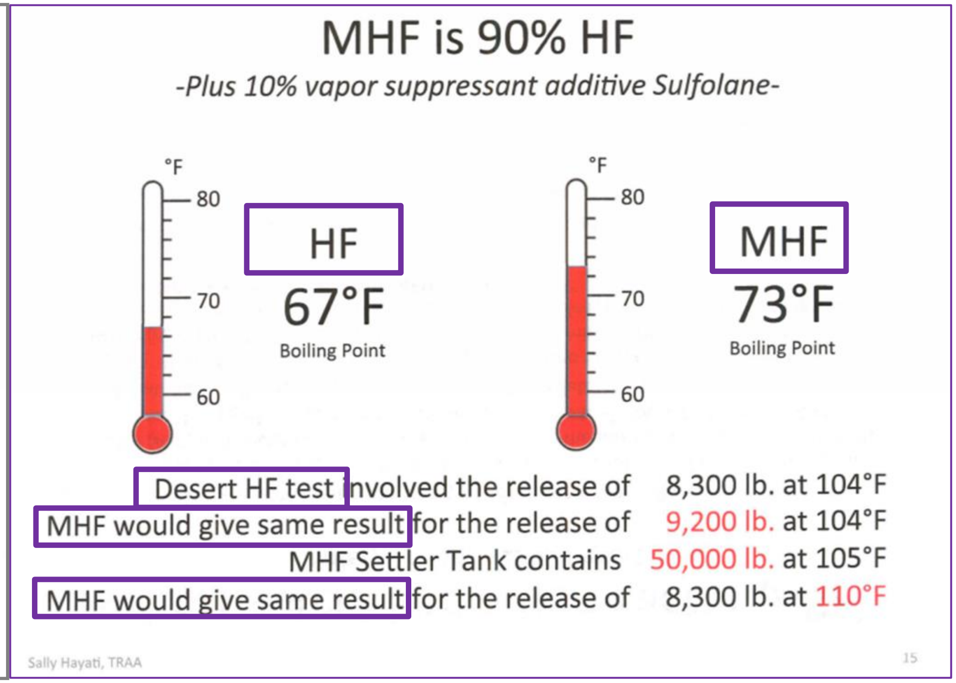

****Note: Purple boxes added to TRAA's original image/text to highlight specific points referenced/discussed***

FACT: AHF tests conducted in the Nevada Desert in 1986 <u>CANNOT</u> be compared to an MHF release

- **TRAA is misrepresenting data as a scare tactic and apparently making calculations with limited knowledge**
- **Testing in 1992 and 1994 showed the Additive in MHF eliminates Flash Atomization of HF associated with a jet release**
- **Testing proved no Flash Atomization was observed for MHF compositions containing as much as 85 wt% HF up to 140°F**
- **Torrance Refinery's MHF Alkylation chemical composition and the unit's numerous safety systems directly impact ARF and SRI**
  - **<u>CANNOT</u>** be directly compared to an unimpeded AHF release that was tested during the 1986 desert testing
- **Conclusion: Testing shows MHF <u>DOES NOT</u> form a dense, ground-hugging cloud as claimed by TRAA**
- **AQMD Quote - "Alkylation Improvement Project, Final EIR", Chapter 2, p. 2-7 - SCH #20030536, certified 12/16/04 regarding Valero's MHF project**
  - "The modified HF catalyst reduces acid vapor pressure sufficiently to suppress the usual flash atomization process of hydrofluoric acid, causing most of the acid to fall to the ground as an easily controlled liquid and reduces the potential for off-site consequences of an accidental HF release."

<u>References</u>

- *Consent Decree/Safety Advisor's Reports, May 1995 and October 1999*
- *DAN 95M-0874 - MHF Airborne HF Reduction estimates*
- *ReVAP Tutorial page 7*

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Chapter 5: MHF Review Process

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MYTH - TRAA Slides 5, 7 & 8:
"No Proprietary Justification for MHF Secrecy"

TRAA "Case Against MHF" Jan 4, 2017 – Slide 5

No Proprietary Justification for MHF Secrecy

-MHF is patented and therefore not eligible for trade secret rights-

Emergency Planning and Community Right-to-Know Act (EPCRA), Substantiating claims of trade secrecy Code of Federal Regulations Title 40, Section 350.7 (40 CFR 350.7) Paragraph (a) substantiation questions:

(4) The information should be a **secret of interest to competitors**
There is no MHF competitor: Honeywell has a monopoly, and since any refinery may purchase it, ExxonMobil has no claim

(4)(ii) Information claimed as trade secrets shouldn't be **publicly revealed.**
We have found the information in patents, material safety data sheets, risk management reports, and news articles on the Internet. (See following charts.)

(4)(iv) The information should be **valuable information to competitors.**
No MHF competitors exist. And if any arise, they'd find the information on-line.

(5) Disclosure should cause **substantial harm to claimant's competitive position.**
Not remotely true, for either Honeywell or ExxonMobil.

COMMUNITY RIGHT TO KNOW

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TRAA "Case Against MHF" Jan 4, 2017 – Slide 7

"Trade Secret" Found in the Public Domain

-The Additive for the Mobil/Phillips MHF (ReVAP) is SULFOLANE-

A dozen patents reveal what the additive is. For example:

"In order to improve the safety factors of the HF alkylation process, one option is to operate with a vapor suppressant additive in the alkylation acid. ... A number of different sulfones have been proposed for this purpose but the one generally preferred is **sulfolane**"
HF alkylation process with acid regeneration, US Patent 7847142 B2, ExxonMobil Research and Engineering Company, 2007 (filing date), http://www.google.com/patents/US7847142

Honeywell Material Safety Data Sheet for MHF reveals what the additive is.
http://bit.ly/21T6yAt

Component	CAS-No.	Weight percent
Hydrogen fluoride	7664-39-3	90.00%
Tetrahydrothiophene 1,1-dioxide	126-33-0	10.00%

Chemical Book, Sulfolane Basic information, ***Sulfolane CAS = 126-33-0***

Valero Wilmington Refinery RMP 2014: MHF 10% Sulfolane to reduce HF vapor
Valero adopted the ReVAP brand of MHF (developed by Mobil/Phillips, now owned by Honeywell) in 2005

WHY DEMAND MHF "TRADE SECRETS" IF WE ALREADY KNOW WHAT THEY ARE? For "credibility" and to eliminate uncertainty. When official data is withheld, Jill Public is easily accused of not knowing what she's talking about.

TRAA "Case Against MHF" Jan 4, 2017 – Slide 8

"Trade Secret" Found in the Public Domain

-Additive concentration used is 10%-

SOURCE 1: Torrance Refinery Safety Advisor Project, Steve Maher, "Evaluation of MHF Alkylation Catalyst (Analysis of proposed additive concentration changes)," 10/1999
– This report reveals that the additive concentration was reduced in 1998. It is unknown if it was reduced again later.

SOURCE 2: Honeywell MHF Material Safety Data Sheet (MSDS). The monopoly manufacturer of MHF.
<http://bit.ly/21T6yAt>
- Hydrofluoric acid 90.00% (also 85%)
- Sulfolane (THT) 10.00% (also 15%)

SOURCE 3: Honeywell via PBF
- A range of 10-15% is given, so it is clear the concentration used is 10%, Otherwise, Honeywell would say just 15%

WHAT IS MODIFIED HYDROFLUORIC (MHF) ACID? PBF
- Modified Hydrofluoric Acid (MHF) is HF that contains an additive that lowers the volatility of the original compound
  - ✓ Reduces risk of exposure in the event of an MHF leak or spill
- The MHF used at the Torrance refinery is designed to reduce the volatility, or vapor potential, of hydrofluoric acid and features an additive that can reduce the volatility by 60 to 90 percent
  - ✓ The MHF delivered to the refinery contains the industry standard of approximately 10 to 15 percent concentration of this additive

SOURCE 4: Valero Wilmington Refinery Risk Management Program Report 2014 (adopted same MHF in 2005)

Worst-Case Toxic Scenarios

Physical State	Gas liquified by pressure
Model Used	SLAB Model
Passive Mitigation - Other	10% sulfolane additive to reduce the HF to form an aerosol on release under pressure to atmosphere. "Diffuser" or Barrier around flange.
Confidential Business Information	No

SOURCE 5: City of Torrance Refinery Workshop October 2015. Mayor P. Furey stated MHF = 90% HF + 10% additive

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FACT: Technology licensors declared MHF information to be 'proprietary' to protect their intellectual property

- **Parties that license MHF technology, including Torrance Refining Company LLC (TORC), are legally obligated to maintain the technology's proprietary status**
- **UOP is the licensor of the MHF technology and considers the MHF testing information proprietary and trade secret**
- **Claims that product sales are an indication that related proprietary information can be publicly shared are irrelevant**
- **With Licensor consent, proprietary MHF technology information has been shared with the City of Torrance, AQMD, EPA, and Cal OSHA**
    - Permitted through licensing and confidentiality agreements, the Consent Decree, and California Public Records Act and Freedom of Information Act
- **Many references in this presentation refer to proprietary documents and data that are unavailable to the public**

MYTH - TRAA Slide 9: "Public was never informed" of change in Additive concentration in 1999

TRAA "Case Against MHF" January 4, 2017 - Slide 9

Operational Failure of MHF in 1997

- The new MHF unit with 30% additive failed at startup.
  - Unit was dangerously unstable, too little product, poor quality product
  - The public was never informed
- Mobil's actions (from Safety Advisor's 1999 report)
  - Mobil slashed additive to 10% to get HF concentration > 88%
  - Mobil added a proprietary barrier technology
  - The public was never informed

Mobil's new safety claims (from Safety Advisor's 1999 report)

1. Lowering the additive concentration didn't make much difference anyway
   "Figure IV.A.12-1b (REDACTED) clearly illustrates that significant gains in ARF are achieved at relatively low additive concentrations, and that the effectiveness curve for additional additive flattens out."
2. Mobil's proprietary barriers more than made up for the missing additive
3. Continuous calculation of ARF & SRI values guarantee community safety.

These claims are contradicted by info & data in Mobil/Phillips patents

Sally Hayati, TRAA

9

****Note: Purple boxes added to TRAA's original image/text to highlight specific points referenced/discussed***

FACT: The Additive concentration was thoroughly vetted and approved through the Consent Decree process, which represented the public interest

- **Additive with use of barriers was thoroughly vetted and approved in the Court-ordered Consent Decree process, involving the following who represented the public interest:**
  - A well respected and experienced Superior Court Judge - Harry Peetris
  - Court Appointed Independent Safety Advisor - Steve Maher
  - City of Torrance - Mayor and Council
  - Torrance Fire Department and its independent Safety Consultants
- **1997: Torrance began using MHF Alkylation technology after AQMD issued permits**
  - The initial higher Additive concentration caused operational instability in the Alkylation Unit and generation of an undesired by-product
- **1998: Mobil approached Court-appointed Safety Advisor, City and TFD to resolve this issue**
  - Prompted reconsideration of the Additive concentration with other mitigation features
  - Through the Consent Decree process, additional testing and barrier technology review
- **1999: The Judge approved lowering Additive concentration in conjunction with the installation of barriers based on Safety Advisor recommendation after his thorough review of the barrier testing and input from City and TFD**
  - *"(Our) analysis show that the final operating configuration would provide an improvement to the level of safety to the Community*."
- **Safety Advisor's Report stated MHF Alkylation Unit ARF increased from 65% in 1995 (MHF-AUA Chemistry) to 89% in 1999 (MHF-AUA chemistry + Barriers)**
  - MHF Technology is successful

Reference

- *Consent Decree Safety Advisor's Report - October 1999*

MYTH - TRAA Slide 9: “New MHF unit with 30% additive” and “Mobil slashed additive to 10% to get HF concentration >88%”

TRAA “Case Against MHF” January 4, 2017 - Slide 9

Operational Failure of MHF in 1997

- The new MHF unit with 30% additive failed at startup.
  - Unit was dangerously unstable, too little product, poor quality product
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1. Lowering the additive concentration didn’t make much difference anyway
   “Figure IV.A.12-1b (REDACTED) clearly illustrates that significant gains in ARF are achieved at relatively low additive concentrations, and that the effectiveness curve for additional additive flattens out.”
2. Mobil’s proprietary barriers more than made up for the missing additive
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These claims are contradicted by info & data in Mobil/Phillips patents

Sally Hayati, TRAA 9

****Note: Purple boxes added to TRAA’s original image/text to highlight specific points referenced/discussed***

Torrance Refining Company

FACT: The Additive concentration was NEVER 30 wt% in 1997, but was 19 wt%

- **1997: 19 wt% MHF concentration caused operational instability and generated an undesired by-product**
  - Additive concentration is misrepresented by TRAA's lack of knowledge
- **1997-1998: Testing and review of barrier technology was undertaken to identify the optimal Additive concentration**
- **1998: Mobil approached Court-appointed Safety Advisor, City and TFD to resolve this issue**
  - Prompted the innovative reconsideration of the Additive concentration in conjunction with other passive mitigation features
  - Through the Consent Decree process, additional testing and barrier technology review
- **1999: Judge approved lowering Additive concentration with the installation of barriers for the Torrance MHF Alkylation Unit**
  - MHF Additive was reduced to ~7 wt% with an HF concentration of ~80 wt%
  - Barrier technology proven by testing
- **Torrance Refinery's MHF Alkylation Unit ARF increased from 65% in 1995 (MHF-AUA Chemistry) to 89% in 1999 (MHF-AUA chemistry + Barriers)**
  - Barrier technology added another layer of protection and safety for MHF use
  - Increase ARF supported by actual testing and information in Mobil and Phillips patents

References

- *Consent Decree Safety Advisor's Report - October 1999*
- *DAN 95M-0874 - MHF Airborne HF Reduction estimates*
- *DAN 98M-0166 - Effects of Active and Passive Mitigation on AHF, AUA, and MHF Releases*

Chapter 6: Vapor Pressure & Additive Concentration

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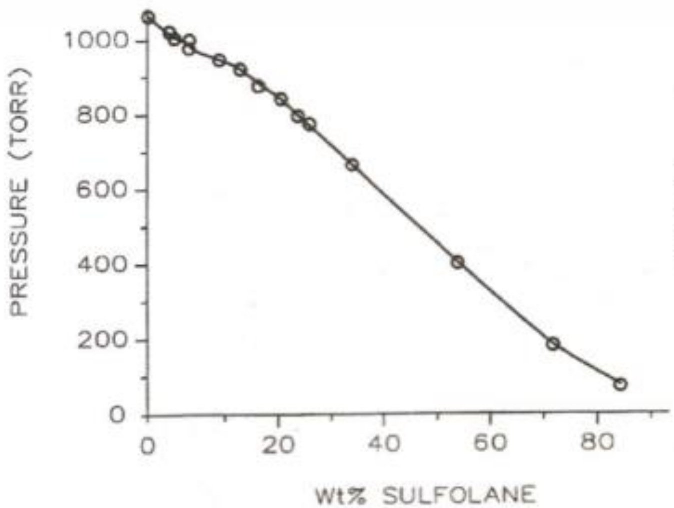
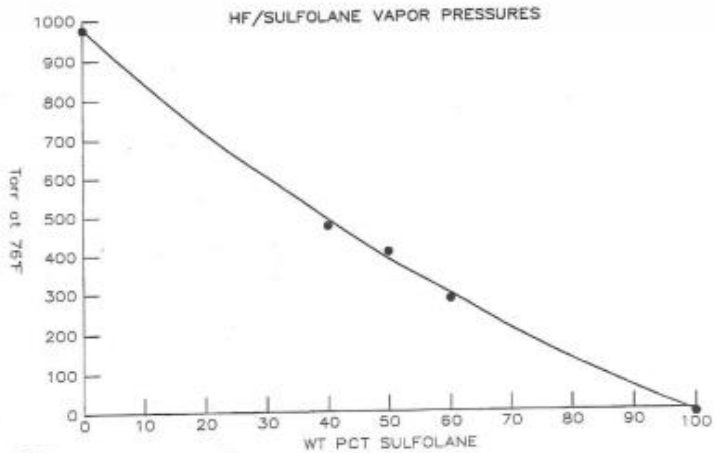
MYTH - TRAA Slide 11: "Vapor pressure is the only fluid property related to the claimed relative safety of MHF."

TRAA "Case Against MHF" Jan 4, 2017 – Slide 11

Vapor Pressure of 10% MHF is close to HF's

Vapor pressure is the only fluid property related to the claimed relative safety of MHF.





Temperature 86ºF.
Phillips Petroleum Company, 1992,
European Patent EP 0796657 B1,
"Alkylation catalyst containing HF and a sulfone,"
<http://bit.ly/2hPLiNr>.

Temperature 76ºF.
Phillips Petroleum Company, 1995
US Patent 5534657,
Isoparaffin-olefin alkylation,
<http://bit.ly/2iWPonl>.

Sally Hayati, TRAA

11

Torrance Refining Company

FACT: Vapor pressure is NOT the key chemical property driving the effectiveness of MHF

- **Additive's primary effectiveness results from formation of hydrogen bonds that hold MHF in liquid phase**
  - Additive is a heavy liquid with very low vapor pressure that does not evaporate
- **Hydrogen bonding helps MHF resist vaporization and prevents large-scale aerosoling of the released liquid**
- **The Additive is only one component that impacts vapor pressure and aerosoling**
  - Water and Acid Soluble Oil (ASO) also have significant positive effects
- **Water is a more effective vapor suppressant than the Additive due to strong hydrogen bonding**
  - However, water content is limited to ~3 wt% to prevent accelerated corrosion
- **Effect of Additive and water on the solution's surface tension, viscosity, and enthalpy of vaporization also reduces the propensity for aerosol formation**
- **AQMD Quote - February 7, 2003, Governing Board Letter, Agenda No. 25, regarding Valero's "enforceable agreement" to phase out HF for MHF:**
  - "The unique physical properties of the additive substantially reduce the volatility of the acid at ambient conditions. This reduction in volatility proportionately reduces the amount of HF that can vaporize and subsequently disperse off-site from a given liquid release quantity."

References

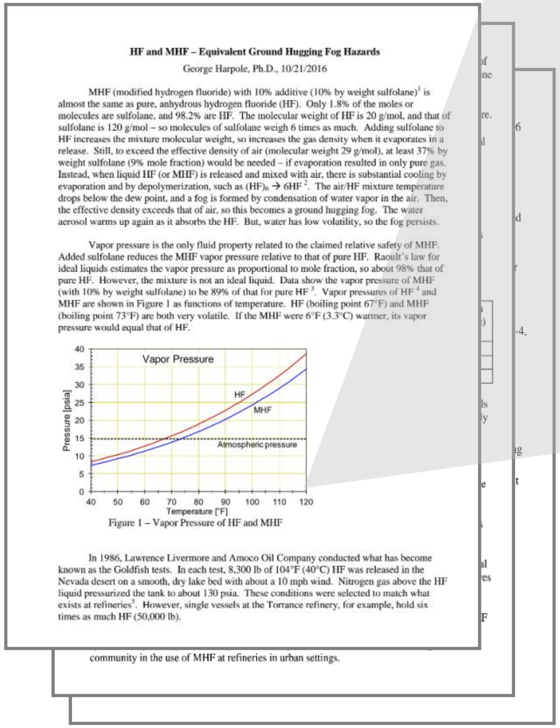
- *DAN 95M-0874 - MHF Airborne HF Reduction estimates*
- *ReVAP Tutorial page 7*

Torrance Refining Company

MYTH - TRAA Slide 12: TRAA's MHF and HF Vapor Pressure Graph is based on actual data

TRAA "Case Against MHF" Jan 4, 2017 – Slide 12

Referenced Article
by TRAA Science Panel Member



HF and MHF – Equivalent Ground Hugging Fog Hazards

George Harpole, Ph.D., 10/21/2016

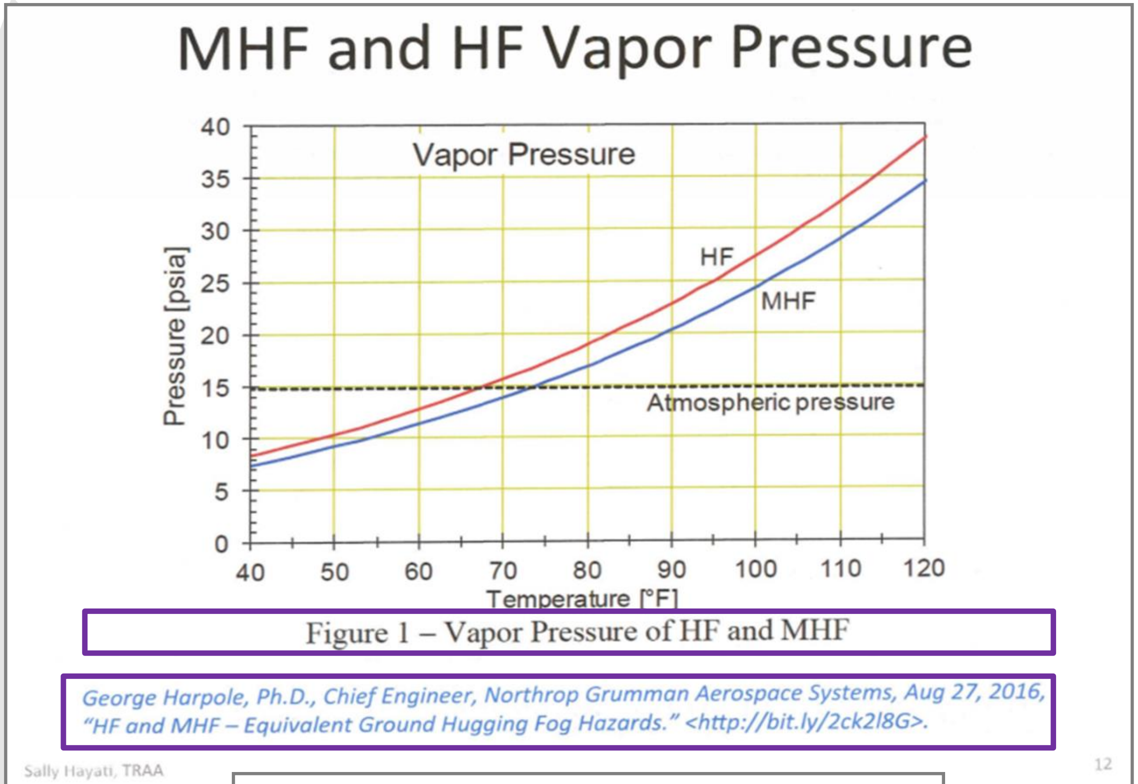
MHF (modified hydrogen fluoride) with 10% additive (10% by weight sulfolane)[1] is almost the same as pure, anhydrous hydrogen fluoride (HF). Only 1.8% of the moles or molecules are sulfolane, and 98.2% are HF. The molecular weight of HF is 20 g/mol, and that of sulfolane is 120 g/mol – so molecules of sulfolane weigh 6 times as much. Adding sulfolane to HF increases the mixture molecular weight, so increases the gas density when it evaporates in a release. Still, to exceed the effective density of air (molecular weight 29 g/mol), at least 37% by weight sulfolane (9% mole fraction) would be needed – if evaporation resulted in only pure gas. Instead, when liquid HF (or MHF) is released and mixed with air, there is substantial cooling by evaporation and by depolymerization, such as $(HF)_6 \rightarrow 6HF$[2]. The air/HF mixture temperature drops below the dew point, and a fog is formed by condensation of water vapor in the air. Then, the effective density exceeds that of air, so this becomes a ground hugging fog. The water aerosol warms up again as it absorbs the HF. But, water has low volatility, so the fog persists.

Vapor pressure is the only fluid property related to the claimed relative safety of MHF. Added sulfolane reduces the MHF vapor pressure relative to that of pure HF. Raoult's law for ideal liquids estimates the vapor pressure as proportional to mole fraction, so about 98% that of pure HF. However, the mixture is not an ideal liquid. Data show the vapor pressure of MHF (with 10% by weight sulfolane) to be 89% of that for pure HF[3]. Vapor pressures of HF[4] and MHF are shown in Figure 1 as functions of temperature. HF (boiling point 67°F) and MHF (boiling point 73°F) are both very volatile. If the MHF were 6°F (3.3°C) warmer, its vapor pressure would equal that of HF.

Figure 1 – Vapor Pressure of HF and MHF

In 1986, Lawrence Livermore and Amoco Oil Company conducted what has become known as the Goldfish tests. In each test, 8,300 lb of 104°F (40°C) HF was released in the Nevada desert on a smooth, dry lake bed with about a 10 mph wind. Nitrogen gas above the HF liquid pressurized the tank to about 130 psia. These conditions were selected to match what exists at refineries[5]. However, single vessels at the Torrance refinery, for example, hold six times as much HF (50,000 lb).

community in the use of MHF at refineries in urban settings.



References and Notes

1. Honeywell MSDS 14512, Modified Hydrofluoric Acid – 90%
2. W. Schotte, "Fog formation of hydrogen fluoride in air," Ind. Eng. Chem. Res., 26, 300-306 (1987).
3. U.S. Patent 5,654,251, Figure 1.
4. Lange's Handbook of Chemistry
5. The temperature of the 50,000 lb of MHF in the Torrance refinery's Acid Settler Tank is nearly identical, at 105°F. Consent Decree Safety Advisor Steve Maher presented a chart titled "AHF/MHF" which listed "Typical settler temperature 105°F" at the 10/13/2015 City of Torrance Workshop regarding ExxonMobil's use of MHF catalyst.
6. R. Muralidhar, G.R. Jersey, F.J. Krambeck, S. Sundaresan, "A two-phase release model for quantifying risk reduction for modified HF alkylation catalysts," J. Hazardous Materials, 44, 141-183 (1995).
7. D. Blewitt, J. Yohn, R. Koopman, and T.C. Brown, 1987, "Conduct of Anhydrous Hydrofluoric Acid". International Conference on Vapor Cloud Modeling, Boston MA, Nov 2-4, (1987).

Torrance Refining Company

****Note: Purple boxes added to TRAA's original image/text to highlight specific points referenced/discussed***

FACT: TRAA's MHF and HF Vapor Pressure Graph is based on theoretical data and unsupported assumptions

- **Patent US 5,654,251 states the following in support of low concentrations of MHF Additive being effective in depressing vapor pressure:**

  *"One **important function** of the presence of the sulfone component in the composition is its vapor pressure depressant effect upon the overall catalyst composition. Therefore, to take advantage of the vapor pressure depressant effects of the sulfone compound, it is **desirable to utilize the sulfone in the catalyst mixture in an amount in the range of from about 2.5 weight percent to about 50 weight percent**. In the situation where both vapor pressure depression and improved catalytic activity and selectivity are desired, the **composition that works best in the alkylation of olefins has less than 30 weight percent sulfone.**" **[Emphasis added.]***

- **TRAA source: Harpole article based on theoretical data rather than actual data**
  - Harpole uses AHF data that is **NOT** relevant/applicable to MHF
  - Harpole does **NOT** include the other components of MHF – water and ASO
  - Harpole's theory is **NOT** supported by testing
  - Harpole's conclusion is **NOT** supported by a third party review

Reference

- *Patent US 5,654,251*

Torrance Refining Company

MYTH - TRAA Slide 12: TRAA's MHF and HF Vapor Pressure Graph is based on actual data

TRAA "Case Against MHF" Jan 4, 2017 – Slide 12

Referenced Article
by TRAA Science Panel Member

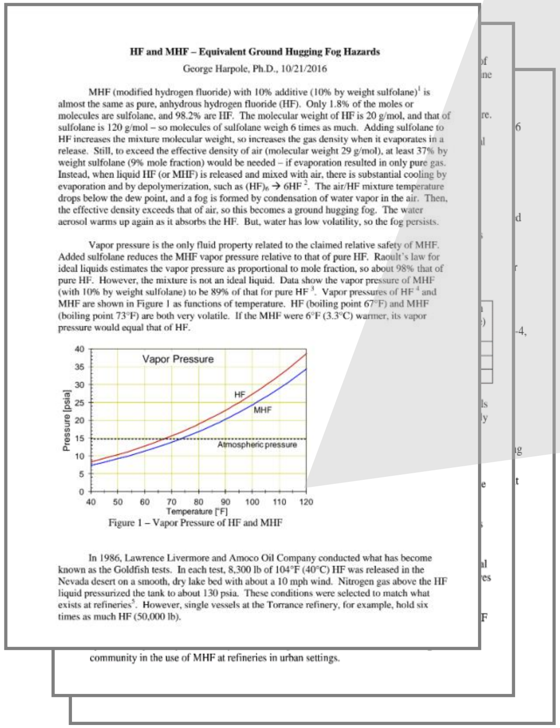


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Figure 1 – Vapor Pressure of HF and MHF

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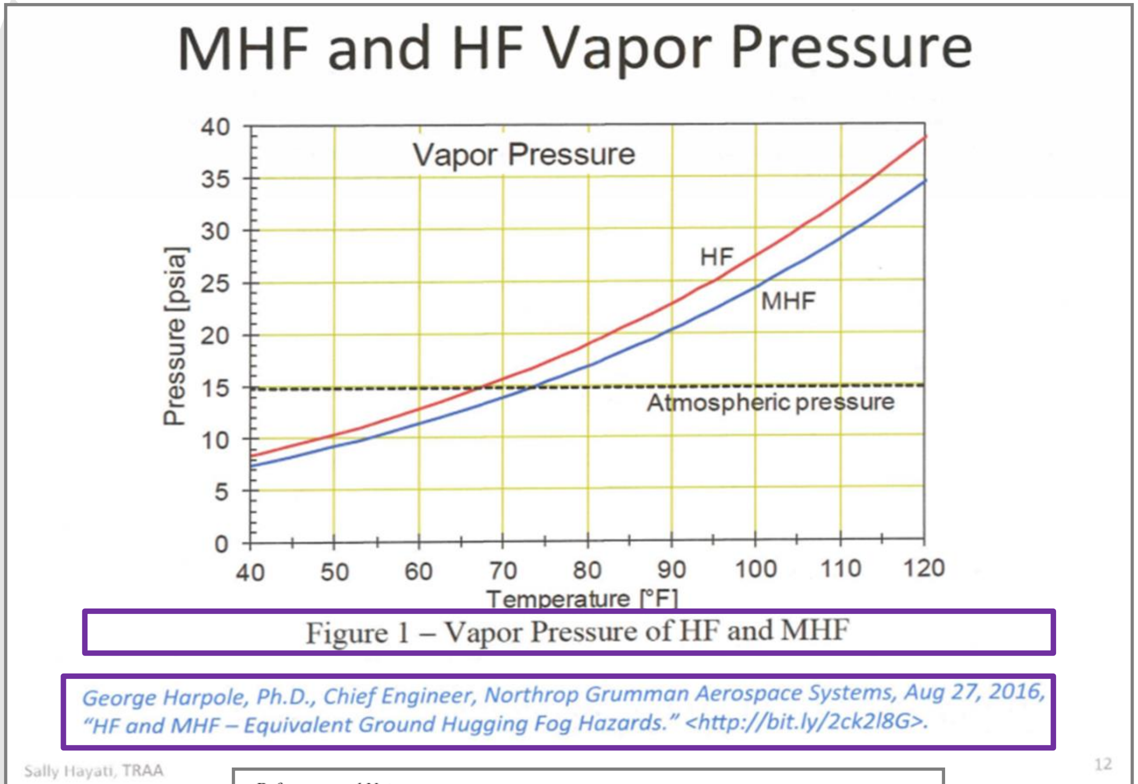

References and Notes

1. Honeywell MSDS 14512, Modified Hydrofluoric Acid – 90%
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Torrance Refining Company

****Note: Purple boxes added to TRAA's original image/text to highlight specific points referenced/discussed***

FACT: TRAA's MHF and HF Vapor Pressure Graph is based on theoretical data and unsupported assumptions

- **1995 Patent referenced in Harpole's article does <u>NOT</u> support his theoretical assumption that Flash Atomization will occur**

- **Referenced 1995 research summary article actually states: *"This aerosolization tendency can be significantly reduced by introducing an additive, which reduces the vapor pressure thereby eliminating flash atomization."***
    - Harpole ignores this and all data that supports testing and MHF efficacy

<u>References</u>

- *Patent US 5,654,251*
- *R. Muralidhar, G.R. Jersey, F.J. Krambeck, S. Sundaresan, "A two-phase release model for quantifying risk reduction for modified HF alkylation catalysts," J. Hazardous Materials, 44, 141-183 (1995)*

Torrance Refining Company

MYTH - TRAA Slide 13: Patent table refers to MHF: "Appearance is 'fuming,' like HF's. NOT SAFE."

TRAA "Case Against MHF" Jan 4, 2017 – Slide 13

MHF with ≤ 20% additive is described as "fuming," like HF

MHF's 1992 European patent submitted by Phillips (Mobil's co-developer) test data is given for additive concentrations from 20% to 50%. No data is given for any lower concentration, since that was too low to confer any "safety" advantage over HF.

Example	1	2	3	4
Catalyst	HF	HF/ Sulfolane (80/20)	HF/ Sulfolane (60/40)	HF/ Sulfolane (50/50)
Appearance	Fuming	Fuming	Liquid	Liquid

Phillips Petroleum Co, 1992, Patent EP 0796657 B1, "Alkylation catalyst containing hydrofluoric acid & a sulfone."

Example column 2 is MHF with 20% additive (Sulfolane) and 80% HF. 71ºF.

- Appearance is "fuming," like HF's. NOT SAFE. MHF w/ 10% additive will be even more like HF.
- ≥ 40% additive appears as a liquid. SAFER, although some HF does get airborne.

Yet Phillips notes, "Alkylate quality… decreased with further Sulfolane" above 20% and isoparaffin/olefin alkylation *ceased* for additive concentration > 50%. MHF isn't viable.

Sally Hayati, TRAA 13

****Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed***

FACT: TRAA's "Table A" includes partial information - NOT the complete, original table, which shows ALL alkylate properties

- **Actual table from patent shows additional information and refers to alkylate product rather than MHF; TRAA misleadingly indicates the table refers to MHF**

Table A

Example	1	2	3	4
Catalyst	HF	HF/ Sulfolane (80/20)	HF/ Sulfolane (60/40)	HF/ Sulfolane (50/50)
Appearance	Fuming	Fuming	Liquid	Liquid
Alkylate Product wt %				
C_5-C_7	5.5	4.7	5.9	8.3
C_8	88.1	89.3	85.5	79.9
C_9+	6.4	6.0	8.6	11.8
TMP/DMH	9.2	9.4	7.5	6.5
Olefin Conv., %	99.9	100	98.0	98.8

EP 0 796 657 B1

**Note: Green box added to original image from Patent to highlight specific point referenced/discussed*

Torrance Refining Company

MYTH - TRAA Slide 13: Patent says "Appearance is 'fuming,' like HF's. NOT SAFE."

TRAA "Case Against MHF" Jan 4, 2017 – Slide 13

MHF with ≤ 20% additive is described as "fuming," like HF

MHF's 1992 European patent submitted by Phillips (Mobil's co-developer) test data is given for additive concentrations from 20% to 50%. No data is given for any lower concentration, since that was too low to confer any "safety" advantage over HF.

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Yet Phillips notes, "Alkylate quality… decreased with further Sulfolane" above 20% and isoparaffin/olefin alkylation *ceased* for additive concentration > 50%. MHF isn't viable.

Sally Hayati, TRAA 13

***Note: Purple boxes added to TRAA's original image/text to highlight specific points referenced/discussed*

Torrance Refining Company

FACT: <u>NOTHING</u> in Patent EP 07 96657 B1 says MHF was fuming and is not safe or viable

- **Patent EP 07 96657 B1 does <u>NOT</u> define fuming and the mentioning of fuming in the patent application is <u>NOT</u> indicative of Rainout from MHF**

- **Sample analyzed in "Table A" on TRAA's slide is alkylate product - <u>NOT</u> acid**
  - Patent lines [0038] [0039] state:

    "Samples of liquid and gas products were analyzed."

- **"Table A" on TRAA's slide includes partial information - <u>NOT</u> the patent's complete, original table, which shows <u>ALL</u> alkylate properties**

- **Patent line [0040] states: "*performance was comparable to pure HF*"**
  - This patent statement refers to alkylate product quality, including appearance, from a mixture of 20 wt% Additive and 80 wt% HF
  - **<u>NOT</u>** that the MHF acid had the same appearance as pure HF

- **Subsequent patents quantify Rainout in great detail**

<u>Reference</u>

- *Patent EP 0796657 B1*

Torrance Refining Company

MYTH - TRAA Slide 13: "No data is given for any lower concentration [MHF with ≤ 20%], since that was too low to confer any safety advantage over HF."

TRAA "Case Against MHF" Jan 4, 2017 – Slide 13

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MHF's 1992 European patent submitted by Phillips (Mobil's co-developer) test data is given for additive concentrations from 20% to 50%. No data is given for any lower concentration, since that was too low to confer any "safety" advantage over HF.

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Sally Hayati, TRAA 13

****Note: Purple boxes added to TRAA's original image/text to highlight specific points referenced/discussed***

Torrance Refining Company

FACT: Patent US 5,654,251 presents data that the Additive was tested at concentrations as low as 2.5 wt% Additive

- **Patent EP 0796657 B1 <u>is silent</u> on whether lower concentrations were tested**
  - 1992: One of Mobil's earliest MHF patents
  - Patent purpose: Test pilot plant alkylate quality comparing MHF to HF catalysts

- **Patent US 5,654,251 used in Harpole's Article and referenced by TRAA indicates that Additive concentrations as low as 2.5 wt% <u>were tested</u>**
  - Harpole and TRAA ignored this information - see Slide 39

- **TRAA misrepresents the patent and ignores data that supports MHF efficacy**

<u>**References**</u>

- *Patent EP 0796657 B1*
- *Patent US 5,654,251*

Torrance Refining Company

MYTH - TRAA Slide 13: " > 40% additive appears as a liquid. SAFER, although some HF does get airborne."

TRAA "Case Against MHF" Jan 4, 2017 – Slide 13

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Sally Hayati, TRAA

13

**Note: Purple boxes added to TRAA's original image/text to highlight specific points referenced/discussed*

FACT: Patent refers to an alkylate sample - <u>NOT</u> an MHF acid sample

- **Patent EP 0796657 B1 does <u>NOT</u> state that at >40% Additive concentration the acid appears as a liquid**
  - Sample analyzed in "Table A" on this slide is alkylate - **<u>NOT</u>** an acid sample
  - Patent does **<u>NOT</u>** state that some MHF becomes airborne at Additive >40%

- **Patent line [0040] states *"performance was comparable to pure HF*"**
  - This patent statement refers to alkylate product quality, including appearance, from a mixture of 20 wt% Additive and 80 wt% HF
  - **<u>NOT</u>** that the MHF acid had the same appearance as pure HF – see Slide 43

<u>Reference</u>

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Torrance Refining Company

MYTH – TRAA Slide 13: "Phillips notes, 'Alkylate quality… decreased with further Sulfolane' above 20% and isoparaffin/olefin alkylation *ceased* for additive concentration > 50%. MHF isn't viable."

TRAA "Case Against MHF" Jan 4, 2017 – Slide 13

MHF with ≤ 20% additive is described as "fuming," like HF

MHF's 1992 European patent submitted by Phillips (Mobil's co-developer) test data is given for additive concentrations from 20% to 50%. No data is given for any lower concentration, since that was too low to confer any "safety" advantage over HF.

Example	1	2	3	4
Catalyst	HF	HF/ Sulfolane (80/20)	HF/ Sulfolane (60/40)	HF/ Sulfolane (50/50)
Appearance	Fuming	Fuming	Liquid	Liquid

Phillips Petroleum Co, 1992, Patent EP 0796657 B1, "Alkylation catalyst containing hydrofluoric acid & a sulfone."

Example column 2 is MHF with 20% additive (Sulfolane) and 80% HF. 71ºF.

- Appearance is "fuming," like HF's. NOT SAFE. MHF w/ 10% additive will be even more like HF.
- ≥ 40% additive appears as a liquid. SAFER, although some HF does get airborne.

Yet Phillips notes, "Alkylate quality… decreased with further Sulfolane" above 20% and isoparaffin/olefin alkylation *ceased* for additive concentration > 50%. MHF isn't viable.

Sally Hayati, TRAA 13

Note: Purple boxes added to TRAA's original image/text to highlight specific points referenced/discussed

Torrance Refining Company

FACT: Patent shows MHF is effective and a viable technology

- **Patent EP 0796657 B1 line [0041] states:**
  "*Alkylate quality increased slightly upon adding 20 wt% Sulfolane to HF and then decreased with further sulfolane dilution. Activity for isoparaffin/olefin alkylation was NOT observed above about 50 wt% sulfolane in HF." (Emphasis added)*

- **Patent line [0040] also states:**
  "Performance diminished slightly upon adding 50 wt% sulfolane to HF. A 40/60 HF/Sulfolane catalyst showed no activity for alkylation."

- **TRAA misrepresents the patent and ignores data that supports MHF efficacy**

Reference

- *Patent EP 0796657 B1*

Torrance Refining Company

MYTH - TRAA Slides 7, 8 and 14:
"MHF is 90% HF"; Acid is delivered with 10% Additive

TRAA "Case Against MHF" Jan 4, 2017 – Slide 7

Honeywell Material Safety Data Sheet for MHF reveals what the additive is.
http://bit.ly/21T6yAt

Component	CAS-No.	Weight percent
Hydrogen fluoride	7664-39-3	90.00%
Tetrahydrothiophene 1,1-dioxide	126-33-0	10.00%

Chemical Book, Sulfolane Basic information, ***Sulfolane CAS = 126-33-0***

Valero Wilmington Refinery RMP 2014: MHF 10% Sulfolane to reduce HF vapor
Valero adopted the ReVAP brand of MHF (developed by Mobil/Phillips, now owned by Honeywell) in 2005

TRAA "Case Against MHF" Jan 4, 2017 – Slide 14

MHF is 90% HF
-Plus 10% vapor suppressant additive Sulfolane-

REF: George Harpole, Ph.D., Chief Engineer at Northrop Grumman Aerospace Systems, Aug 27, 2016, "HF and MHF – Equivalent Ground Hugging Fog Hazards." <http://bit.ly/2ck2I8G>.

Sally Hayati, TRAA 14

TRAA "Case Against MHF" Jan 4, 2017 – Slide 8

"Trade Secret" Found in the Public Domain
-Additive concentration used is 10%-

SOURCE 1: Torrance Refinery Safety Advisor Project, Steve Maher, "Evaluation of MHF Alkylation Catalyst (Analysis of proposed additive concentration changes)," 10/1999

– This report reveals that the additive concentration was reduced in 1998. It is unknown if it was reduced again later.

SOURCE 2: Honeywell MHF Material Safety Data Sheet (MSDS). The monopoly manufacturer of MHF.
<http://bit.ly/21T6yAt>

- Hydrofluoric acid 90.00% (also 85%)
- Sulfolane (THT) 10.00% (also 15%)

SOURCE 3: Honeywell via PBF

- A range of 10-15% is given, so it is clear the concentration used is 10%, Otherwise, Honeywell would say just 15%

WHAT IS MODIFIED HYDROFLUORIC (MHF) ACID? PBF

- **Modified Hydrofluoric Acid (MHF) is HF that contains an additive that lowers the volatility of the original compound**
  - ✓ Reduces risk of exposure in the event of an MHF leak or spill
- **The MHF used at the Torrance refinery is designed to reduce the volatility, or vapor potential, of hydrofluoric acid and features an additive that can reduce the volatility by 60 to 90 percent**
  - ✓ The MHF delivered to the refinery contains the industry standard of approximately 10 to 15 percent concentration of this additive

SOURCE 4: Valero Wilmington Refinery Risk Management Program Report 2014 (adopted same MHF in 2005)

Worst-Case Toxic Scenarios

Physical State	Gas liquified by pressure
Model Used	SLAB Model
Passive Mitigation - Other	10% sulfolane additive to reduce the HF to form an aerosol on release under pressure to atmosphere. "Diffuser" or Barrier around flange.
Confidential Business Information	No

SOURCE 5: City of Torrance Refinery Workshop October 2015. Mayor P. Furey stated MHF = 90% HF + 10% additive

Sally Hayati, TRAA 8

Torrance Refining Company

****Note: Purple boxes added to TRAA's original image/text to highlight specific points referenced/discussed***

FACT: MHF is delivered at 85 wt% HF and 15 wt% Additive

- **The positive effect of MHF results from the combination of four components: Additive, Water, Acid Soluble Oil, and Hydrocarbons**
- **Torrance Refinery MHF Alkylation Unit acid concentration**

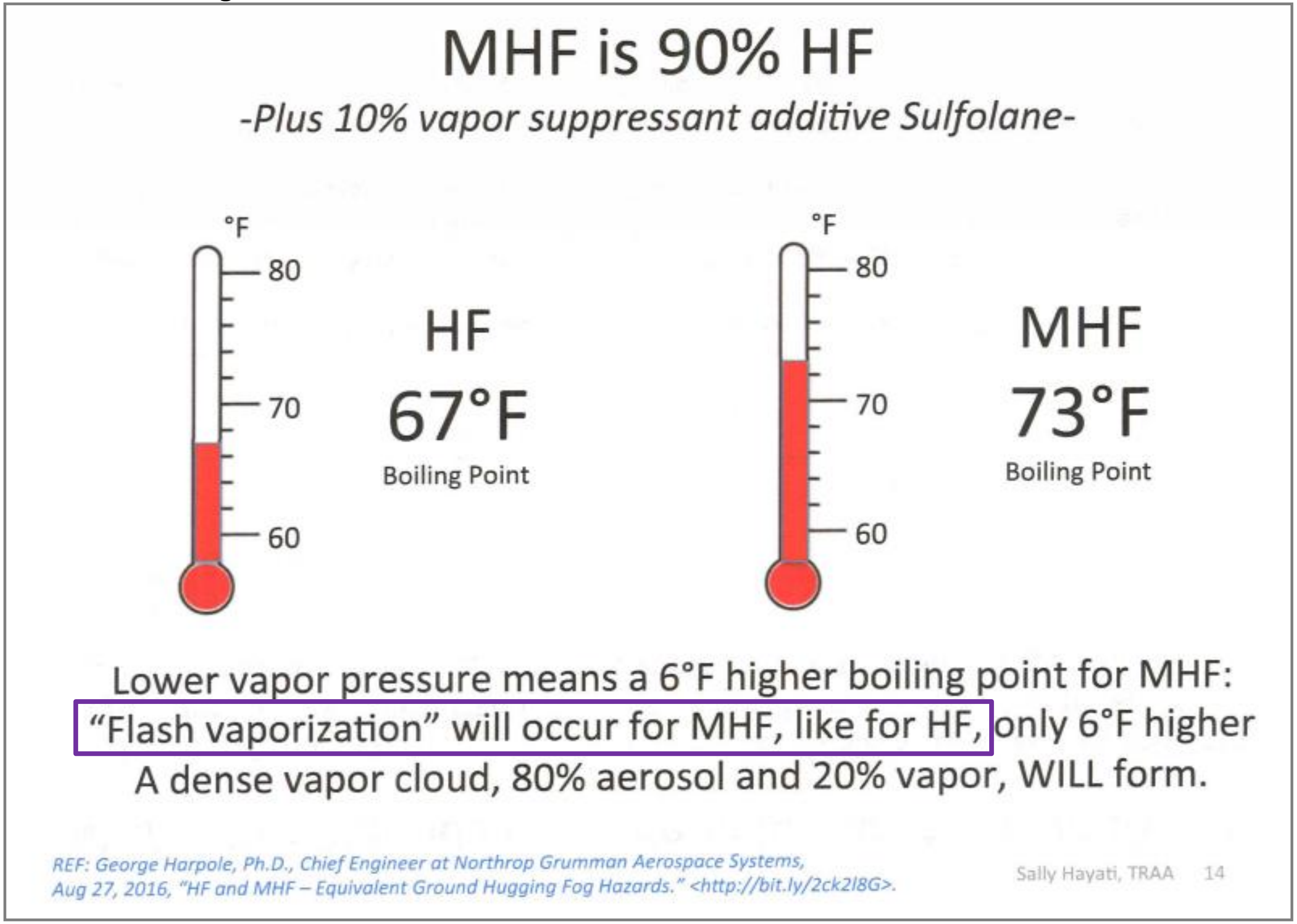
December 2016	Monthly Average	Minimum	Maximum
HF wt%	80.0	78.0	82.5
Additive wt%	7.0	5.5	8.5
Acid Soluble Oil wt%	3.0	2.2	5.2
Water wt%	3.0	2.4	3.0
Hydrocarbons wt%	7.0		
Airborne Reduction Factor %	55		

References

- *Bill of Lading from Honeywell for delivered MHF*
- *December 2016 monthly ARF email submission to Torrance Fire Department*

MYTH - TRAA Slide 14:
"Flash vaporization will occur for MHF, like for HF"

TRAA "Case Against MHF" Jan 4, 2017 – Slide 14



****Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed***

Torrance Refining Company

FACT: Hydrogen bonding prevents MHF from flash atomizing

- **Hydrogen bonding of the Additive resists vaporization of HF and prevents large-scale aerosoling of the released liquid**
- **Experiments showed that the addition of the Additive causes a significant fraction of the released HF to fall on the ground as liquid rainout**
- **Testing in 1992 and 1994 showed inclusion of Additive eliminates Flash Atomization of HF associated with a jet release**
- **Testing proved no Flash Atomization was observed for MHF compositions containing as much as 85 wt% HF up to 140°F**
- **<u>NO</u> technical data or test data supports TRAA's claim that the boiling point of MHF is 6ºF higher than HF and that flash atomization will occur**
- **TRAA's source - Harpole Article - is based on theoretical data**
  - 1995 Patent referenced in article does **<u>NOT</u>** support the theoretical assumption that Flash Atomization will occur
  - **<u>No</u>** test data supports Harpole Article and was **<u>NOT</u>** reviewed by third party

<u>References</u>

- *DAN 95M-0874 - MHF Airborne HF Reduction estimates*
- *ReVAP Tutorial page 7*
- *Patent US 5,654,251*

Torrance Refining Company

Chapter 7: Airborne Reduction Factor & Societal Risk Index

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MYTH - TRAA Slide 16: “MHF w/ <20% additive was never TESTED.” - ARF extrapolated

TRAA “Case Against MHF” Jan 4, 2017 – Slide 16

Airborne Acid Reduction Factor (ARF)

-Safety Advisor’s 1999 Report-

IV.A.12 - ARF Extrapolations Beyond Designated Concentration Range

- Figures IV.A.12-1a & IV.A.12-1b [REDACTED] illustrate the correlation of Airborne Reduction Factor (ARF) to the wt% HF and the wt% additive within the process. Figure IV.A.12-1b clearly illustrates that significant gains in ARF are achieved at relatively low additive concentrations, and that the effectiveness curve for additional additive flattens out.
- Ref. 5 [REDACTED] identifies the following equation “used to predict” Airborne Reduction Factor (ARF) (“the fraction of the total HF in the catalyst mixture that remains “bonded” to the additive portion of the mixture & rain-out with it after release”) “for mixtures varying from {REDACTED } wt% to approximately {REDACTED } wt% HF”

WHY “EXTRAPOLATE”? Because MHF w/ <20% additive was never TESTED.

WHY NOT? No “safety” advantage is gained over HF at MHF additive levels <30%.

Estimates of the ARF achieved by 10% additive can best be derived from MHF test data, not from equations written in 1998 to justify an additive reduction by a factor of three.

Sally Hayati, TRAA 16

*Note: Purple box added to TRAA’s original image/text to highlight specific points referenced/discussed

Torrance Refining Company

FACT: MHF at <20 wt% was tested – Airborne Reduction Factor (ARF) was <u>NOT</u> extrapolated

- **Additive range of concentrations <u><</u>20 wt% were tested in 1992 and 1994**
  - Tests confirmed the Additive increases ARF even at low concentrations
- **Unit ARF calculated as a function of acid, Additive, water, reactor temperature**
  - Validated rainout model has good agreement with ARF test results
- **Figure 5 shows ARF tested at different concentrations at the same temperature**
- **Figure 4 shows ARF tested at different temperatures and concentrations**

Figure 5

Effect of Composition at 105 F

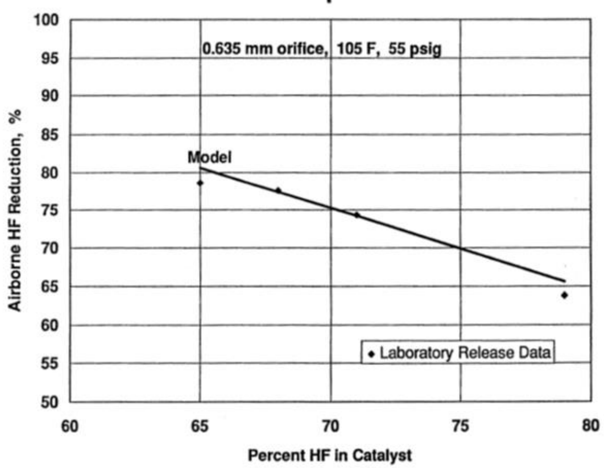
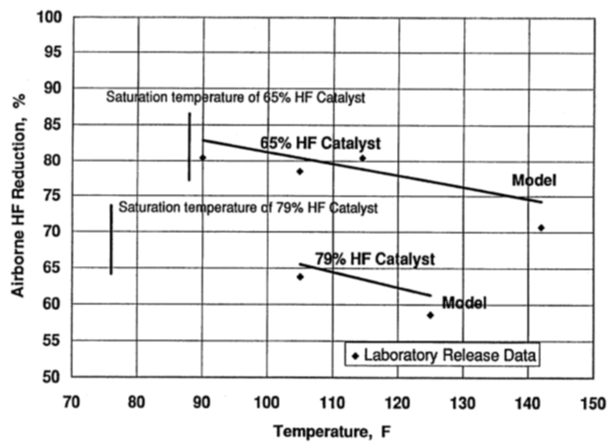


Figure 4

Effect of Temperature on Airborne HF Reduction



<u>Reference</u>

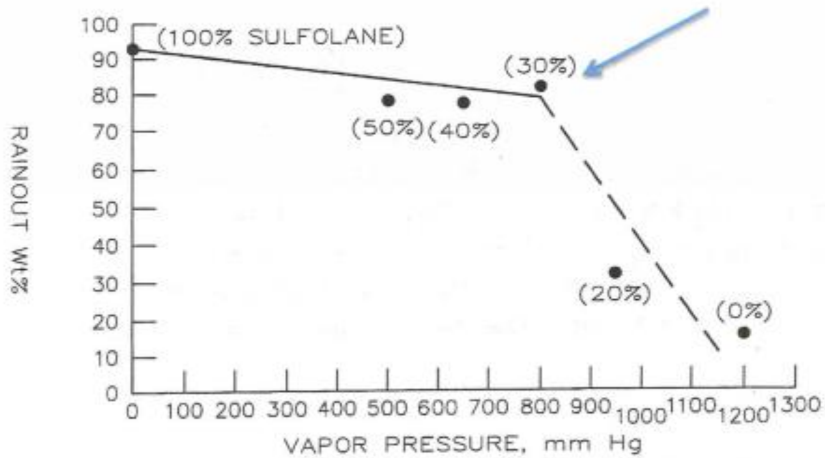
- *DAN 96M-0144 - Small Scale HF/Additive Tests at MHF Design Conditions*
- *DAN 95M-0874 - MHF Airborne HF Reduction estimates*
- *DAN 98M-0166 - Effects of Active and Passive Mitigation on AHF, AUA, and MHF Releases*
- *DAN 93M-0408 - HF/Additive Release Tests at Quest*

Torrance Refining Company

MYTH - TRAA Slide 17: “MHF ARF was Determined by Lab Testing” - ARF the sole function of vapor pressure

TRAA “Case Against MHF” Jan 4, 2017 – Slide 17

MHF ARF was Determined by Lab Testing



Phillips Patent US 5534657, 1995, "Isoparaffin-olefin alkylation."

SAFETY ADVISOR’S 1999 REPORT:

Figure IV.A.12-1b [REDACTED] clearly illustrates that significant gains in ARF are achieved at relatively low additive concentrations, and that the effectiveness curve for additional additive flattens out.

This data curve and graph show that for additive concentrations < 30%, ARF falls precipitously.

10% additive gets no higher than 10% ARF, but that falls to zero when temperatures exceed the critical superheat value and flash atomization occurs.

Table C

Conditions: about 50 psig (0,45 MPa), 90°F (32°C), 0.635 mm orifice diameter.			
Example No.	Sulfolane Wt %	TMP Wt %	Rainout, wt % by Material Balance
8	60	*	
9	50		76
10	50	69	76
11	50		82
12	40	73	76
13	40		78
14	30	78	81
15	20	80	32

* Less than 5 wt %.

Phillips Patent EP 0796657 B1, 1992,. “Alkylation catalyst containing hydrofluoric acid and a sulfone.”

Sally Hayati, TRAA

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Torrance Refining Company

FACT: ARF is <u>NOT</u> a function of Vapor Pressure

- **ARF is a function of four components: Additive, Water, Acid Strength, and Reactor Temperature – see slide 59**
    - Process chemistry safety of MHF is measured by ARF, a "release behavior" property of MHF
- **ARF represents the amount of HF that remains a liquid relative to the amount of HF potentially released to the atmosphere after a release**
    - The larger the ARF, the less potential for HF to become airborne
- **Referenced patent by TRAA is based on early MHF testing in 1992 and was filed using preliminary data**
    - Data in the chart and table are both from the 1992 testing
        - Patent updated in 1995 only with corrosion test data
    - Data had a large degree of uncertainty during early testing due to testing apparatus
        - Before the relationship between the Additive and aerosolization had been rigorously explored
    - Considerable research and testing was performed subsequent to the patent application
        - Completed large scale tests at Quest and additional small scale tests with improvements to apparatus
        - Tested additional parameters to prove MHF efficacy – see slide 59 for an example

<u>**References:**</u>

- *Patent US 5,534,657*
- *Consent Decree Safety Advisor's Report, October 1999, p 1B.A-34*
- *DAN 96M-0144 - Small Scale HF/Additive Tests at MHF Design Conditions*
- *DAN 93M-0408 - HF/Additive Release Tests at Quest*

MYTH - TRAA Slide 17: “This data curve and graph show that for additive concentrations below < 30%, ARF falls precipitously.”

TRAA “Case Against MHF” Jan 4, 2017 – Slide 17

MHF ARF was Determined by Lab Testing

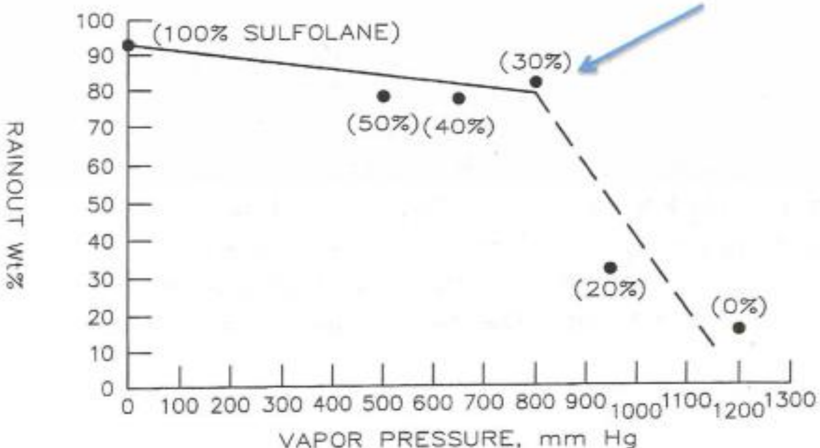

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Figure IV.A.12-1b [REDACTED] clearly illustrates that significant gains in ARF are achieved at relatively low additive concentrations, and that the effectiveness curve for additional additive flattens out.

This data curve and graph show that for additive concentrations < 30%, ARF falls precipitously.

10% additive gets no higher than 10% ARF, but that falls to zero when temperatures exceed the critical superheat value and flash atomization occurs.

Sally Hayati, TRAA 17

****Note: Purple boxes added to TRAA’s original image/text to highlight specific points referenced/discussed***

Torrance Refining Company

FACT: There are multiple errors in the analysis, assumptions, and conclusions on TRAA's Slide 17

- **Referenced patent by TRAA was a study of MHF alkylate product quality**
  - **NOT** an in-depth study of MHF Rainout and ARF
- **Error: Top table in TRAA's slide measures "Rainout" - NOT ARF**
  - MHF Rainout is different than ARF
    - Rainout - The act of a substance forming a liquid and dropping or "raining" to the ground. "Rainout percent" refers to the percentage of released liquid HF which remains as a liquid due to rainout
    - ARF - Airborne Reduction Factor **-** The percent reduction in airborne HF as compared to an unmitigated AHF release
- **Rainout and ARF associated with MHF were extensively established through rigorous lab and field testing**
  - Research and testing conducted in 1992, 1994, and 1996
- **AQMD Quote - "Addendum, Mitigated Negative Declaration, Mobil Modified Hydrogen Fluoride Conversion Project", p. 2 - July 9, 1997**
  - "The experimental testing indicated that the addition of the Mobil additive to HF was an effective method for reducing or elimination the amount of aerosol formed during a release."

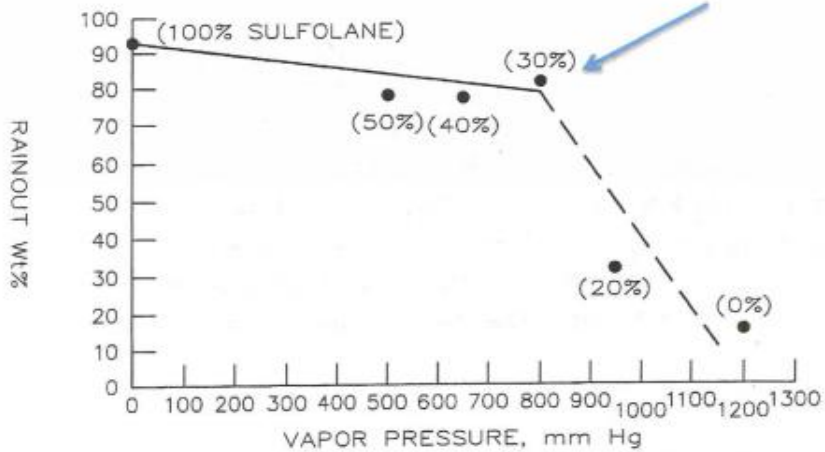
References

- *Patent US 5,534,657*
- *DAN 96M-0144 - Small Scale HF/Additive Tests at MHF Design Conditions*
- *DAN 95M-0874 - MHF Airborne HF Reduction estimates*
- *DAN 98M-0166 - Effects of Active and Passive Mitigation on AHF, AUA, and MHF Release*

MYTH - TRAA Slide 17: ARF "… falls to zero when temperatures exceed critical superheat and flash atomization occurs."

TRAA "Case Against MHF" Jan 4, 2017 – Slide 17

MHF ARF was Determined by Lab Testing



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15	20	80	32

* Less than 5 wt %.

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10% additive gets no higher than 10% ARF, but that falls to zero when temperatures exceed the critical superheat value and flash atomization occurs.

Sally Hayati, TRAA 17

****Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed***

Torrance Refining Company

FACT: No flash atomization occurs for superheated MHF

- **Testing proved no Flash Atomization was observed for MHF compositions containing as much as 85 wt% HF up to 140°F**
- **Testing showed operating temperatures as high as 140ºF do not significantly degrade MHF Rainout performance, and Flash Atomization was not apparent**
  - MHF critical superheat was not exceeded at temperatures tested
  - MHF does not flash atomize at vapor pressures above atmospheric pressure while at temperatures below critical superheat
    - Release dominated by jet hydrodynamic drop break up and droplet vaporization
  - Testing proved lower Additive concentrations had ARF that was above 50% - see slide 59
- **Testing in 1992 and 1994 showed inclusion of Additive eliminates Flash Atomization of HF associated with a jet release**
- **AQMD Quote - Wilmington Refinery Alkylation Improvement Project, Final EIR Chapter 2, p. 2-7 - SCH #20030536, certified December 16, 2004 regarding Valero's MHF Project**
  - "The modified HF catalyst reduces acid vapor pressure sufficiently to suppress the usual flash atomization process of hydrofluoric acid, causing most of the acid to fall to the ground as an easily controlled liquid and reduces the potential for off-site consequences of an accidental HF release."

References

- *DAN 96M-0144 - Small Scale HF Additive release tests at MHF design conditions*
- *DAN 95M-0874 - HF Airborne HF Reduction estimates*

Chapter 8: Using Barriers to Enhance Safety

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MYTH - TRAA Slide 18:
Table accurately reflects patent reference

TRAA "Case Against MHF" January 4, 2017 - Slide 18

MHF Lab Tests used Barriers & Collection Plates w/H2O

HF/Additive Tests — Pressure: 140 psig

HF concentration wt %	Additive wt %	Temperature °F.	Impact Plate & Pad Yes/No	Rainout wt %
50	50	110	N	64
50	50	110	Y	99
66	34	90	N	53

Mobil's Proprietary Barrier technology

Patent US5286456, 1992, Mobil Oil Corporation, Containment of an Aerosolable liquid jet,

- "Proprietary mitigation technologies" used in MHF testing (SA '95 report, V-2 (p 92))
  - Barriers to enhance droplet fallout (liquid separator)
  - Water in collection trays to act as a liquid pool evaporation suppressant
- MHF performance claims significantly less when those technologies weren't used.
  - But Alky unit 1994 design did not include any of either measure, the 1998 unit just a few barriers.
- 1994 Stipulation and Order: MHF should achieve 65% ARF using 30% additive.
  - Mobil's 1993 data table indicates that 34% additive achieves only 53% rainout (~ARF) without proprietary barriers (impact plate & pad). 30% would get less.

Sally Hayati, TRAA 18

****Note: Purple boxes added to TRAA's original image/text to highlight specific points referenced/discussed***

Torrance Refining Company

FACT: TRAA altered the Table in this patent by inserting an Additive wt% column and deleting a test number row

HF/Additive Tests

Test No	HF concentration wt %	Pressure psig	Temperature °F.	Impact Plate & Pad Yes/No	Rainout wt %
34	50	140	110	N	64
36	50	140	110	Y	99
33	66	140	90	N	53
37	69	140	90	Y	94

***Note: This is the original table from the patent*

Green boxes highlight specific points discussed on slide 71

References

- *Patent US 5,286,456*
- *DAN 98M-0166 - Effects of Active and Passive Mitigation on AHF, AUA & MHF Releases*

Torrance Refining Company

MYTH - TRAA Slide 18:
"MHF Lab Test used Barriers & Collection Plates w/H20"

TRAA "Case Against MHF" January 4, 2017 - Slide 18

MHF Lab Tests used Barriers & Collection Plates w/H2O

Mobil's Proprietary Barrier technology

HF concentration wt %	Additive wt %	Temperature °F.	Impact Plate & Pad Yes/No	Rainout wt %
	HF/Additive Tests		Pressure: 140 psig	
50	50	110	N	64
50	50	110	Y	99
66	34	90	N	53

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Sally Hayati, TRAA

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****Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed***

Torrance Refining Company

FACT: There are multiple errors in TRAA analysis, assumptions, and conclusions on TRAA Slide 18

- **TRAA altered the table in Slide 18 from the original patent document**
  - Deleted data – test number column
  - Deleted data – entire last row in original table – test no. 37
  - Deleted the "Pressure, psig" column
  - Manipulated data - Additive wt% column added using a font type that mimics the original patent
  - Incorrectly assumed Additive concentrations in patent table were "1 - HF"
  - See actual table from patent on slide 69

- **Collection trays containing water referenced in the patent were used to capture and prevent HF from escaping the test apparatus**
  - Collection trays were <u>NOT</u> considered barriers for testing purposes
  - Three collection trays filled with water in lab testing apparatus were <u>NOT</u> meant to mitigate or evaluate barrier effectiveness
  - 1998 MHF design had many barriers as stated in the Safety Advisors 1999 Report

- **The patent's author references the deleted data featured in Test No. 37: "Tests 36 and 37 of the Table, installation of an impact plate covered with steel mesh demister pads at approximately 3 feet the orifice increased rainout by about 35-40%."**

<u>**Reference**</u>

- *Patent US 5,286,456*

MYTH - TRAA Slide 18: "Mobil's 1993 data table indicates that 34% additive achieves only 53% rainout (~ARF)" - "1994 Stipulation and Order: MHF should achieve 65% ARF using 30% additive."

TRAA "Case Against MHF" January 4, 2017 - Slide 18

MHF Lab Tests used Barriers & Collection Plates w/H2O

HF concentration wt %	HF/Additive Tests: Additive wt %	Temperature °F.	Pressure: 140 psig: Impact Plate & Pad Yes/No	Rainout wt %
50	50	110	N	64
50	50	110	Y	99
66	34	90	N	53

Mobil's Proprietary Barrier technology

Patent US5286456, 1992, Mobil Oil Corporation, Containment of an Aerosolable liquid jet,

- "Proprietary mitigation technologies" used in MHF testing (SA '95 report, V-2 (p 92))
  - Barriers to enhance droplet fallout (liquid separator)
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Sally Hayati, TRAA 18

**Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed*

Torrance Refining Company

FACT: There are multiple errors in the analysis, assumptions, and conclusions on TRAA Slide 18

- **1995 Court-order stated 65% ARF - NOT an Additive percentage**
  - The initial Consent Decree was 65% ARF with ~19 wt% Additive
  - 1998 MHF Alkylation Unit had **ALL** barriers in place
    - Flange shrouds, settler vessel bellypans, and pump barriers

- **TRAA's altered table in slides 68, 70 and 72 is from Mobil Patent US 5,286,456 filed in 1992 NOT 1993**

- **Patent US 5,286,456 references the Large Scale Tests conducted at Quest**
  - Additive concentration in Quest tests was **NOT** "1-HF" as TRAA misleadingly represents
  - Quest test measured MHF Rainout NOT ARF

- **TRAA misstates the actual intent of Patent US 5,286,456**

References

- *Patent US 5,286,456*
- *DAN 93M-0408 - HF/Additive Release Tests at Quest*

Torrance Refining Company

MYTH - TRAA Slide 20: "Significant differences between lab test setup and Alky Unit Barriers" and "never tested"

TRAA "Case Against MHF" Jan 4, 2017 – Slide 20

Barriers to Enhance HF Rainout

-Significant Differences between lab test setup and Alky Unit barriers-

	Temp ºF	Additive %	Barrier Distance, in.	% HF Rainout
Tested	89.6	29	40	89-90
Modeled	105.0	10	1 - 3	95.8

- Barrier technology employed in small scale lab performance MHF testing
  - Patent US5286456, 1992, Mobil Oil Corporation, Containment of an aerosolable liquid jet
  - Release orifice diameter: 0.025" (0.635 mm); Flow chamber size: 40" x 12" x 6."
  - End of chamber impingement plate (barrier) covered by steel wool to minimize splashing
  - 3 collection trays filled with water at chamber bottom to suppress vaporization
- 1998 alky unit barrier configuration very different from lab setup
  - Releases from 2-inch holes in the open air, not from .025" holes in a small chamber
  - Higher temp, lower additive %, shorter barrier distance, no steel wool, no H2O
  - **Barriers only "protect" bottom acid settler tanks (3"), acid circulation pump seals (1")**
  - Clear polymer flange pipe shrouds: so poorly conceived Mobil stopped claiming credit
- The alkylation unit configuration performance never tested, just simulated
  - Software model used had known weaknesses with unquantified inaccuracies

Sally Hayati, TRAA

20

*Note: Purple boxes added to TRAA's original image/text to highlight specific points referenced/discussed

FACT: There are multiple errors in TRAA's analysis, assumptions, and conclusions on Slide 20

- **1992 Patent US 5,286,456 references lab apparatus used for testing different HF concentrations, NOT the Torrance Refinery MHF Alkylation Unit barriers**
  - TRAA misrepresents patent's intent and subject matter
- **Table referenced in TRAA's slide is NOT included in Patent US 5,286,456**
  - TRAA created this table - contains erroneous data with no sources cited
    - Additive percentage not included in original patent
  - HF Rainout associated with the Additive is accurate as shown
  - Barrier effectiveness at short distances (< 1 foot) and current MHF Alkylation Unit operating conditions (105ºF) were tested, not modeled, during the Small Scale Tests
- **Testing proved that MHF Additive coupled with barriers effectively prevents Flash Atomization and increases Rainout**
- **Safety Advisor's October 1999 Report found the ARF for Torrance Refinery's MHF Alkylation Unit increased from 65% in 1995 (MHF-AUA Chemistry) to 89% in 1999 (MHF-AUA chemistry + Barriers)**

References

- *Patent US 5,286,456*
- *DAN 98M-0166 - Effects of Active and Passive Mitigation on AHF, AUA & MHF Releases*
- *DAN 96M-0144 - Small Scale HF Additive Release test at MHF design conditions*

MYTH - TRAA Slide 20: "Significant differences between lab test setup and Alky Unit Barriers" and "never tested"

TRAA "Case Against MHF" Jan 4, 2017 – Slide 20

Barriers to Enhance HF Rainout

-Significant Differences between lab test setup and Alky Unit barriers-

	Temp ºF	Additive %	Barrier Distance, in.	% HF Rainout
Tested	89.6	29	40	89-90
Modeled	105.0	10	1 - 3	95.8

- Barrier technology employed in small scale lab performance MHF testing
  - Patent US5286456, 1992, Mobil Oil Corporation, Containment of an aerosolable liquid jet
  - Release orifice diameter: 0.025" (0.635 mm); Flow chamber size: 40" x 12" x 6."
  - End of chamber impingement plate (barrier) covered by steel wool to minimize splashing
  - 3 collection trays filled with water at chamber bottom to suppress vaporization
- 1998 alky unit barrier configuration very different from lab setup
  - Releases from 2-inch holes in the open air, not from .025" holes in a small chamber
  - Higher temp, lower additive %, shorter barrier distance, no steel wool, no H2O
  - **Barriers only "protect" bottom acid settler tanks (3"), acid circulation pump seals (1")**
  - Clear polymer flange pipe shrouds: so poorly conceived Mobil stopped claiming credit
- The alkylation unit configuration performance never tested, just simulated
  - Software model used had known weaknesses with unquantified inaccuracies

Sally Hayati, TRAA

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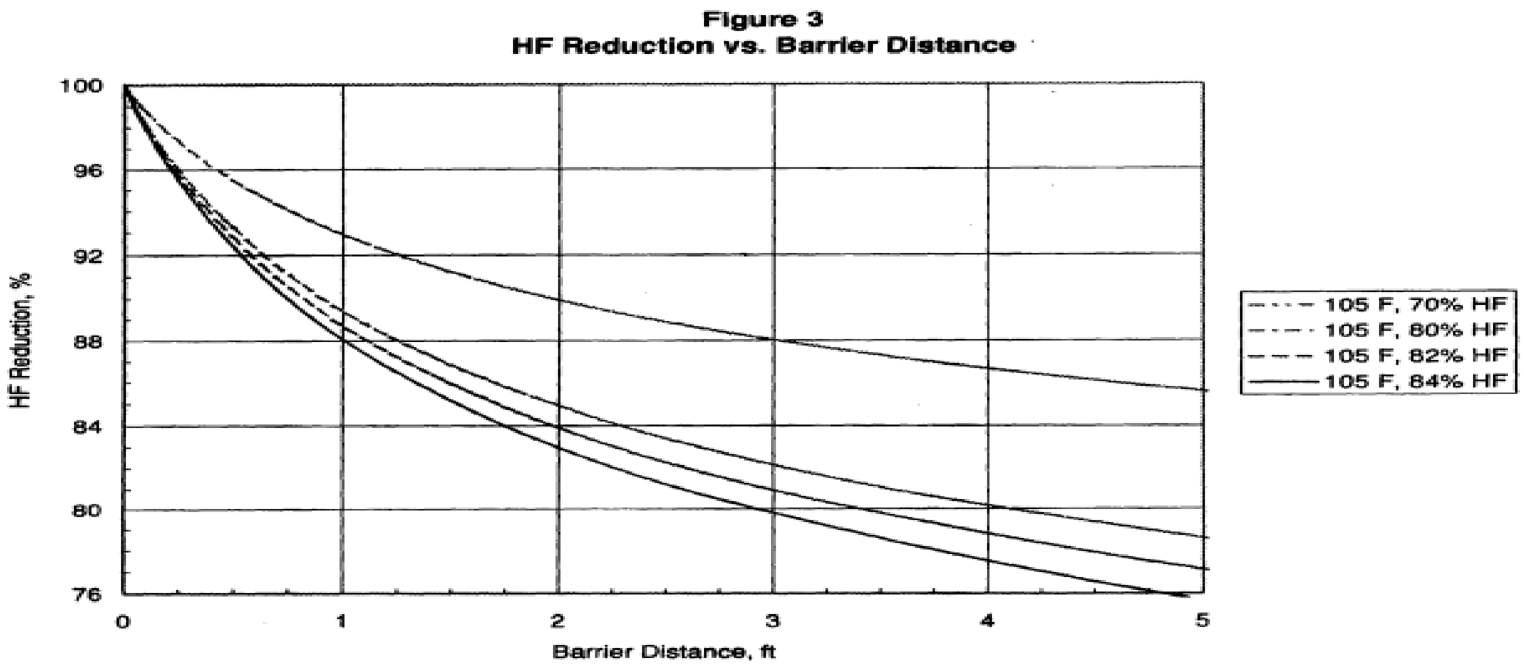
****Note: Purple boxes added to TRAA's original image/text to highlight specific points referenced/discussed***

Torrance Refining Company

FACT: Testing showed barriers are effective and confirmed ARF data



- **Figure shows barrier effectiveness over distances less than one foot provides greater than 90% ARF**

<u>Reference</u>

- *DAN 98M-0166 - Effects of Active and Passive Mitigation on AHF, AUA & MHF Releases*

MYTH - TRAA Slide 20: "Mobil stopped claiming credit" for pipe flange shrouds

TRAA "Case Against MHF" Jan 4, 2017 – Slide 20

Barriers to Enhance HF Rainout

-Significant Differences between lab test setup and Alky Unit barriers-

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  - Software model used had known weaknesses with unquantified inaccuracies

Sally Hayati, TRAA 20

**Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed*

FACT: “Mobil DID claim credit for pipe flange shrouds”

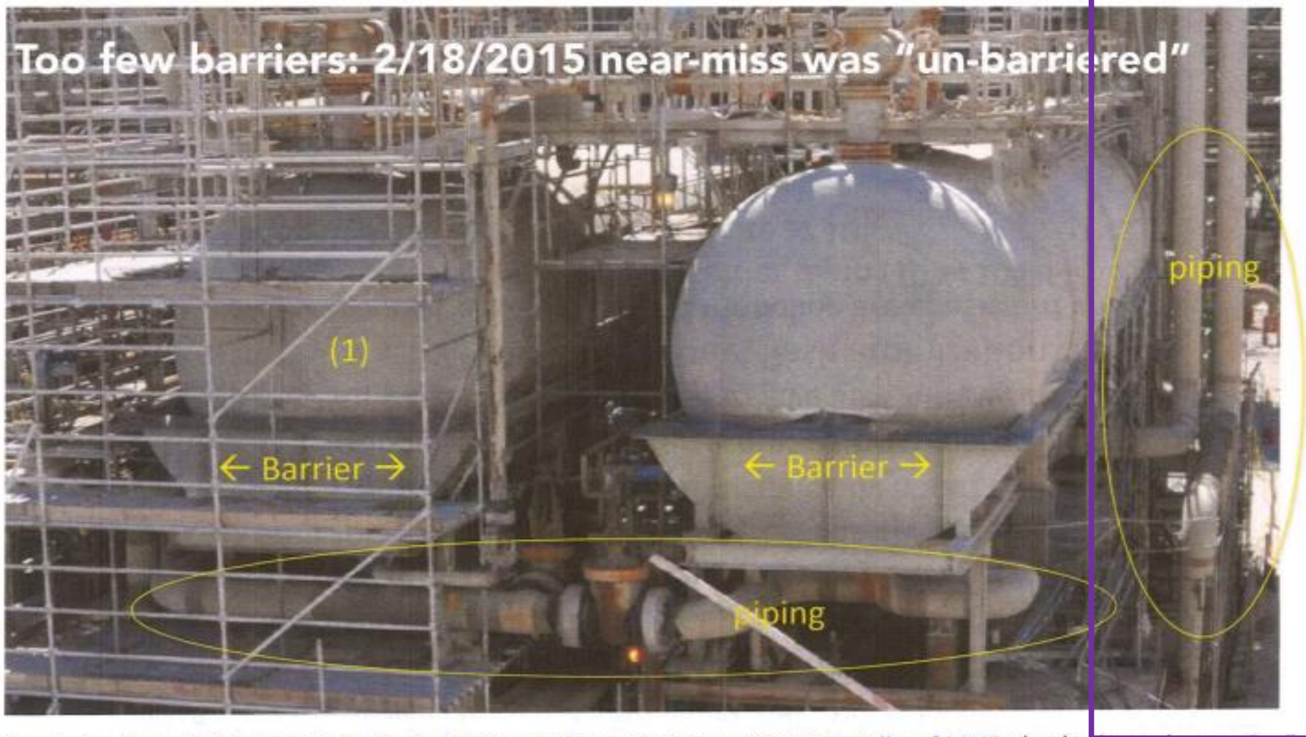
- **Mobil claimed credit for pipe flange shrouds after testing in 1997 proved their effectiveness**
  - Barrier testing in 1992 occurred before flange barriers were developed
- **Flange barrier testing simulated large catastrophic leak on 15 different types of barriers**
  - Shroud material tested and proved compatible with MHF
  - Current MHF Alkylation Unit flange shrouds pressure-tested annually with TFD present
    - Shrouds pass annual test at 250 psig and continue functioning as designed
- **All barriers, including pipe flange shrouds, are used in QRA calculations to determine SRI**
- **Torrance MHF Alkylation Unit Operators monitor the integrity of all barriers daily**
  - TFD notified if a barrier is not fully functional
- **Steel mesh pad installed in flange barrier outlets diffuse liquid flow to minimize splashing**

References

- *DAN 98M-0166 - Effects of Active and Passive Mitigation on AHF, AUA & MHF Releases*
- *DAN 98M-0699 - Cold Flow Experiments to develop Flange Barriers for the Torrance MHF Unit*
- *TFD Chief Dumais' presentation at the Torrance City Council - TORC Workshop on February 28, 2017*

MYTH – TRAA Slide 21: "MHF would form a gas and flash out of the tank from a breach anywhere, including the top"

TRAA "Case Against MHF" Jan 4, 2017 – Slide 21



CSB's photo of alkylation unit Acid Settlers (1) and (2), each containing 50,000 lb. of MHF plus hydrocarbons. On Feb. 18, 2015, an 80,000 lb. piece of the ESP crashed feet from tank (2). ExxonMobil claims their settler tank is impervious. But piping isn't. ExxonMobil claims MHF couldn't escape even if a hole were made in the tank top because acid settles to the bottom. Thus the apron barrier. But at Texas City Marathon refinery in 1987, 65K lb. of HF were released after falling equipment broke a 2" pipeline above the liquid level. The SA says the typical settler temperature is 105°F. MHF's boiling point is 73°F. MHF is "liquid under pressure." MHF would form a gas and flash out of the tank from a breach anywhere, including the top. Approximately 80% of released MHF would be an aerosol and 20% vapor.

Sally Hayati, TRAA

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****Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed***

FACT: Liquid at the top of the Settler is primarily hydrocarbons that would auto-refrigerate if Settler were breached

- **Both Torrance acid settlers are 2" thick carbon steel vessels**
  - MHF resides at the bottom of the settler below the settler barrier
  - If a settler is breached, liquid hydrocarbons would auto-refrigerate
  - Release from settlers above barriers would be ~98 wt% hydrocarbons and ~1.5 wt% HF
    - Material would be quickly contained and suppressed by safety systems
- **Comparing MHF settler leak to the 1987 Marathon HF incident is misleading, inappropriate, and creates unwarranted fears**
  - Marathon leak was a vapor release of HF-AUA, **NOT** MHF
  - No fatalities
- **Myth: TRAA claims exposed piping to right of settlers in slide 80 contains MHF**
  - Fact: Image shows out-of-service cooling water pipes - **NO** threat of MHF release
- **1992 and 1994 testing showed HF Additive eliminates Flash Atomization of HF associated with a jet release**
  - Testing proved no Flash Atomization was observed for MHF compositions containing as much as 85 wt% HF up to 140°F

References

- *UOP Design Process Flow Diagram (Heat & Material Balance)*
- *DAN 95M-0874 (MHF Airborne HF Reduction estimates)*

MYTH - TRAA Slide 22: "Barriers Won't Work as Claimed … SW [software] could not model flash atomization."

TRAA "Case Against MHF" Jan 4, 2017 – Slide 22

Barriers Won't Work as Claimed

- 2-phase software model used to estimate performance
  - based on hydrodynamics of jet releases & thermodynamic equilibrium
  - "A two phase release model for quantifying risk reduction for modified HF alkylation catalysts," R. Muralidhar, Mobil, 7 April 1995, Journal of Hazardous Materials 44 (1995) 141-183, <http://bit.ly/2hNYvXz>.
- SW model was never validated against the different alky unit setup
- Safety Advisor admitted that this model …
  - was accurate only for a barrier distances exceeding 3 ft
  - didn't account for "increased splashing" at 1-3" barrier distance
  - "Overpredicted" ARF for shorter barrier distance by about 6%
- 89% is the ARF Mobil assumed for every release obstructed by any barrier.
  - "fudge factor" for each case was chosen to give 89% ARF, w/ no justification
- Most importantly: the SW could not model flash atomization.
  - Mobil & SA ('99 report, p. xiv): data and modeling are consistent with no aerosolization at'98 concentration and settler temp (10%, 105ºF)
  - But MHF with 10% additive will flash atomize at 105ºF

Sally Hayati, TRAA 22

*Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed

Torrance Refining Company

FACT: Testing proves barriers work - agreement exists between models and experimentally measured ARF

- **Rainout Model predictions for ARF at short distances show steep increase toward 100% airborne reduction**
- **Rainout Model is based on "first principles" and appears to over-predict ARF at distances less than one foot, while predictions for 3 feet and beyond are accurate**
  - Reasoning: liquid hitting a target at close range drops to the ground with some splashing
  - First principles: Hydrodynamics of jet releases and thermodynamic equilibrium
- **ARF at very short barrier distances is only minimally dependent on the acid concentration**
  - HF reduction results primarily from reducing jet release flight time rather than from suppressing vapor pressure
  - Barriers are intended to break the velocity and momentum of the escaping jet stream
- **Testing proved no Flash Atomization was observed for MHF compositions containing as much as 85 wt% HF up to 140°F**

References

- *DAN 96M-0144 - Small Scale HF/Additive Tests at MHF Design Conditions*
- *DAN 98M-0166 - Effects of Active and Passive Mitigation on AHF, AUA & MHF Releases*
- *DAN 95M-0874 - MHF Airborne HF Reduction estimates*

MYTH - TRAA Slide 22: " 'Fudge factor' for each case was chosen to give 89% ARF"

TRAA "Case Against MHF" Jan 4, 2017 – Slide 22

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  - But MHF with 10% additive will flash atomize at 105ºF

Sally Hayati, TRAA 22

**Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed*

Torrance Refining Company

FACT: 89% ARF based on actual testing with barriers

- **Barriers on the acid settlers are 3” from potential leak source**
  - Model predicts 95.8% ARF for these conditions
  - Conservative 89% ARF was used - adjusted for shorter travel distance of 3” vs 8”

- **ARF was conservatively adjusted to 89% for pipe flange covers at <1” distance**
  - Same ARF as acid settler barriers - also adjusted because collected liquid that drops to ground will experience small amount of vaporization

- **Acid circulation pump seal barriers at 89% ARF are also conservatively estimated**

Reference

- *DAN 98M-0166 - Effects of Active and Passive Mitigation on AHF, AUA & MHF Releases*

MYTH - TRAA Slide 23: "Rained out acid rapidly forms a vapor with some droplets"; "Double credit taken for the questionable benefits of this technology"

TRAA "Case Against MHF" Jan 4, 2017 – Slide 23

Barriers Won't Work as Claimed

- Rained out acid rapidly forms a vapor with some droplets
  - Rained out acid will still becomes airborne although at a slower rate.
  - Some level of cloud concentration reduction is the only benefit.
  - Because of the energy of release, water in pan can't stop vaporization.
- Double credit taken for the questionable benefits of this technology
  - The MHF test setup included a barrier, wire mesh, plus collection tray w/ water setup
  - Basic MHF ARF claims are valid only with this technology ("impact plate & pad").
  - 1997 MHF unit design didn't have barriers; couldn't have achieved promised 65% ARF.

		HF/Additive Tests		Pressure: 140 psig	
Test No	HF concentration wt %	Addi itive wt %	Temper- ature °F.	Impact Plate & Pad Yes/No	Rainout wt %
34	50	50	110	N	64
36	50	50	110	Y	99
33	66	34	90	N	53
37	69	31	90	Y	94

1990: 50% add → 100% rainout

1994: 30% add → 65% rainout

Sally Hayati, TRAA

23

**Note: Purple boxes added to TRAA's original image/text to highlight specific points referenced/discussed*

Torrance Refining Company

FACT: There are multiple errors in the analysis, assumptions, and conclusions on TRAA Slide 23

- **Double credit is <u>NOT</u> taken - the Additive's hydrogen bonding helps hold MHF in a liquid pool, which minimizes evaporation after Rainout**
  - Tests prove rained out MHF acid does **<u>NOT</u>** "rapidly" form a vapor cloud
  - Flange barriers in the MHF Alkylation Unit do have wire mesh pads

- **Testing in 1992 and 1994 showed inclusion of Additive eliminates Flash Atomization of HF associated with a jet release**

- **If released, rained out MHF will be diluted by water mitigation**

- **AQMD Quote – "Alkylation Improvement Project, Final EIR", Chapter 2, p. 2-7 - SCH #20030536, certified 12/16/04, regarding Valero's MHF project:**
  - "The modified HF catalyst reduces acid vapor pressure sufficiently to suppress the usual flash atomization process of hydrofluoric acid, causing most of the acid to fall to the ground as an easily controlled liquid and reduces the potential for off-site consequences of an accidental HF release."

<u>Reference</u>

- *DAN 96M-0144 - Small Scale HF/Additive Release Tests at MHF Design Conditions*

MYTH - Slide 23:
The table accurately reflects the patent reference

TRAA "Case Against MHF" Jan 4, 2017 – Slide 23

Barriers Won't Work as Claimed

- Rained out acid rapidly forms a vapor with some droplets
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1994: 30% add → 65% rainout

Sally Hayati, TRAA 23

Note: Purple boxes added to TRAA's original image/text to highlight specific points referenced/discussed

Torrance Refining Company

FACT: This table has been altered from the original Patent document

- **TRAA manipulated the data from the original Patent document**
    - Additive wt% was **NOT** in the original patent shown on Slide 88
        - The column was inserted by TRAA
    - TRAA incorrectly presents Additive concentration as "1 - HF" concentration

- **Torrance HF Alkylation Unit was modified in 1997 to use MHF based on the Court-ordered Consent Decree process - achieved 65% ARF without barriers**
    - Acid strength was ~70 wt% - accurately represented in the patent's original, unaltered table

Reference

- *DAN 98M-0166 - Effects of Active and Passive Mitigation on AHF, AUA & MHF Releases*

Torrance Refining Company

Quantitative Risk Analysis
and the
Societal Risk Index

Torrance Refining Company

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MYTH - TRAA Slide 25:
"Quantitative Risk Analysis: a Poor Tool"

TRAA "Case Against MHF" Jan 4, 2017 – Slide 25

Quantitative Risk Analysis: a Poor Tool

- A pretense of more quantitative knowledge than is available
  - approximately 20% of critical pump leaks involve seals/gaskets; but the severity or leak size is unknown. p.40 SA2)
  - Determining potential leakage rates outside of the proposed shrouded/ barriered area. (p.40)
  - Information on low frequency events is scarce due to lack of sharing between companies, no transparency
- No risk weighting
  - Negligible risk contributors (p.39 SA2) are ignored
  - Very low probability is assigned to high consequence releases
  - There should be "risk weighting" for consequences too great to tolerate.
- We are expected to TRUST (Mobil and the Safety Advisor) without VERIFYING. This is not the scientific standard.

FACT: “Quantitative Risk Assessment is an effective tool and industry risk management standard”

- **Quantitative Risk Assessment (QRA) is used throughout industry to improve safety and reliability of equipment / processes**
  - QRA follows Center for Chemical Process Safety (CCPS) guidelines
    - Considered a global scientific standard
  - Torrance Refinery also follows American Petroleum Institute's “Recommended Practice 751 - Safe Operation of Hydrofluoric Acid Alkylation Units”
    - Includes periodic third-party audits and other safety requirements
- **As part of the Consent Decree process, a QRA was conducted to determine if, “MHF (including mitigation) presents no greater risk than Sulfuric Acid alkylation plant producing a comparable amount of alkylate.” The QRA:**
  - Provided quantitative estimates of risks
  - Considered broad range of scenarios
  - Applied appropriate allowances for likelihood of occurrence
  - Facilitated comparison of different processes - i.e., MHF vs. Sulfuric Acid
  - Highlighted most effective risk mitigation options - provides layers of protection
- **Leak size and frequency was derived from industry data and modeled in the MHF QRA, which includes a range of release sizes**

References

- *CCPS CPQRA published guideline book*
- *American Petroleum Institute Recommend Practice 751*
- *MHF Alkylation Risk Assessment, October 1994*
- *1998 QRA Report - The Modified Hydrofluoric Acid Process Assessment of the Offsite Risk Impact Associated with Modification/Changes in the MHF Process*

MYTH - TRAA Slide 25: "We are expected to TRUST (Mobil and the Safety Advisor) without VERIFYING."

TRAA "Case Against MHF" Jan 4, 2017 – Slide 25

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Sally Hayati, TRAA 25

****Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed***

FACT: MHF Alkylation efficacy WAS verified and approved by the Court and Permitted by AQMD

- **Approval of MHF Alkylation followed comprehensive Court-ordered Consent Decree and AQMD permitting processes**
- **Change of Additive concentration and addition of barriers were thoroughly vetted and approved in 1999 through the Court-ordered Consent Decree and involved:**
  - A well respected and experienced Superior Court Judge – Hon. Harry Peetris
  - A Court Appointed independent Safety Advisor – Steve Maher
  - City of Torrance Mayor and Council Members
  - Torrance Fire Department and its independent Safety Consultant
- **1999 Safety Advisor's report concluded:**
  - *"[Our] analysis show that the final operating configuration would provide an improvement to the level of safety to the Community."*
  - The report also found that the ARF for the MHF Alkylation Unit increased from 65% in 1995 (MHF-AUA Chemistry) to 89% in 1999 (MHF-AUA chemistry + Barriers)
- **TRAA documents have <u>NOT</u> been verified – <u>NOT</u> a scientific standard**
- **AQMD Quote – "Alkylation Improvement Project, Final EIR", Chapter 2, p. 2-7 - SCH #20030536, certified 12/16/04, regarding Valero's MHF project:**
  - "The modified HF catalyst reduces acid vapor pressure sufficiently to suppress the usual flash atomization process of hydrofluoric acid, causing most of the acid to fall to the ground as an easily controlled liquid and reduces the potential for off-site consequences of an accidental HF release."

<u>Reference</u>

- *Consent Decree Safety Advisor's Report, October 1999*

MYTH - TRAA Slides 26 & 31: “Catastrophic failures such as … earthquakes were never addressed.”; “Earthquakes pose a significant risk of MHF release … with little to no mitigation”

TRAA “Case Against MHF” Jan 4, 2017 – Slide 26

Other SRI Weaknesses

- Catastrophic failures such as rupture of the alkylation reactor or settler due to earthquake, fire, large fallen objects, or terror attack were never addressed
- Claim: MHF w/ 10% additive does not “flash atomize.”
  - It has never been demonstrated, experimentally or using a theoretical model, that flash atomization does not occur with the MHF used in the Torrance Refinery today.
  - Yet all safety claims (MHF & barriers) depend on this
- Mobil’s claim that MHF has a factor of three margin in favor of MHF societal risk estimate compared with sulfuric acid alkylation best estimate shows that the risk analysis is totally invalid .

Sally Hayati, TRAA 26

TRAA “Case Against MHF” Jan 4, 2017 – Slide 31

Earthquakes Pose a Significant Risk of MHF Release

-LARGE AMOUNTS OF MHF COULD BE QUICKLY RELEASED WITH LITTLE TO NO MITIGATION-

- Our region is prone to earthquakes
  - The Newport-Inglewood fault E of refinery, “one of the most dangerous in So CA,” capable of a mag 7 quake.
  - Chance of 6.7 earthquake in So CA w/in 30 yrs. is 97%,
  - Chance of a 7.5 earthquake in So CA w/in 30 yrs. is 37%.
- Refineries are known to be vulnerable to earthquakes
  - 2014 study, SF Bay Area governments found that a 5.0 earthquake on a small local fault could shut down refineries two miles away
  - CDC warns that earthquakes can release HF. Cal OES warns of the danger of natural disasters triggeringindustrial accidents (natechs).
  - The CDC has warned earthquakes can release HF.
- 1990 Torrance court brief pointed out specific vulnerabilities
  - The potential [for] catastrophe at the…refinery…from a significant earthquake… on at least six different [nearby] faults is extreme.
  - Mobil’s…documents…prove that due to the age of the Torrance refinery, its process units are highly congested and don’t meet Mobil's minimum fire and safety standards for between the units.
  - Mobil's own insurers warned of "a domino-type catastrophe should even 1 unit [catch]… fire."
- **Despite seismic improvements, the Safety Advisor admitted**
  - **“a seismic event of sufficient magnitude could result in both a breach & a concurrent failure of one or more mitigation systems.”**

2011, mag 9, 200 mi away, Cosmo Oil Ref, Tokyo

1999, mag 7.5, Tupras Refinery, Turkey

Sally Hayati, TRAA 31

**Note: Purple boxes added to TRAA’s original image/text to highlight specific points referenced/discussed*

Torrance Refining Company

FACT: To comply with CalARP, the refinery must be able to withstand an earthquake that occurs once every 2500 years

- **Torrance Refinery conducts a seismic assessment every five years per CalARP**
  - Upgrades are made as recommended by assessment's results
  - Intended to reduce likelihood of release of significant quantities of regulated substances in the event of an earthquake
  - Since the use of MHF in 1997, there has **NOT** been an offsite release of HF
  - Torrance Refinery used HF in the Alkylation Unit without any HF offsite release from 1966 until 1997, a period that includes the Sylmar and Northridge earthquakes

- **Torrance Refinery's QRA includes catastrophic release cases without distinguishing between internal or external release**

- **Consent Decree required Safety Advisor to conduct detailed seismic review**
  - Addressed in multiple locations of the Safety Advisor's reports and presentations
    - Analysis and report on seismic safety of MHF Unit's final design and construction
    - Walk-down of MHF Alkylation Unit prior to commissioning and operating

- **MHF Additive and barrier protection provide mitigation for potential releases**
  - Testing shows that the Additive will reduce airborne concentrations of HF and prevent Flash Atomization

References

- *CalARP Seismic Analysis*
- *Safety Advisor Reports May 1995, October 1999 and presentation October 2000*

MYTH - TRAA Slide 26: "Never been demonstrated, experimentally or using a theoretical model, that flash atomization does not occur with the MHF used in the Torrance Refinery today."

TRAA "Case Against MHF" Jan 4, 2017 – Slide 26

Other SRI Weaknesses

- Catastrophic failures such as rupture of the alkylation reactor or settler due to earthquake, fire, large fallen objects, or terror attack were never addressed
- Claim: MHF w/ 10% additive does not "flash atomize."
  - It has never been demonstrated, experimentally or using a theoretical model, that flash atomization does not occur with the MHF used in the Torrance Refinery today.
  - Yet all safety claims (MHF & barriers) depend on this
- Mobil's claim that MHF has a factor of three margin in favor of MHF societal risk estimate compared with sulfuric acid alkylation best estimate shows that the risk analysis is totally invalid .

Sally Hayati, TRAA

26

****Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed***

FACT: Testing in 1992 & 1994 showed MHF Additive eliminates Flash Atomization associated with a jet release

- **Testing proved no Flash Atomization was observed for MHF compositions containing as much as 85 wt% HF up to 140°F**

- **Testing in 1992 and 1994 showed inclusion of Additive eliminates Flash Atomization of HF associated with a jet release**
  - The Additive bonds to HF, changing the catalyst's characteristics

- **AQMD Quote – "Addendum, Mitigated Negative Declaration, Mobil Modified Hydrogen Fluoride Conversion Project", p. 2 - July 9, 1997**
  - "The experimental testing indicated that the addition of the Mobil additive to HF was an effective method for reducing or elimination the amount of aerosol formed during a release. The additive is a water-soluble, thermally stable compound that is solid at ambient conditions. In addition, the health data indicate that the additive has very low toxicity and limited health impacts as compared to HF which has more severe health impacts."

Reference

- *DAN 96M-0144 - Small Scale HF/Additive Release Tests at MHF Design Conditions*

Torrance Refining Company

MYTH - TRAA Slide 26: “Mobil’s claim that MHF has a factor of three margin in favor of MHF societal risk estimate compared with sulfuric acid … is totally invalid.”

TRAA “Case Against MHF” Jan 4, 2017 – Slide 26

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Sally Hayati, TRAA 26

****Note: Purple box added to TRAA’s original image/text to highlight specific points referenced/discussed***

FACT: Results of 1998 QRA update show that mitigation systems favor MHF Alkylation

- **1998 QRA demonstrated the MHF Alkylation Unit has safety mitigation systems that provide an SRI 24x lower than a Sulfuric Acid Unit of comparable capacity**
  - QRA excluded transportation, regeneration, and incineration of spent Sulfuric Acid
    - When added to QRA, risk from sulfuric acid increases significantly
  - Post-1998 additions: MHF-sensitive flange paint, perimeter HF lasers, additional water mitigation and camera play back, water cannons controls to control room
    - These additional safety measures, if included in the QRA, would further lower the SRI associated with use of MHF vs sulfuric acid

- **QRA results show toxic risks associated with Sulfuric Acid Alkylation are higher than for comparable MHF Alkylation Unit**
  - Both processes were shown to represent very low risk
  - Number of people potentially exposed and evacuation zone area were higher for Sulfuric Acid Alkylation than MHF Alkylation

References

- *MHF Alkylation Risk Assessment, October 1994*
- *Safety Advisor Presentation - MHF vs Sulfuric Acid Alkylation Risk Assessment 1998*
- *1998 QRA Report - The Modified Hydrofluoric Acid Process Assessment of the Offsite Risk Impact Associated with Modification/Changes in the MHF Process*

Chapter 10: Additional Safety Measures and Equipment

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MYTH - TRAA Slide 28: “Emergency systems at best reduce but don’t eliminate the impact of a release, -And they may also fail”

TRAA “Case Against MHF” Jan 4, 2017 – Slide 28

COULD EMERGENCY SYSTEMS SAVE THE DAY?

-FACT: EMERGENCY SYSTEMS AT BEST ***REDUCE BUT DON’T ELIMINATE*** *THE IMPACT OF A RELEASE,*

-AND THEY MAY ALSO FAIL -

1. Water suppression systems can be used to knock down some of the airborne acid
2. Rapid de-inventory systems can dump the acid to other locations so less acid leaks

Industry studies in the 1990s revealed “vulnerabilities and weaknesses” of these so-called “active” HF mitigation systems. That motivated the development of MHF.

- Min 40:1 water to HF ratio needed, difficult and $$$ to cover every angle and location where a release could occur, especially with variable wind direction.
- Best case performance of operational water systems:
  - 80-90% reduction airborne acid. Mobil’s goal was 80%.
  - Actual performance is “always worse.” (Dr. Koopman)
- Typical field system performance is less than optimal
- Much less effective for serious incidents, high rate leakage
- Require time to activate.
  - 30 sec–1 min is very “quick,” usu. takes longer
- Can be damaged by explosions, fire, or earthquakes
- Can fail due to poor maintenance and human error

MHF plus active mitigation measures might reduce impact, but won’t “keep us safe”

Sally Hayati, TRAA

28

FACT: Redundant emergency systems are routinely tested, validated, and work as designed

- **Torrance MHF Alkylation Unit includes redundant, active mitigation systems**
  - Water systems
    - Nine water cannons are tested weekly
    - Acid service pumps deluge systems are tested monthly
    - Fixed water sprays on vessels are tested annually
  - Detailed inspection of barriers completed weekly
  - Acid Evacuation System tested monthly
  - Risk Management Prevention Plan (RMPP) interlocks are tested monthly
  - HF sensors tested monthly
  - Acid off-loading system tested prior to every truck delivery
  - Active routine and preventive maintenance Inspection program
  - TFD is invited to witness all testing
  - Operator physically present in unit at all times
- **Testing shows that using MHF catalyst with barriers provides 89% ARF**
  - Active mitigation systems as designed would contain a release on site
- **There have been <u>NO</u> offsite releases since MHF alkylation was introduced in 1997**
- **Global Alkylation experts publically informed AQMD that Torrance MHF Alkylation Unit features the most comprehensive safety systems in the world**

<u>Reference</u>

- *Actual unit configuration, performance and testing*

MYTH - TRAA Slide 28: The Acid Evacuation System (AES) "[usually] takes longer" than one minute to activate

TRAA "Case Against MHF" Jan 4, 2017 – Slide 28

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MHF plus active mitigation measures might reduce impact, but won't "keep us safe"

Sally Hayati, TRAA

28

***Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed**

Torrance Refining Company

FACT: The Alkylation Unit's Acid Evacuation System (AES) has been activated within seconds

- **Example: On February 18, 2015, MHF Alkylation Unit Supervisor on duty activated the Unit's AES system within ten seconds when responding to the ESP incident**
  - Acid settlers emptied within 2 to 3 minutes
  - <u>Entire MHF Alkylation Unit acid inventory was completely emptied within 7 minutes</u>

- **AES has only been activated three times since installation in 1991**

- **Based on these three activations, the acid in the settlers is transferred to the AES in 2 to 3 minutes - removing most of the acid**
  - Remaining acid in the unit will take approximately 3 to 4 minutes more to be transferred to the AES

<u>Reference</u>

- *Actual unit performance*

Torrance Refining Company

Chapter 11: Appropriate Use of EPA "Planning Circles"

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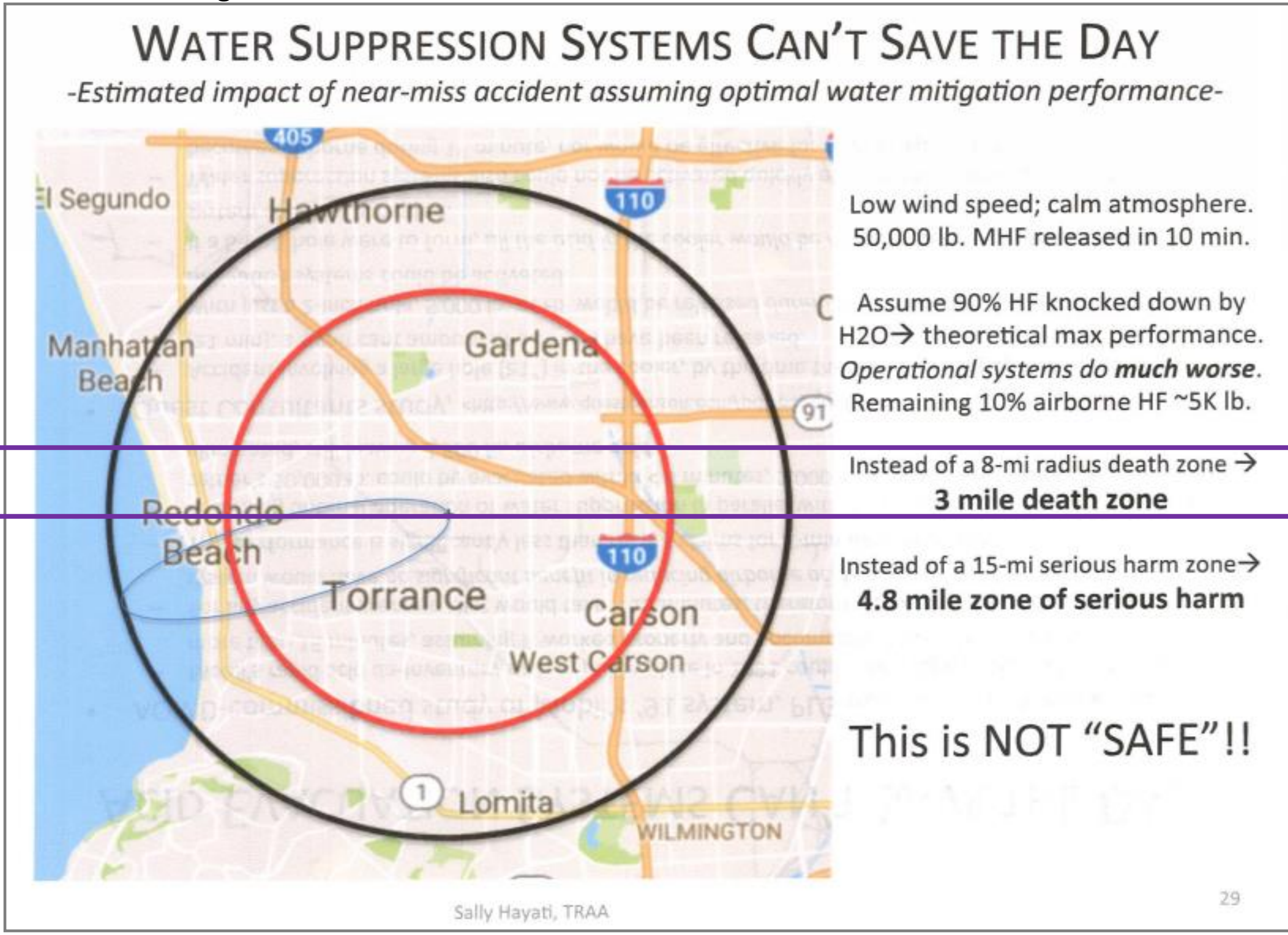
MYTH - TRAA Slide 29: TRAA's interpretation of the RMP follows EPA guidelines and accurately reflects potential community impact

TRAA "Case Against MHF" Jan 4, 2017 – Slide 29



****Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed***

Torrance Refining Company

FACT: TRAA misrepresents EPA's RMP guidelines for "planning circles"

- **Repeated references to "Circle of Death" and "Death Zone" are misleading and inconsistent with EPA guidelines, creating unnecessary public panic and fear**
  - Misrepresents "planning circles" in EPA's Risk Management Program (RMP)
    - Specifically: Worst-Case Scenario and Off-site Consequence Analysis

- **EPA RMP methodology uses an "endpoint value" referred to as "ERPG-2," developed by the American Industrial Hygiene Association**
  - ERPG-2 represents an "Emergency Planning Area" **NOT** a "Death Zone"
    - ERPG: "Emergency Response Planning Guideline" measures potential exposure
  - Under the Consent Decree process, the Safety Advisor used more conservative ERPG-3 values in analyzing MHF release impacts compared to Sulfuric Acid

- **AQMD Quote – "Alkylation Improvement Project, Statement Of Findings, Statement Of Overriding Considerations, And Mitigation Monitoring Plan", p. 9 - SCH #20030536, certified 12/16/04, regarding Valero's MHF project**
  - "An accidental release of HF could migrate off the Refinery property and expose individuals in the surrounding community. The proposed (MHF) project will substantially reduce the potential hazard impacts associated with an accidental release of HF."

References

- *USEPA, General Guidance on Risk Management Programs for Chemical Accident Prevention EPA 555-B-04-001March 2009*
- *Consent Decree Safety Advisor Report, May 1995*

Torrance Refining Company

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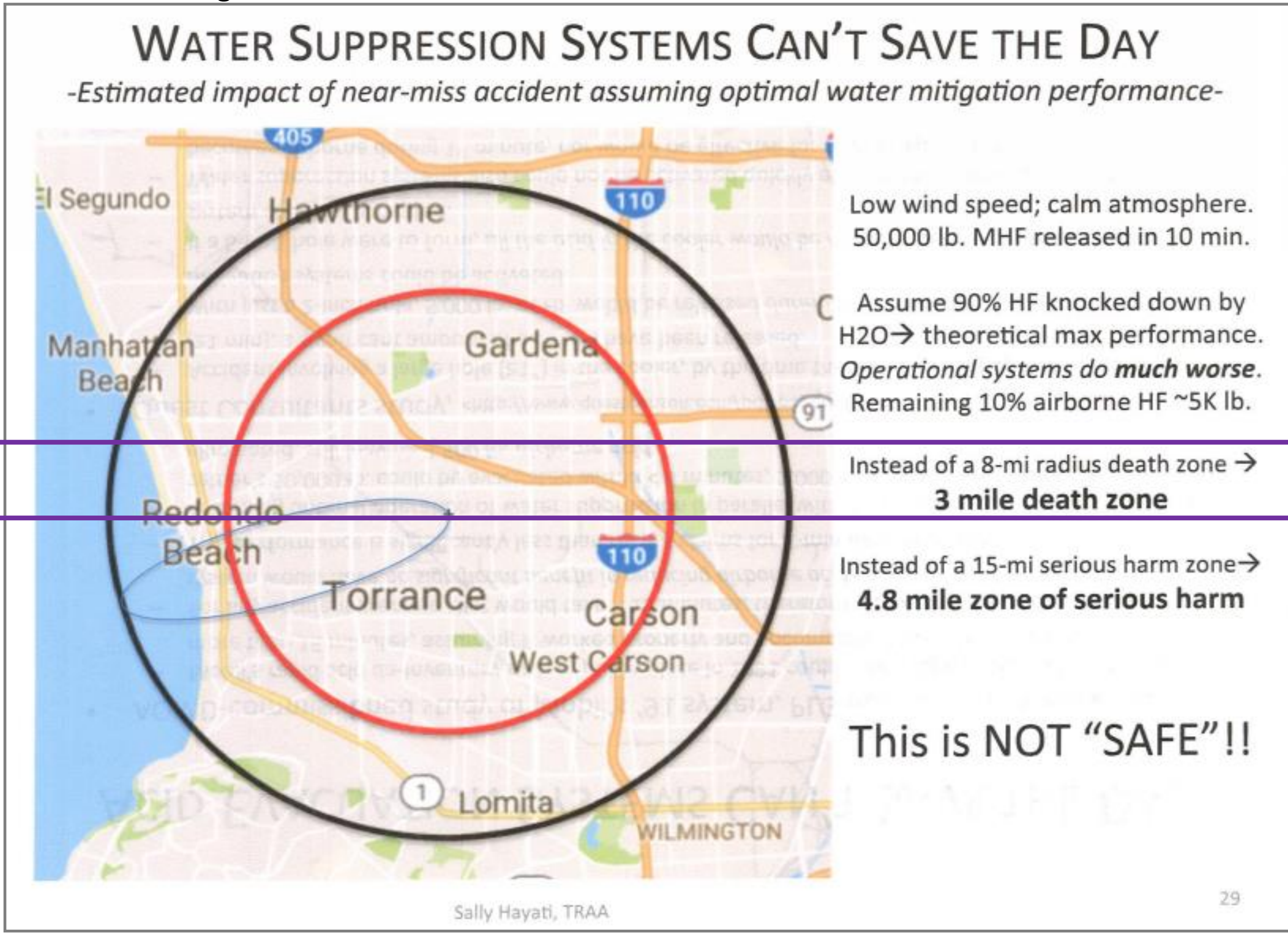
TRAA "Case Against MHF" Jan 4, 2017 – Slide 29



****Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed***

Torrance Refining Company

FACT: TRAA misrepresents EPA's RMP guidelines for "planning circles"

- **EPA's RMP guidance clearly demonstrate agency's intentions:**
  - *"EPA intends the estimated distances to provide a basis for a discussion among the regulated community, emergency planners and responders, and the public, rather than a basis for any specific predictions or actions."*
  - *"The distance (to endpoint) is intended to provide an estimate of the maximum possible area that might be affected by a catastrophic release from your facility. It is intended to ensure that no potential risks to public health are overlooked, but **the distance to an endpoint estimated under worst-case conditions should not be considered a 'public danger zone.' " (Emphasis added.)***
  - EPA also cautions that *"[c]haracterizing data using only worst-case scenarios can be misleading and unnecessarily alarming." See Id*., p. 7.

- **EPA RMP guidelines acknowledge the WCS uses unrealistic modeling parameters and is an ultra-conservative, unrealistic scenario:**
  - *"Because the assumptions required for the worst-case analysis are very conservative, the results likely will also be very conservative ... The distance to the endpoint estimated under worst-case conditions should not be considered a zone in which the public would likely be in danger, instead it is intended to provide an estimate of the maximum possible area that might be affected in the unlikely event of catastrophic conditions."*

Reference

- *USEPA, General Guidance on Risk Management Programs for Chemical Accident Prevention EPA 555-B-04-001March 2009*

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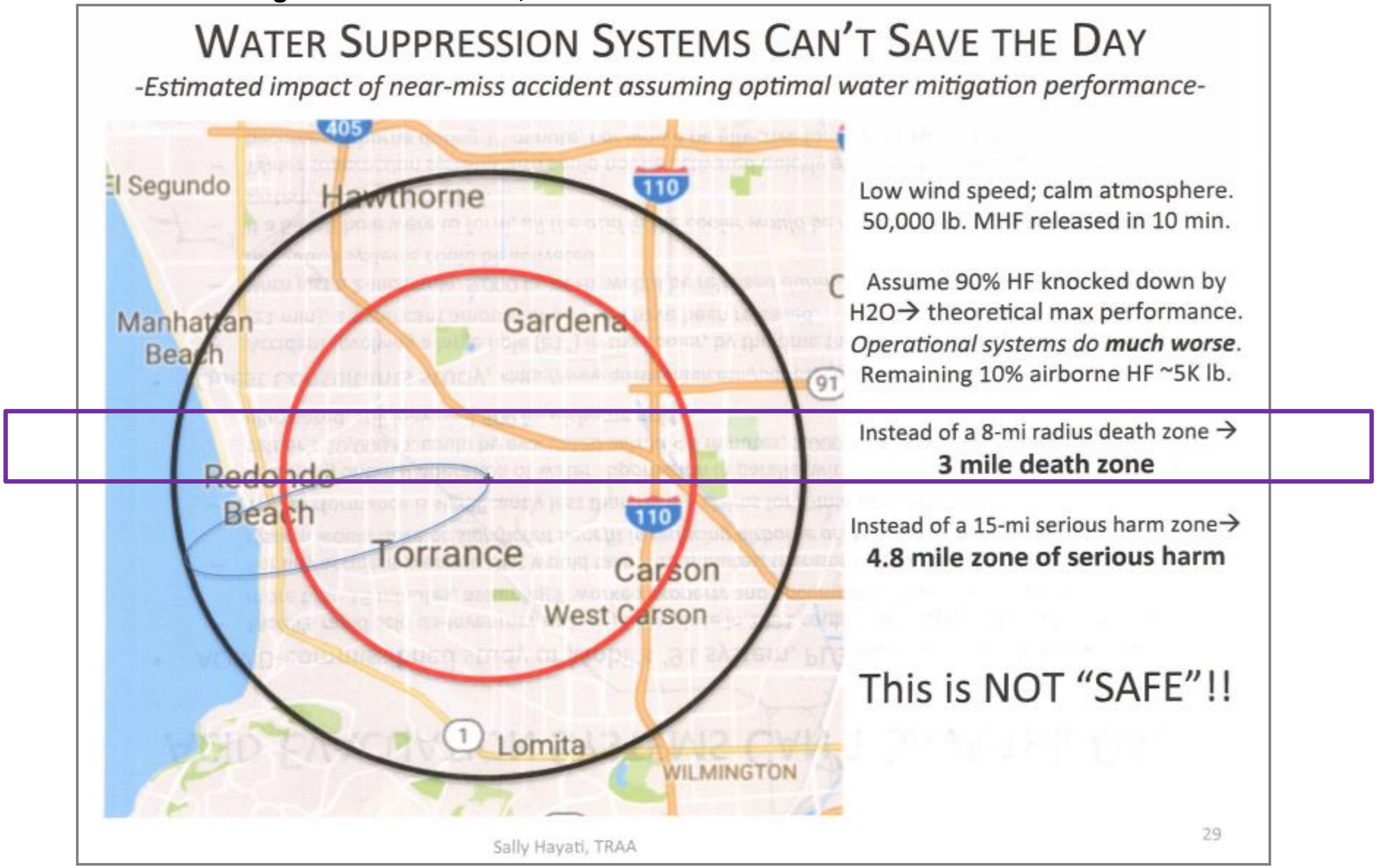
TRAA “Case Against MHF” Jan 4, 2017 – Slide 29



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Torrance Refining Company

FACT: The Additive and barriers reduce potential airborne concentrations of HF

- **TRAA ignores the proven effectiveness of the Additive and barrier technology**
- **Testing shows the Additive and barriers reduce airborne concentrations of HF**
- **Safety Advisor's 2001 report evaluated benefits of MHF Additive and barrier protection - concluding these contributed to airborne reduction of MHF**
- **AQMD Quote - "Addendum, Mitigated Negative Declaration, Mobil Modified Hydrogen Fluoride Conversion Project", p. 2 - July 9, 1997**
  - "The experimental testing indicated that the addition of the Mobil additive to HF was an effective method for reducing or elimination the amount of aerosol formed during a release. The additive is a water-soluble, thermally stable compound that is solid at ambient conditions. In addition, the health data indicate that the additive has very low toxicity and limited health impacts as compared to HF which has more severe health impacts."

Reference

- *Consent Decree Safety Advisor Report, September 2001 - Alkylation Unit Quantitative Risk Assessment Updates*

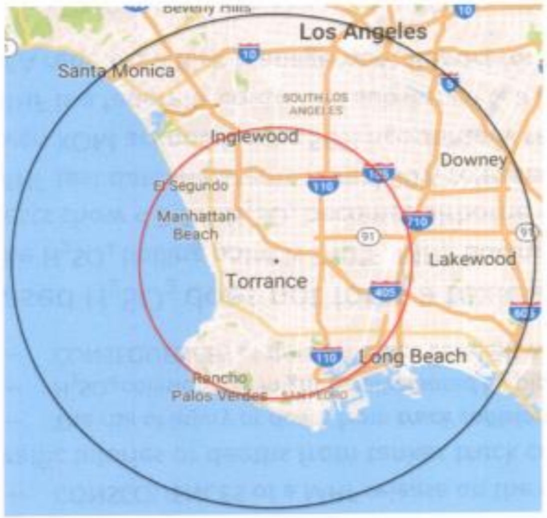
Torrance Refining Company

MYTH - TRAA Slide 36: MHF vs. Sulfuric Acid – RMP Worst-Case Scenario Planning Circles Go Away

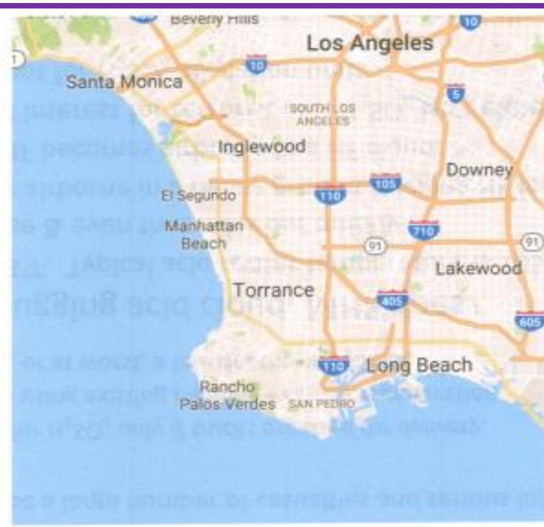
TRAA "Case Against MHF" Jan 4, 2017 – Slide 36

Sulfuric Acid Alkylation

-Far Safer for the Community-



Torrance Refinery MHF Alky unit
Realistic Worst Case Scenario



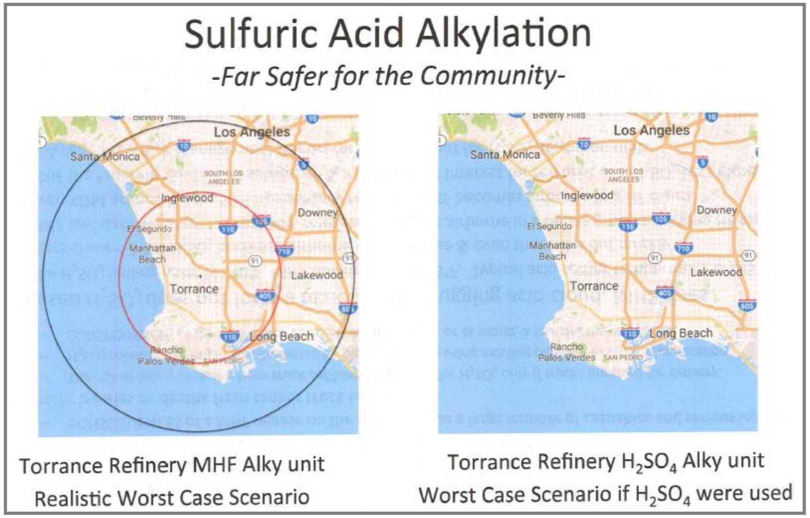
Torrance Refinery H_2SO_4 Alky unit
Worst Case Scenario if H_2SO_4 were used

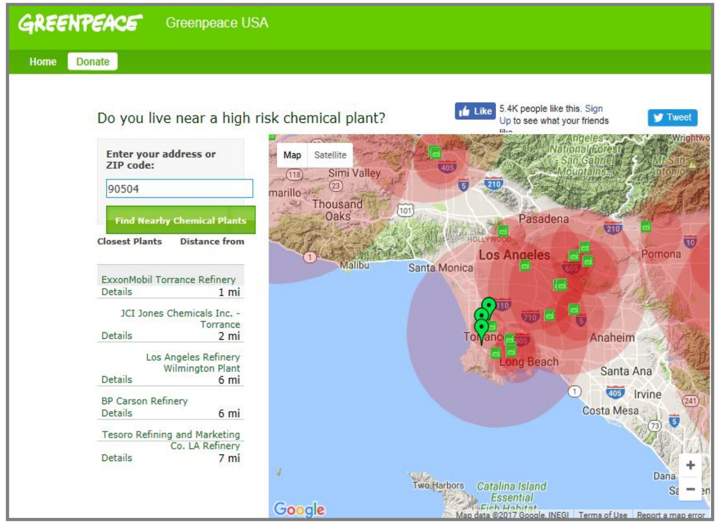
[The] use [of] "modified HF acid" for alkylation is a strategy that I oppose vigorously. This is an approach the majority of the refining industry does not use. There have been good options from the beginning [namely, sulfuric acid] ...There are those in the industry that cling to their belief in "modified HF" and the supporting technology. Most of those advocates either sell the design or license it. ...When all else fails, the advocates for such a strategy resort to the claim that...the two acids are equally safe."
Donald Hall, former refinery manager for the Big West in Bakersfield & Texaco's Los Angeles plant, 2008

*Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed

Torrance Refining Company

FACT: If Sulfuric Acid Alkylation replaces MHF, the City of Torrance would still be within multiple "planning circles"





- **TRAA is correct - sulfuric acid is not a toxic substance per EPA RMP guidance**
  - Spent sulfuric acid is toxic and listed as a carcinogen by the International Agency for Research on Cancer
- **The RMP Worst-Case Scenario emergency planning area would go away with conversion to a Sulfuric Acid Alkylation Unit**
  - What the TRAA doesn't state is that the "emergency planning area" does not completely go away with conversion to sulfuric acid
- **EPA RMP emergency planning areas do not completely go away**
- **There are many other facilities that require RMPs in Torrance and the Los Angeles basin**

References

- *USEPA, General RMP Guidance - Chapter 4: Offsite Consequence Analysis*
- *http://usactions.greenpeace.org/chemicals/map*

Torrance Refining Company

Chapter 12: Irresponsibly Creating Public Fear and Outrage

The Torrance Refinery Alkylation unit began operating in 1966 and has never had an offsite release

- **1966 - 1997: Hydrofluoric acid - HF**
- **1997 - 2018: Modified Hydrofluoric Acid - MHF**

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MYTH - TRAA Slide: Torrance MHF Alky Unit release will result in an incident like the Bhopal, India 1984 incident

TRAA Presentation Modified Hydrofluoric Acid (MHF) – Wolf in Sheep's Clothing (Nov. 16, 2016, Slide 2)

Ban MHF to Prevent a South Bay Bhopal!

-World's Worst Industrial Disaster-

*Bhopal, India 1984: release of a **toxic volatile gas**, methyl isocyanate*
600K exposed, ≥ 15K died, unknown 100Ks injured, many of whom were permanently impaired.

1989 City of Torrance Public Nuisance Lawsuit against Mobil refinery:

A hydrofluoric acid release "could cause a DISASTER OF BHOPAL-LIKE PROPORTIONS... damage could extend to other areas of LA County...100,000's...could be killed and double that...seriously injured."

THOSE STATEMENTS ARE JUST AS TRUE NOW

Sally Hayati, TRAA 2

***Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed*

Torrance Refining Company

FACT: Photo and content designed to instill fear and outrage

- **Cited incident occurred in India 30+ years ago at a chemical plant that did NOT use MHF and had NO redundant safety mitigation systems**
  - Risk Communication refers to this tactic as using "outrage factors". Examples:
    - Activists linking graphic images/descriptions of tragedies to a targeted company, facility product, etc., to produce fear and outrage
    - Using children as victims - TRAA uses images of children playing soccer overcome by gas to make residents fearful
      - Inciting fear and outrage in residents same as showing RMP "planning circles" as "Circles of Death" or "Death Zones"
    - Misrepresenting risk is counterproductive when the objective is protecting the community and workforce

- **Quote cited on slide was made before MHF, barriers, and other safety systems were installed and used in the Torrance Refinery Alkylation Unit**
  - Refinery began using MHF and installed additional, redundant safety systems to make the plant safer for workers *and* residents
  - Since the use of MHF in 1997, there has not been an offsite release of HF at the Torrance Refinery

- **AQMD Quote: "*Highly Toxic Chemical to be Phased Out at Valero Refinery, February 7, 2003***
  - *"Modified HF … contains additives that significantly reduce the chemical's ability to form a vapor cloud in the event of an accidental release."*

Reference

- *Covello & Sandman - "Risk communication: Evolution and Revolution." 2001*

Chapter 13: Sulfuric Acid Alkylation is a False Choice

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MYTH - TRAA Slides 33, 37, & 40: Conversion to Sulfuric Acid Alkylation H2SO4 – would be cheap and easy

TRAA "Case Against MHF" Jan 4, 2017 – Slide 33

Alternatives Exist

-SCAQMD Study of MHF Alternatives agreed with TRAA's recommendations-

- Sulfuric Acid (H_2SO_4)
  - 80% (all but 2) refinery alkylation units in CA use this catalyst
  - A toxic liquid—boiling point 640°F. No dense ground hugging acid cloud.
- Solid Acid Catalyst (SAC)
  - Newer, safe and more environmentally benign
  - Pilot plant has been built in the US
  - Commercial plant in China has successfully operated for one year producing excellent quality alkylate

Conversion cost estimates: $100M (AQMD)-$300M + (refinery)

- This is consistent with other mandates to protect public health--
  - Cost of Electrostatic Precipitator (ESP), $300M in '08: $330M
  - Cost to repair ESP after 2015 explosion: $161M
- Mobil's cost to add mitigation systems, develop MHF, convert the HF unit to MHF: ~$160M during the late 1980's early 1990's $275M

Sally Hayati, TRAA 33

TRAA "Case Against MHF" Jan 4, 2017 – Slide 37

Sulfuric Acid Can Do the Job, Safely

Solid Acid Catalyst (SAC) can also do the job; transition time should be same as H_2SO_4

- Sulfuric acid (H_2SO_4) would eliminate the toxic airborne risk
  - DHS: MHF is chemical of interest to terrorists, H_2SO_4isn't
  - EPA: toxic offsite consequence analysis is required for MHF, not for H_2SO_4
  - Experience: 2011 Motiva Delaware City Refinery H_2SO_4release: a total of 1.1 M gallons spent H_2SO_4 with alky unit hydrocarbons were released. There was not one mention of a vapor cloud in the CSB report. No airborne toxic consequence
- All but 2 CA refineries survive in the same marketplace using H_2SO_4
  - Feedstock identical to Torrance's are processed & same additive is made w/ H_2SO_4
- Half of existing and the vast majority of new US alky units use H_2SO_4
  - 86% of new alkylation units in 1990s chose H_2SO_4
- Studies have been done on HF conversion; R&D not needed.
  - CB&I CDAlky low temperature sulfuric acid process. CDTech study.
    - Major pieces of HF equipment can be retained
  - Stratco Alkysafe Process: low-cost conversion method patented.
    - Phillips and UOP designed HF alkylation units can be converted and expanded into H2SO4 alkylation units with minimum capital expense.
- Sulfuric acid might be piped in using existing pipeline from Carson, and regenerated on site. This eliminates the need for increased truck traffic.
- But the community prefers H_2SO_4 over MHF even if trucks must be used

Sally Hayati, TRAA 37

TRAA "Case Against MHF" Jan 4, 2017 – Slide 40

THE COST OF CATALYST CONVERSION

-Estimates vary-

TO SULFURIC ACID

- $23M (based on 1995 quote: $15M) Stratco
- $24M-$35M (based on 2006 quote: $20-30M) Stanford Prof. L. W. Wein
- $50M-$166M (based on 2009 quote: $45M-$150M) Nat'l Petrochem & Refiners
- $100M (order of magnitude) AQMD Norton Study of MHF alternatives
- $180M (based on 1990 quote: $100M) Mobil
- $300M for a new (~0.6 x smaller) H_2SO_4 unit. Valero
  - The cost to build a unit twice this size would not be twice the price. "The cost of the conversion from HF alkylation to H2SO4 alkylation is a fraction of that of a grassroots unit as it uses most of the existing equipment." Dupont.

TO SOLID ACID CATALYST (SAC)

- $64M, based on data provided by Exelus for ExSact SAC
  - Exelus claims the cost of H_2SO_4 conversion is double that for SAC, so $128M
- $100M, AQMD Norton Study of MHF alternatives

This is consistent with other mandates to protect public health--

Cost of Electrostatic Precipitator (ESP), $300M in '08: $330M

Cost to repair ESP after 2015 explosion: $161M

Mobil's cost to add mitigation systems, develop MHF, and convert the HF unit to MHF: ~$160M during the late 1980's early 1990's $275M

Sally Hayati, TRAA 40

Torrance Refining Company

FACT: No HF / MHF Alkylation Unit has ever been converted to a Sulfuric Acid Alkylation Unit and new unit is extremely expensive

- **There are many technical reasons conversion has never been done**
  - Processing equipment and metallurgy differ between technologies
    - Vessels, piping, and equipment are not interchangeable
    - New grassroots Sulfuric Acid Alkylation Unit would be required
- **April 1, 2017 SCAQMD testimony on conversions incorrect and unfounded**
  - Bay Area: Units originally built as Sulfuric Acid - never converted from HF
  - UK: 4 of 6 refineries are HF Alkylation - 2 others have no Alkylation Units
  - Europe: No Alkylation Units have ever been converted to Sulfuric Acid
- **SCAQMD's Norton Engineering Study cost conversion estimate grossly too low**
  - Failed to consider the cost of acid regeneration and incineration
  - Estimate was based on replacement of reaction section only
  - Failed to consider regulatory and construction costs in Southern California
  - New 30 kbd grass roots units third-party cost estimate is significantly higher
  - DuPont at the AQMD August 23, 2017 Proposed Rule 1410 working meeting confirmed the Norton Study estimates were low and not representative of a new unit in Southern California. DuPont provided the estimate to Norton and was based on Gulf Coast costs and did not include scale up or outside the battery limits
- **Cost estimates from the 1990's and early 2000's are irrelevant to today's cost**
  - Cost today for a new Sulfuric Acid Unit with Regeneration is approximately $900MM

<u>References</u>

- *Norton Engineering Study and presentation at American Fuel & Petrochemical Manufacturers meeting February 2016*
- *Burns and McDonnell Report Brief – Alkylation Study and Estimate July 2017*

MYTH - TRAA Slides 38 & 40: In January 2016 Valero announced plans to build a new sulfuric alky unit – with startup in 2018 – two years with permitting

TRAA "Case Against MHF" Jan 4, 2017 – Slide 38

The Transition Period Should be Minimized

- The Consent Decree mandated HF elimination by 1997. It's past time-

- Consent Decree gave 3 years to construct a MHF or sulfuric acid alky unit: 1994-97. Mobil stated in Feb. 1995 it needed no more than two years to switch to MHF.
- In Jan. 2016 Valero announced plans to build a new 13,000 b/d alkylation unit at its Houston refinery with startup in 2018. That's 2 years allocated, including permitting.
- "To construct a sulfuric acid alkylation unit within the existing Refinery... the existing [HF] unit would have to be shutdown and demolished. This and construction of a new alkylation would require approximately 1 year." Valero, Wilmington, 2004
- The refinery should temporarily operate without alkylation if the transition takes > 3 years
  - Alkylation feeds could be transported to alkylation units elsewhere or (possibly) sold for other purposes.
  - Transportation needs for (prev) alky inputs should be similar to & replace current needs for alky output
  - ExxonMobil accepted and stored crude oil shipments for > 1 year during the shut down. It coped.
- Components of the H_2SO_4 alky unit might be (like the ESP)
  - prefabricated at a safer location inside the refinery, then
  - lifted and transported to the final site for installation

"The module approach [to ESP construction] allowed the project to install piling, foundations and structural steel in parallel with ESP assembly, shortening the construction span significantly."

ESP being moved in 2008 to its final location

Sally Hayati, TRAA

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TRAA "Case Against MHF" Jan 4, 2017 – Slide 40

THE COST OF CATALYST CONVERSION

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Sally Hayati, TRAA

40

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Torrance Refining Company

FACT: Valero announced its new US Gulf Coast Sulfuric Acid Alkylation Plant project in January 2016, with completion expected in 1H2019

- **Valero is building a new $300 million (MM), 13MBD Sulfuric Acid Alkylation Plant in Texas**
  - Estimate excludes added cost of spent sulfuric acid regeneration and incineration plants
    - Regeneration and incineration keep acid supply constant
- **Basic project designs and permitting processes typically take at least two years**
- **Duration of the permitting process in Southern California is lengthy and indeterminate**
- **Valero project entered detailed engineering, procurement and construction phase**
  - Expected to take longer than three years to complete
- **Torrance MHF Alkylation Unit is ~30MBD, more than 2x larger than Valero's new Texas unit**
  - Regulatory, construction and operating costs are significantly higher in California
- **Replacement cost estimates for building a Sulfuric Acid Alky Unit at Torrance Refinery**
  - Burns & McDonnell: New grass roots unit ~ $600MM
  - Cost of Sulfuric Acid Regeneration and Incineration plants would be an additional ~$300MM
  - Acquisition cost of the Torrance Refinery was $187.5MM

References

- *Valero First Quarter 2016 Results*
- *Burns and McDonnell Report Brief – Alkylation Study and Estimate July 2017*
- *Public Company Records on Refinery Sale and Purchase*

MYTH TRAA Slides 38: A new Torrance Sulfuric Acid unit can be constructed in modules like the ESP

TRAA "Case Against MHF" Jan 4, 2017 – Slide 38

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ESP being moved in 2008 to its final location

Sally Hayati, TRAA

38

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Torrance Refining Company

FACT: A modular approach is irrelevant for a Sulfuric Acid Alkylation Unit at Torrance

- **Equipment required for a processing unit is very different from the Torrance Refinery's FCC ESP, which is an emissions control device**

- **Most processing equipment for a Sulfuric Acid Alkylation Unit cannot be manufactured and constructed modularly like the ESP**
  - Consists of towers, heat exchangers, other pressure vessels, pumps, piping networks, instrumentation, and many other types of equipment
  - There are many long lead items that take years to design/engineer, procure, fabricate, and deliver
    - Long lead items can include pressure vessels, towers, heat exchanges and valves
    - Certain sections could be modularly constructed but would not significantly reduce overall construction time due to long lead items

Reference

- *Construction Fundamentals*

MYTH -TRAA Slide 37: "Sulfuric Acid might be piped in using existing pipeline from Carson"

TRAA "Case Against MHF" January 4, 2017 - Slide 37

Sulfuric Acid Can Do the Job, Safely

Solid Acid Catalyst (SAC) can also do the job; transition time should be same as H_2SO_4

- Sulfuric acid (H_2SO_4) would eliminate the toxic airborne risk
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  - EPA: toxic offsite consequence analysis is required for MHF, not for H_2SO_4
  - Experience: 2011 Motiva Delaware City Refinery H_2SO_4release: a total of 1.1 M gallons spent H_2SO_4 with alky unit hydrocarbons were released. There was not one mention of a vapor cloud in the CSB report. No airborne toxic consequence
- All but 2 CA refineries survive in the same marketplace using H_2SO_4
  - Feedstock identical to Torrance's are processed & same additive is made w/ H_2SO_4
- Half of existing and the vast majority of new US alky units use H_2SO_4
  - 86% of new alkylation units in 1990s chose H_2SO_4
- Studies have been done on HF conversion; R&D not needed.
  - CB&I CDAlky low temperature sulfuric acid process. CDTech study.
    - Major pieces of HF equipment can be retained
  - Stratco Alkysafe Process: low-cost conversion method patented.
    - Phillips and UOP designed HF alkylation units can be converted and expanded into H2SO4 alkylation units with minimum capital expense.
- Sulfuric acid might be piped in using existing pipeline from Carson, and regenerated on site. This eliminates the need for increased truck traffic.
- But the community prefers H_2SO_4 over MHF even if trucks must be used

Sally Hayati, TRAA 37

****Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed***

Torrance
Refining Company

FACT: There is NO sulfuric acid pipeline from Carson to Torrance

- **Building fresh and spent sulfuric acid pipelines would be virtually impossible in Southern California**
  - Requires acquisition of appropriate rights-of-way and permits through various private property owners, municipalities and regulatory agencies

- **Transportation of spent and fresh sulfuric acid offsite poses additional safety risks to the community**
  - Spent sulfuric acid contains dissolved sulfur dioxide and hydrocarbons
    - Spent solution is corrosive and can be potentially unstable and reactive
  - Concentrated fresh and spent Sulfuric Acid are highly dangerous and produce insidious burns to human flesh
  - Spent sulfuric acid is an Acutely Hazardous material
  - Trucks and railcars have over-pressured to atmosphere in the past
    - Releasing a vapor/liquid mixture can form a hazardous aerosol
    - There would be ~1440 truck shipments per month if regenerated offsite

References

- *EcoServices Plant Representative*
- *MHF Alkylation Risk Assessment, October 1994*
- *1998 QRA Report - The Modified Hydrofluoric Acid Process Assessment of the Offsite Risk Impact Associated with Modification/Changes in the MHF Process*

MYTH -TRAA Slide 37: "Sulfuric Acid might be piped in using existing pipeline from Carson"

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Sally Hayati, TRAA 37

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Torrance Refining Company

FACT: There is NO sulfuric acid pipeline from Carson to Torrance

- **Process hazard analysis for an MHF vs. Sulfuric Acid Unit siting decision must consider transportation and regeneration risks**
  - Combined risk may result in a different risk management decision than considering the process risk alone
  - During the Consent Decree process, a comprehensive QRA was conducted to compare the risk of MHF to Sulfuric Acid
    - QRA determined that MHF with mitigation was safer than Sulfuric Acid
    - QRA conservatively omitted Sulfuric Acid transportation and regeneration risks

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- *EcoServices Plant Representative*
- *MHF Alkylation Risk Assessment, October 1994*
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Chapter 14: Emerging Alkylation Technologies are Unproven

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MYTH - TRAA Slides 33, 37, & 40: Commercially available alternatives to MHF exist for Torrance

TRAA "Case Against MHF" Jan 4, 2017 – Slide 33

Alternatives Exist

-SCAQMD Study of MHF Alternatives agreed with TRAA's recommendations-

- Sulfuric Acid (H_2SO_4)
  - 80% (all but 2) refinery alkylation units in CA use this catalyst
  - A toxic liquid—boiling point 640°F. No dense ground hugging acid cloud.
- Solid Acid Catalyst (SAC)
  - Newer, safe and more environmentally benign
  - Pilot plant has been built in the US
  - Commercial plant in China has successfully operated for one year producing excellent quality alkylate

Conversion cost estimates: $100M (AQMD)-$300M + (refinery)

- This is consistent with other mandates to protect public health--
  - Cost of Electrostatic Precipitator (ESP), $300M in '08: $330M
  - Cost to repair ESP after 2015 explosion: $161M
- Mobil's cost to add mitigation systems, develop MHF, convert the HF unit to MHF: ~$160M during the late 1980's early 1990's $275M

Sally Hayati, TRAA 33

TRAA "Case Against MHF" Jan 4, 2017 – Slide 37

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Sally Hayati, TRAA 37

TRAA "Case Against MHF" Jan 4, 2017 – Slide 40

THE COST OF CATALYST CONVERSION

-Estimates vary-

TO SULFURIC ACID

- $23M (based on 1995 quote: $15M) Stratco
- $24M-$35M (based on 2006 quote: $20-30M) Stanford Prof. L. W. Wein
- $50M-$166M (based on 2009 quote: $45M-$150M) Nat'l Petrochem & Refiners
- $100M (order of magnitude) AQMD Norton Study of MHF alternatives
- $180M (based on 1990 quote: $100M) Mobil
- $300M for a new (~0.6 x smaller) H_2SO_4 unit. Valero
  - The cost to build a unit twice this size would not be twice the price. "The cost of the conversion from HF alkylation to H2SO4 alkylation is a fraction of that of a grassroots unit as it uses most of the existing equipment." Dupont.

TO SOLID ACID CATALYST (SAC)

- $64M, based on data provided by Exelus for ExSact SAC
  - Exelus claims the cost of H_2SO_4 conversion is double that for SAC, so $128M
- $100M, AQMD Norton Study of MHF alternatives

This is consistent with other mandates to protect public health--

Cost of Electrostatic Precipitator (ESP), $300M in '08: $330M

Cost to repair ESP after 2015 explosion: $161M

Mobil's cost to add mitigation systems, develop MHF, and convert the HF unit to MHF: ~$160M during the late 1980's early 1990's $275M

Sally Hayati, TRAA 40

Torrance Refining Company

FACT: No alternatives are commercially viable for Torrance, including Sulfuric Acid

- **Solid Acid Catalyst (SAC)**
  - Norton Engineering Study: Too early to be considered commercially viable technology
  - CB&I has one small 2,700 BPD unit in a chemical plant in China
    - Issues with catalyst regeneration cause periodic, unplanned shut downs
  - **NO** commercial plant in the United States
  - April 01, 2017 SCAQMD testimony about UK refinery conversion to SAC was false
    - Checked with numerous sources including the co-owner and a Union Leader of the Grangemouth Refinery - confirmed there never was a unit conversion
    - CB&I stated at AQMD August 02, 2017 Proposed Rule 1410 working meeting that the China Plant is the only commercialized Solid Acid Catalyst Alkylation Unit in the world

- **Liquid Ionic Catalyst: nascent technology is only in initial test phase**
  - Only one ~200 gallon per day demonstration unit running today
  - Norton Engineering Study: Too early to be considered commercially viable technology
  - Chevron plans to install small ~5,000 BPD unit in Salt Lake City
  - August 02, 2017 - AQMD Proposed Rule 1410 Working Group meeting: Chevron confirmed that their technology will not be commercially proven until the Salt Lake City unit is built and operated for a significant multi-year time period
  - UOP in its letter stated that a prudent refinery would wait 4 to 6 years to prove a new technology

References

- *DuPont Design Basis for a new plant in Torrance*
- *Norton Engineering Study and presentation at American Fuel & Petrochemical Manufacturers meeting February 2016*
- *Honeywell UOP Letter to SCAQMD, September 2017*

MYTH - TRAA Slide 33: “Alternatives Exist” – per SCAQMD’s Norton Engineering Study

TRAA “Case Against MHF” Jan 4, 2017 – Slide 33

Alternatives Exist

-SCAQMD Study of MHF Alternatives agreed with TRAA’s recommendations-

- Sulfuric Acid (H_2SO_4)
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  - A toxic liquid—boiling point 640°F. No dense ground hugging acid cloud.
- Solid Acid Catalyst (SAC)
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  - Pilot plant has been built in the US
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- Mobil’s cost to add mitigation systems, develop MHF, convert the HF unit to MHF:

~$160M during the late 1980’s early 1990’s $275M

Sally Hayati, TRAA 33

FACT: We advised SCAQMD that there are multiple inaccuracies in the Norton Engineering Study

- **Torrance Refinery critiqued the Norton Engineering Study**
  - Significantly understates capital cost estimates and disregards operating cost differentials
  - Norton never validated their assumptions with the Torrance Refinery
  - Burns and McDonnell cost estimate was provided to AQMD presents a realistic cost estimate and addresses the deficiencies of the Norton Report
    - Assumptions do not hold up - resulting in a much higher cost estimate
  - No refinery has ever switched from MHF alkylation to a different alkylation technology
    - Equipment is fundamentally different
    - New grassroots process unit would be required
    - April 1, 2017 SCAQMD testimony on conversions was inaccurate and unfounded

- **AQMD August 23, 2017 Proposed Rule 1410 working meeting: DuPont confirmed the Norton Study estimates were low and not representative of a new unit in Southern California. DuPont provided the estimate to Norton, which was based on Gulf Coast costs and did not include scale-up or outside the battery limits scope**

References

- *TORC Letter Submitted to AQMD (Dec. 8, 2016) Re: Norton Engineering Alkylation Study, related to the use of Hydrofluoric Acid in Refinery Alkylation Units*
- *Burns and McDonnell Report Brief – Alkylation Study and Estimate July 2017*

MYTH - TRAA Slides 33 & 37: "Alternatives Exist - SCAQMD Study of MHF Alternatives agreed with TRAA's recommendations-"

TRAA "Case Against MHF" Jan 4, 2017 – Slide 33

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Sally Hayati, TRAA 33

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Sally Hayati, TRAA 37

FACT: PBF continues evaluating alternative technologies

- **We have met with experts from Honeywell / UOP, Stratco, DuPont and Burns & McDonnell, as well as independent alkylation experts to explore alternatives**
  - Sulfuric Acid Alkylation is the only commercially viable alternative
    - Presents unique challenges
  - Solid Catalyst and Liquid Ionic Alkylation have been in development for decades
    - There are no commercially viable units running in the U.S.

- **Through the Court-ordered Consent Decree process, MHF Alkylation was determined to be "…as safe as or safer than Sulfuric Acid technology"**
  - Converting to or building a grassroots Sulfuric Acid Alkylation Unit would be inconsistent with the Consent Decree, increase risk to the public, not any safer than MHF, increase emissions, and does **NOT** make sense

- **Before transitioning from MHF Alkylation to a catalyst other than Sulfuric Acid at the Torrance Refinery, the new technology must be proven**
  - Inherently safer than MHF Alkylation
  - Commercially viable in scope and scale to our existing unit

- **We are confident the safety systems on the MHF Alkylation Unit protect our employees and the community while reliably producing CARB gasoline**

MYTH - TRAA Slides 33 & 37: Alternatives Exist – SCAQMD Study of MHF Alternatives agreed with TRAA's recommendations"

TRAA "Case Against MHF" Jan 4, 2017 – Slide 33

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Sally Hayati, TRAA 37

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Torrance Refining Company

FACT: SCAQMD's Norton Engineering Study does <u>NOT</u> agree with TRAA's recommendation

- **Norton Engineering's Study states that Sulfuric Acid Alkylation is the only currently available alternative to MHF Alkylation**
- **Sulfuric Acid Alkylation introduces a different set of risks and impacts**
  - Risks and impacts include direct and indirect increases in greenhouse gases and criteria pollutants, and community risk
- **Norton Engineering's Study also states that Solid Acid Catalyst (SAC) is in the early stages of development and needs time to be proven safe and reliable**
  - Rules out SAC as a commercially viable alternative to MHF Alkylation
  - Silent on whether a pilot plant has been built in the U.S., as TRAA states
  - Various companies have been developing SAC technology for decades and the process and catalyst are not commercially viable
  - CB&I stated at AQMD August 02, 2017 Proposed Rule 1410 working meeting that the China Plant is the only commercialized Solid Acid Catalyst Alkylation Unit in the world
    - Operating details, product quality, run length and turnaround interval, catalyst regeneration, and feedstocks are currently unknown
    - Technology is not commercially viable

<u>Reference</u>

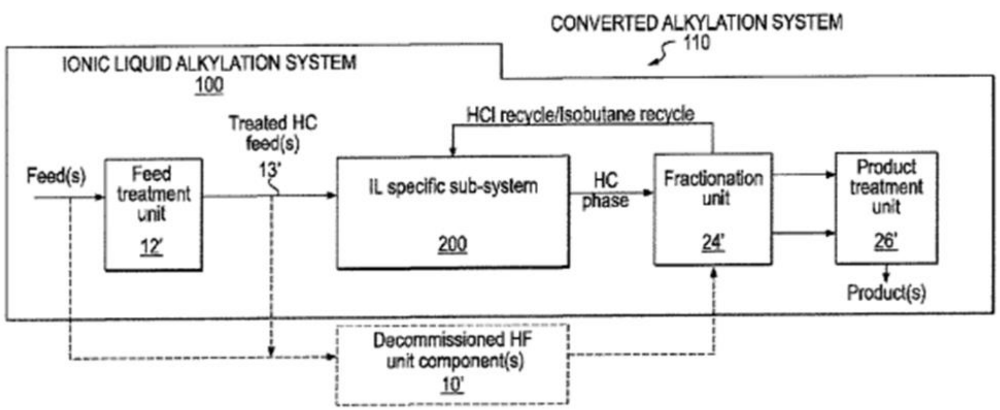
- *Norton Engineering Study*

MYTH - TRAA Slide 34: "TRC's Interest in ILA [Ionic Liquid Alkylation] is a Delay Tactic"

TRAA "Case Against MHF" Jan 4, 2017 – Slide 34

TRC's Interest in ILA is a Delay Tactic

- Norton investigated ILA. The Honeywell ILA announcement added no new info.
  - It concluded (as did TRAA) that ILA is not available to refineries other than Chevron,
  - There's no guaranteed date by which ILA will be available, nor accurate cost estimates, etc.
- ILA provides no significant technical, cost, or societal benefit over SAC or H2SO4
  - ILA needs a substantially longer transition period: there's no justification for that
  - Chevron/Honeywell state the conversion cost is comparable to H2SO4
- PBF won't voluntarily convert after Chevron switch and ILA commercial availability
  - PBF would be free to claim (still) it can't afford conversion and would have to shut down
- We need a max 3-yr deadline for MHF elimination, by 2020. No time for R&D.
  - No more blind trust in industry R&D projects
  - Choice of an alternative should be left to the refinery



Sally Hayati, TRAA

34

Torrance Refining Company

FACT: PBF continues to evaluate alternative technologies

- **PBF has met with Honeywell / UOP to discuss ILA technology**
  - Researchers from various companies have been working on ILA technology for decades, yet ILA is still not commercially viable

- **PBF will continue to monitor ILA development**
  - Chevron announced they will build an ILA unit ~15% the size of the Torrance unit

- **Chevron at AQMD August 02, 2017 Proposed Rule 1410 Working Group meeting stated that the ILA technology will not be commercially proven until the Salt Lake City unit is built and operated for some indeterminate time period**
  - Even after built and operated for some indeterminate time, the technology may not be commercially proven
  - Chevron stated that its Salt Lake City Refinery HF Alkylation Unit has never impacted its community

- **If ILA technology becomes commercially viable, PBF will evaluate, but replacement alkylation unit justification will likely not exist based on safe MHF alkylation operations and cost prohibitive nature of a wholesale unit replacement**
  - Must be inherently safer than MHF Alkylation
  - Must be comparable in scope and scale to the Torrance Refinery's existing unit
  - Must run for two, four-year turnaround cycles to be proven reliable

References

- *UOP/ Chevron Data for Salt Lake City refinery*
- *Norton Engineering Study*

MYTH - TRAA Slide 34: ILA, SAC and Sulfuric Acid have comparable societal benefit

TRAA "Case Against MHF" Jan 4, 2017 – Slide 34

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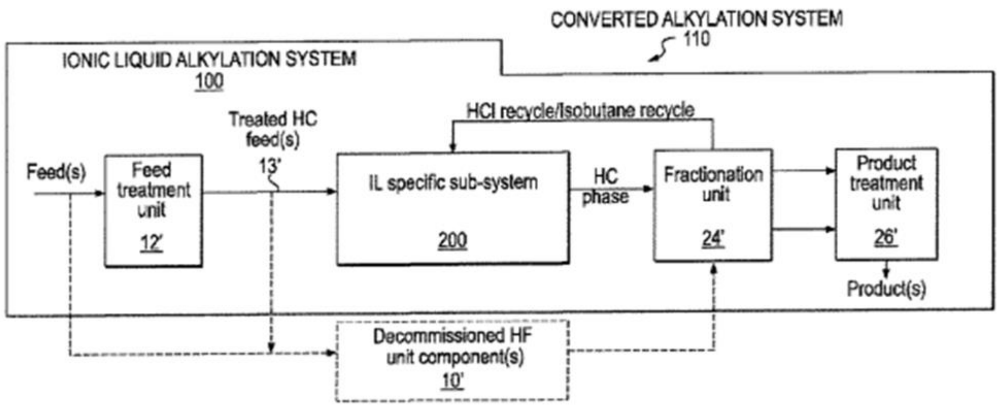

Sally Hayati, TRAA

34

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Torrance Refining Company

FACT: A QRA has not been performed on ILA or SAC, so their societal risk cannot / has not been determined

- **Despite decades of development, ILA and SAC technologies are not yet commercially viable**
  - QRAs comparing ILA and SAC to Sulfuric Acid or MHF Alkylation cannot be performed until they are commercially proven
- **Sulfuric Acid Alkylation is one of two commercially-viable alkylation technologies**
  - In the Torrance Consent Decree, MHF "(including mitigation) presents no greater risk than Sulfuric Acid Alkylation plant producing a comparable amount of alkylate"
  - Converting to or building a grassroots Sulfuric Acid Alkylation Unit would be inconsistent with the Consent Decree, increase risk to the public, increase emissions, and does **NOT** make sense
- **Torrance Alkylation Unit is ~30MBD and there are NO commercially viable ILA or SAC plants in the US at or anywhere near this capacity**
  - There are two ILA and SAC demonstration units in operation
    - ILA - Salt Lake City: ~420 gallons per day (ten barrels)
    - SAC - China: 2,500 barrels per day chemical plant reportedly has been unreliable
    - Chevron and CB&I stated at the August 02, 2017 AQMD Proposed Rule 1410 working meeting that these are the only two commercial units and that both technologies are not commercially viable

References

- *UOP/ Chevron Data for Salt Lake City refinery*
- *Norton Engineering Study*

Chapter 15: Converting the Alkylation Unit Is Implausible

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MYTH - TRAA Slides 37 & 40: "Studies have been done on HF conversion; R&D [Research & Development] not needed."

TRAA "Case Against MHF" Jan 4, 2017 – Slide 37

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Sally Hayati, TRAA 37

TRAA "Case Against MHF" Jan 4, 2017 – Slide 40

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-Estimates vary-

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  - The cost to build a unit twice this size would not be twice the price. "The cost of the conversion from HF alkylation to H2SO4 alkylation is a fraction of that of a grassroots unit as it uses most of the existing equipment." Dupont.

To Solid Acid Catalyst (SAC)

- $64M, based on data provided by Exelus for ExSact SAC
  - Exelus claims the cost of H_2SO_4 conversion is double that for SAC, so $128M
- $100M, AQMD Norton Study of MHF alternatives

This is consistent with other mandates to protect public health--

Cost of Electrostatic Precipitator (ESP), $300M in '08:	*$330M*
Cost to repair ESP after 2015 explosion:	*$161M*
Mobil's cost to add mitigation systems, develop MHF, and convert the HF unit to MHF: ~$160M during the late 1980's early 1990's	*$275M*

Sally Hayati, TRAA 40

****Note: Purple boxes added to TRAA's original image/text to highlight specific points referenced/discussed***

FACT: There has NEVER been an M/HF Alkylation unit converted to another alkylation technology

- **A Stratco Alkysafe Unit has NEVER been built or commercially proven**
  - Additionally, DuPont's current equivalent technology ConvEx is not commercially available
    - ❑ Merely a concept - only completed paper case studies
    - ❑ No pilot or field testing - no conversion has ever been undertaken
- **There has NEVER been an MHF/HF unit converted to Solid Acid Catalyst**
  - Confirmed by CB&I at the August 2, 2017 AQMD Proposed Rule 1410 Working Group meeting
    - ❑ There is only one 2,500 BPD grassroots SAC plant in China
    - ❑ Would have to vet design to validate re-use of equipment
    - ❑ Impossible to validate cost because conversion has **NEVER** been done
- **Transitioning from MHF Alkylation to a catalyst other than Sulfuric Acid at the Torrance Refinery, the new technology has to be proven**
  - Must be inherently safer than MHF Alkylation
  - Commercially viable in scope and scale to our existing unit

References

- *DuPont Design Basis for Torrance*
- *Norton Engineering Study*
- *Burns and McDonnell Report Brief – Alkylation Study and Estimate, July 2017*
- *HF Alkylation Consultants White Paper*

MYTH - TRAA Slides 37 & 40: “Sulfuric acid (H_2SO_4) would eliminate the toxic airborne risk”

TRAA “Case Against MHF” Jan 4, 2017 – Slide 37

Sulfuric Acid Can Do the Job, Safely

Solid Acid Catalyst (SAC) can also do the job; transition time should be same as H_2SO_4

- Sulfuric acid (H_2SO_4) would eliminate the toxic airborne risk
  - DHS: MHF is chemical of interest to terrorists, H_2SO_4isn’t
  - EPA: toxic offsite consequence analysis is required for MHF, not for H_2SO_4
  - Experience: 2011 Motiva Delaware City Refinery H_2SO_4release: a total of 1.1 M gallons spent H_2SO_4 with alky unit hydrocarbons were released. There was not one mention of a vapor cloud in the CSB report. No airborne toxic consequence
- All but 2 CA refineries survive in the same marketplace using H_2SO_4
  - Feedstock identical to Torrance’s are processed & same additive is made w/ H_2SO_4
- Half of existing and the vast majority of new US alky units use H_2SO_4
  - 86% of new alkylation units in 1990s chose H_2SO_4
- Studies have been done on HF conversion; R&D not needed.
  - CB&I CDAlky low temperature sulfuric acid process. CDTech study.
    - Major pieces of HF equipment can be retained
  - Stratco Alkysafe Process: low-cost conversion method patented.
    - Phillips and UOP designed HF alkylation units can be converted and expanded into H2SO4 alkylation units with minimum capital expense.
- Sulfuric acid might be piped in using existing pipeline from Carson, and regenerated on site. This eliminates the need for increased truck traffic.
- But the community prefers H_2SO_4 over MHF even if trucks must be used

Sally Hayati, TRAA 37

TRAA “Case Against MHF” Jan 4, 2017 – Slide 40

The Cost of Catalyst Conversion

-Estimates vary-

TO SULFURIC ACID

- $23M (based on 1995 quote: $15M) Stratco
- $24M-$35M (based on 2006 quote: $20-30M) Stanford Prof. L. W. Wein
- $50M-$166M (based on 2009 quote: $45M-$150M) Nat’l Petrochem & Refiners
- $100M (order of magnitude) AQMD Norton Study of MHF alternatives
- $180M (based on 1990 quote: $100M) Mobil
- $300M for a new (~0.6 x smaller) H_2SO_4 unit. Valero
  - The cost to build a unit twice this size would not be twice the price. “The cost of the conversion from HF alkylation to H2SO4 alkylation is a fraction of that of a grassroots unit as it uses most of the existing equipment.” Dupont.

To Solid Acid Catalyst (SAC)

- $64M, based on data provided by Exelus for ExSact SAC
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Sally Hayati, TRAA 40

*Note: Purple boxes added to TRAA’s original image/text to highlight specific points referenced/discussed

FACT: Sulfuric Acid Alkylation DOES NOT eliminate toxic airborne risk - the risk increases

- **With a Sulfuric Acid Alkylation Unit, released sulfuric acid mixed with hydrocarbons can become and remain airborne**
  - Quest Sulfuric Acid experiments convincingly demonstrate this phenomenon
- **Motiva Delaware City H_2SO_4 release cited by TRAA occurred in 2001, not 2011**
  - Caused one onsite fatality, eight injuries, and offsite fish kill
- **Criteria pollutant emissions - SO_2 & SO_3 - are produced from combusting spent Sulfuric Acid in an incinerator during the regeneration process**
  - MHF Alkylation does **NOT** produce SO2 or SO3
- **Sulfuric Acid Alkylation consumes ~2x utilities as MHF Alkylation**
  - Results in increased GHG emissions and larger carbon footprint
  - Each new piece of equipment is a potential source of VOC fugitive emissions
- **Spent Sulfuric Acid is highly corrosive, reactive, flammable**
  - Produces a carcinogenic mist that is more toxic than HF mist per the International Agency on Research for Cancer
  - Spent Sulfuric Acid is listed in the same hazardous material category as M/HF
  - Concentrated fresh and spent Sulfuric Acid are highly dangerous and produce insidious burns to human flesh

Reference

- *CSB Investigation Report (October 2002), Motiva Delaware City Refinery Spent Sulfuric Acid storage tank explosion and fire on July 17, 2001*

MYTH - TRAA Slide 38: "The refinery should temporarily operate without alkylation if the transition takes > 3 years"

TRAA "Case Against MHF" January 4, 2017 - Slide 38

The Transition Period Should be Minimized

- The Consent Decree mandated HF elimination by 1997. It's past time-

- Consent Decree gave 3 years to construct a MHF or sulfuric acid alky unit: 1994-97. Mobil stated in Feb. 1995 it needed no more than two years to switch to MHF.
- In Jan. 2016 Valero announced plans to build a new 13,000 b/d alkylation unit at its Houston refinery with startup in 2018. That's 2 years allocated, including permitting.
- "To construct a sulfuric acid alkylation unit within the existing Refinery... the existing [HF] unit would have to be shutdown and demolished. This and construction of a new alkylation would require approximately 1 year." Valero, Wilmington, 2004
- The refinery should temporarily operate without alkylation if the transition takes > 3 years
  - Alkylation feeds could be transported to alkylation units elsewhere or (possibly) sold for other purposes.
  - Transportation needs for (prev) alky inputs should be similar to & replace current needs for alky output
  - ExxonMobil accepted and stored crude oil shipments for > 1 year during the shut down. It coped.
- Components of the H_2SO_4 alky unit might be (like the ESP)
  - prefabricated at a safer location inside the refinery, then
  - lifted and transported to the final site for installation

"The module approach [to ESP construction] allowed the project to install piling, foundations and structural steel in parallel with ESP assembly, shortening the construction span significantly."

ESP being moved in 2008 to its final location

Sally Hayati, TRAA

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**Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed*

Torrance
Refining Company

FACT: Torrance Refinery becomes uncompetitive if the Alkylation Unit outage lasts more than 30 days

- **ExxonMobil estimated daily gross revenue losses of ~$1 million to $1.5 million due to the closure of the FCC and Alkylation Unit starting in February 2015**
  - When the MHF Alkylation Unit is down, FCC throughput must be reduced to minimum
  - FCC will be limited to one month of operation due to railcar logistics

- **MHF unit makes alkylate for producing cleaner-burning CARB gasoline**
  - Alkylate availability is limited due to high global demand and transport costs

- **The Torrance MHF Alkylation Unit produces a critical blending component for making cleaner-burning CARB gasoline for Southern California and the State of California**
  - Alkylate is required to meet stringent state-mandated gasoline specifications
  - Torrance Refinery supplies ~20% of daily regional demand and ~10% statewide

- **Refinery projects take many years to complete**
  - From permitting design to construction and then startup, each stage is critical to long-term, safe, reliable operations
  - Permitting process is uncertain
  - If steps are skipped or rushed, then mistakes can happen

- **TRAA have no knowledge of refinery / Alkylation - never designed, built, or run a refinery**
  - Unfamiliar with operating, design, procurement, or construction

Reference

- *Seeking Alpha: "Exxon Mobil: About The Torrance Refinery," April 4, 2016*

MYTH - TRAA Slide 38: "Consent Decree gave 3 years to construct a MHF or sulfuric acid alky unit"

TRAA "Case Against MHF" Jan 4, 2017 – Slide 38

The Transition Period Should be Minimized

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ESP being moved in 2008 to its final location

Sally Hayati, TRAA

38

**Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed*

FACT: Consent Decree gave seven years to design, test and construct the Torrance MHF Alkylation Unit

- **Court entered Consent Decree with Mobil and City of Torrance in October 1990**

- **May 1995: After more than two years of study, analysis, and testing, the Court ordered the phase-out of AHF and replacement with MHF**
  - Based on the Safety Advisor's recommendation to the Court

- **1997: After SCAQMD issued required permits, MHF Alkylation Unit started up**
  - Unit only required modifications rather than a complete rebuild

Reference

- *Consent Decree Safety Advisor Report , October 1999*

Torrance Refining Company

MYTH - TRAA Slide 39: PBF Energy paid $537.5M for the refinery

TRAA "Case Against MHF" Jan 4, 2017 – Slide 39

THE TORRANCE REFINERY: NOT A THROW AWAY

-THE REFINERY WOULD NOT BE SHUTDOWN SIMPLY TO AVOID THE COST OF CONVERSION-

750 acres: 1 mi x 0.76 mi
High-conversion 155K BPD, delayed-coking refinery,
Nelson Complexity: 14.9
Strategically positioned. Advantaged logistics: flexible raw material sourcing and products to/from CA, NV, AZ.
171-mile crude oil gathering & transportation system delivering San Joaquin Valley crude oil. Crude oil pipelines from ports of LA & Long Beach
Jet fuel pipeline to LAX. ~8.6M barrel crude/product storage capacity.

***PBF**: "The Torrance Refinery acquisition is another significant step in the continued growth of PBF Energy ... So. CA is a very attractive market and we are excited to become a supplier in the region...[W]e are entering at a very attractive purchase price for the Torrance refinery."* ***TRC**: The refinery [$537.5M price] is a $1B value, the XOM pipelines alone were sold for $350M to another PBF subsidiary. A new refinery would cost $2-4B."*

Sally Hayati, TRAA

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*Note: Purple box added to TRAA's original image/text to highlight specific points referenced/discussed

Torrance Refining Company

FACT: PBF Energy paid a total of $537.5MM for the refinery *and* logistics assets - the refinery alone was valued at $187.5MM

- **The cost of the refinery must be taken into consideration when evaluating the replacement of the MHF Alkylation Unit or any other major investment**
  - Estimate for a new Sulfuric Acid Alkylation Unit is ~$600MM, with an additional ~$300MM for a Sulfuric Acid Regeneration Unit and Incinerator
    - Combined project cost estimate is ~$900MM

References

- *Public Record on refinery price and PBF value*
- *Burns and McDonnell Report Brief – Alkylation Study and Estimate, July 2017*

Chapter 16: A Phase-Out or Ban is Illogical

Torrance Refining Company

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MYTH - TRAA Slide 41: "PBF Energy can deal with a MHF Ban"

TRAA "Case Against MHF" Jan 4, 2017 – Slide 41

PBF Energy Can Deal With a MHF Ban

2015: PBF Energy purchased a 189,000 b/d refinery in Chalmette, Louisiana, from ExxonMobil and Venezuelan national oil firm PdV. 189.

"PBF closes in on swift expansion," Argus Media, <https://www.argusmedia.com/pages/NewsBody.aspx?id=1127621&menu=yes>

- This refinery has an idled hydrocracker, catalytic reformer and coker.
- PBF told the press they might operate the refinery without those units but will bring these units up if that proves to be "economic."
- PBF anticipates the need for immediate changes in the types of crude oil the refinery processes, such as using medium and heavy sours.
- PBF anticipates the need for immediate changes in products sold by the refinery.
- Yet PBF states that a ban on MHF at Torrance refinery would require a shutdown
  - Would need to raise capital for improvements (~$300M), possibly tolerate one idled unit for 3-4 years, and the need to sell a different set of products while the alkylation unit is idled. Possible need to use different feedstock upon the switch from HF to sulfuric acid.
  - These are essentially the same challenges Chalmette poses.
- PBF is adapting with equanimity to 3 idle units and the need for changes in feedstock and products at the Chalmette refinery.

So why would PBF abandon their entire investment in the high capacity, high complexity Torrance refinery rather than tolerate a single idled unit (alkylation) while converting to a new catalyst?

Sally Hayati, TRAA 41

Torrance Refining Company

FACT: Torrance Refinery MHF Alkylation Unit must be kept running to make CARB gasoline required by California

- **MHF Alkylation Unit produces a critical blending component for making clean-burning CARB gasoline for Southern California and the State of California**
  - Alkylate is required to meet stringent state-mandated gasoline specifications
  - Torrance Refinery supplies ~20% of daily regional demand and ~10% statewide

- **When the Torrance Refinery MHF Alkylation Unit was down following the ExxonMobil 2015 ESP incident, most of the refinery's gasoline was sent out of state**
  - Unable to meet CARB specs - refinery not viable with MHF Alkylation Unit down
  - California motorists reportedly paid a premium of $1/gallon when the Torrance Refinery MHF Alkylation Unit was down following the February18, 2015 ESP incident

- **California Energy Commission statement from AQMD Proposed Rule 1410 Working Group Meeting September 2, 2017**
  - "Supply impacts of two refineries being close down expected to be greater in magnitude, of longer duration, and higher in costs to motorists and truckers than those resulting from the temporary loss of gasoline production capability at Torrance Refinery following the ESP explosion on 2/18/15"

<u>**Reference**</u>

- *California Energy Commission Presentation, September 20, 2017*

Torrance
Refining Company

MYTH - TRAA Slide 42: "The Refinery Can Survive a Temporary Suspension of Alkylate Production"

TRAA "Case Against MHF" Jan 4, 2017 – Slide 42

The Refinery Can Survive a Temporary Suspension of Alkylate Production

- A firm deadline must be mandated for MHF removal.
  - Gasoline still be produced at refinery even if the alky unit is offline temporarily

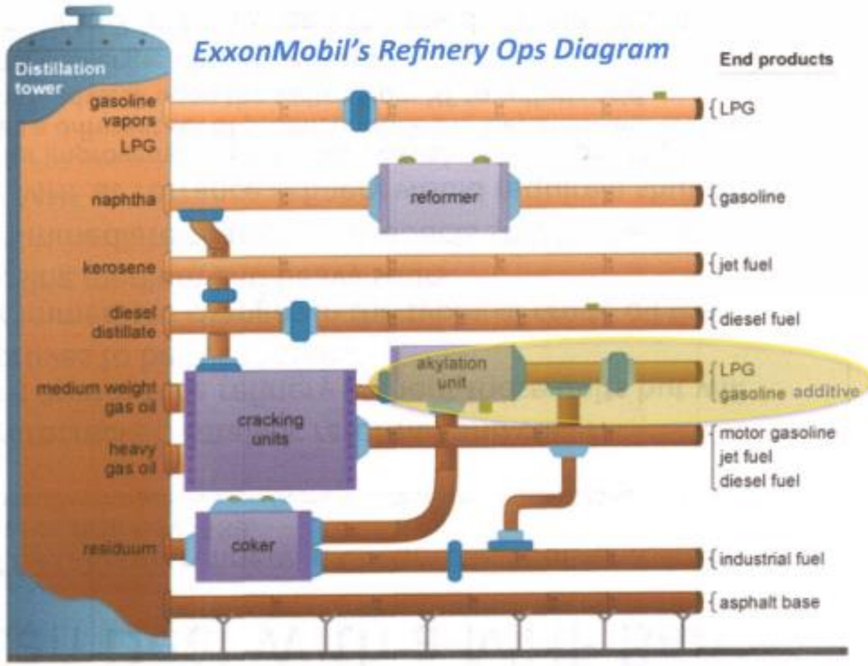
Input feeds to alky unit would require alternate treatment, shipping, sale, or storage

- This is not unimaginable: Marathon plans stand-alone alkylation units similar to MTBE units (earlier tech)

The industry can innovate when it's in its interest to do so

- MarkWest plans to create stand-alone alkylation "hub" in the Ohio natural gas fields, > 60 mi. from nearest refinery, to use butane

So innovation to protect public health & safety is also possible



Sally Hayati, TRAA

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FACT: Idling the MHF Alkylation Unit at the Torrance Refinery would cause the site to be immediately unprofitable

- **MHF Alkylation enables Torrance to meet California's strict gasoline requirements**
  - Refinery must comply with CARB gasoline requirements
  - If unit is idled, the Refinery would have to purchase expensive alkylate that would normally be produced by the unit

- **Torrance Refinery lacks rail capacity to sell its complete Alkylation feed volume from the FCC, which would force the refinery to reduce production**

- **Long-term viability is threatened whether FCC is at reduced rates or shut down**
  - Evidenced by 2015/2016 refinery losses related to shutdown of the Torrance Refinery's FCC and MHF Alkylation Unit following the February 18, 2015 ESP incident

- **TRAA slide cites one-time deals, describes unattainable petroleum market conditions**
  - Slide references a PFD that does **NOT** reflect current Torrance refinery operations
  - Slide illustrates TRAA's lack of expertise and experience in commercial petroleum transactions, logistics movements, and refinery operations

References

- *Site experience post ExxonMobil February 18, 2015 ESP Incident*
- *Market economics*

Torrance Refining Company

MYTH - TRAA Slide 43: California market will not be impacted by a reduction in alkylate production

TRAA "Case Against MHF" Jan 4, 2017 – Slide 43

CA Can Survive a Temporary Reduction in Alkylate Production

- Torrance refinery can produce gasoline even if the alkylation unit is down
  - Alkylate used as blendstock to produce 84 and 88.5 octane LA CARBOB grades.
- Alkylate for CA can be and has been purchased from out of state
  - Routine during strikes and when refineries blow themselves up
    - Golden Eagle in Martinez "completely shut" due to strike: 12,000 b/d alkylate production
    - ExxonMobil 2/18/2016 explosion: 24,200 b/d alkylate production
  - Why not, to promote public safety, import alkylate while building new alky unit?
  - 760,350-1,183,00 barrels of gasoline and alkylate were delivered in March 2015 to the US West Coast, including alkylate exports from Japan.
  - Maersk Miyajima carries 331,000 barrels of alkylate.
- Even CA gasoline itself is routinely produced outside of CA
  - Domestic sources: Washington State, US Gulf Coast.
  - Foreign sources: Canada, Finland, Germany, US Virgin Islands, Middle East, Asia
- Statistics show cost fluctuation is not direct function of CA production levels

Sally Hayati, TRAA 43

****Note: Purple boxes added to TRAA's original image/text to highlight specific points referenced/discussed***

Torrance Refining Company

FACT: California markets rely on alkylate production to comply with CARB regulations for cleaner-burning gasoline

- **Banning MHF Alkylation would drive demand for and cost of alkylate higher**
  - Alkylate would have to be imported into California
    - Foreign imports would be dependent on global octane demand and pricing
  - Banning effect: would likely increase cost of gasoline to consumers as evidenced by the reported $1/gallon spike following the February 18, 2015 ESP incident

- **According to California Energy Commission**
  - Permanent production loss in gasoline blending components would be 60.4% greater than the temporary loss associated with the February 18, 2015 ESP incident
  - Incremental impacts on gasoline costs for consumers and businesses could be as bad or worse than those experienced as a result of the ESP incident
  - Gasoline prices averaged 26 cents per gallon greater than normal for 17 months
  - Equates to increased incremental costs of $5.6 billion for motorists and businesses
  - Closure of two refineries would also increase prices for diesel and jet fuel

References

- *CEC September 20, 2017 Presentation "Potential Transportation Fuel Supply and Price Impacts of HF Ban, Proposed Rule 1410 Working Group Meeting #6", Slide 27 – "HF Ban – Fuel Price Implications"*

MYTH - TRAA Slide 41: Gulf Coast market economics are identical to California's market

TRAA "Case Against MHF" January 4, 2017 - Slide 41

PBF Energy Can Deal With a MHF Ban

2015: PBF Energy purchased a 189,000 b/d refinery in Chalmette, Louisiana, from ExxonMobil and Venezuelan national oil firm PdV. 189.

"PBF closes in on swift expansion," Argus Media, <https://www.argusmedia.com/pages/NewsBody.aspx?id=1127621&menu=yes>

- This refinery has an idled hydrocracker, catalytic reformer and coker.
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- PBF anticipates the need for immediate changes in products sold by the refinery.
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  - Would need to raise capital for improvements (~$300M), possibly tolerate one idled unit for 3-4 years, and the need to sell a different set of products while the alkylation unit is idled. Possible need to use different feedstock upon the switch from HF to sulfuric acid.
  - These are essentially the same challenges Chalmette poses.
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Sally Hayati, TRAA 41

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Torrance Refining Company

FACT: Market economics on the Gulf Coast - PADD 3 - and West Coast - PADD 5 - are distinct and unassociated

- **Chalmette and Torrance operate in distinct, separate markets with different product specifications and demands**
  - Make different products with specifications that vary from each other
  - 57 operating refineries in PADD 3 (Gulf Coast); 30 operating refineries in PADD 5 (West Coast)

- **Potential crude changes at Chalmette have nothing in common and have very different consequences than alkylation feed changes at Torrance**
  - Absolutely no connection between idle operating units at Chalmette and Torrance not operating an Alky Unit - Chalmette's HF Alky Unit was never idled
  - Idling the MHF Alkylation Unit at the Torrance Refinery would cause the site to be unprofitable due to CARB's strict gasoline blending requirements
  - This example shows TRAA's lack of expertise and experience regarding the refining industry, operations, and markets

References

- *Site experience post ExxonMobil February 18, 2015 ESP Incident*
- *Market economics*
- *US Energy Information Administration - Number and Capacity of Petroleum Refineries (as of Jan 2016)*

Chapter 17: Summary

Summary: Torrance Refinery's use of MHF is safe

- **MHF is the safest, most recent, commercially proven advance in Alkylation technology available to Torrance Refinery**
  - Rigorous testing and modeling were conducted by Mobil and Phillips Petroleum
  - Reviews & approvals: Safety Advisor, Superior Court, City of Torrance, SCAQMD
  - Torrance MHF Unit product yield and quality are comparable to HF alkylation

- **There has never been an offsite M/HF release from the Torrance Alkylation Unit**
  - 1966: HF Alkylation Unit commissioned
  - 1997: Switched to MHF
  - 51 years of operation without an offsite release
    - Includes 6.5+ magnitude Sylmar (1971) and Northridge (1994) earthquakes

- **TRAA activists oppose MHF Alkylation**
  - Use illegitimate examples to attack MHF efficacy
  - None of their self-styled "Science Advisory Panel" members have relevant education or experience in refining or alkylation
  - Use misinformation and disinformation to generate fear and outrage among a small group of residents

***Note:** Prior slides provided supporting statements and references*

Summary: Alternative Technologies

- **TRAA endorsed Sulfuric Acid Alkylation based on a FLAWED assumption of significantly lower risk than MHF**
  - Sulfuric Acid Alkylation is also hazardous and offers no advantage over MHF
  - U.S.: 50 M/HF units and 39 sulfuric acid plants, which require more processing

- **Alternative alkylation technologies are evolving, yet unproven at full scale**
  - There are **NO** commercially proven, new alternative alkylation solutions available at this time

- **PBF continues evaluating emerging alkylation technologies**

Note: *Prior slides provided supporting statements and references*

Summary: MHF in AQMD's Own Words

The following quotes are from public AQMD documents - the information presented is applicable to MHF and barrier use at the Torrance Refinery

- **News release: "Highly Toxic Chemical to be Phased Out at Valero Refinery" 2/7/03:** "Once this refinery stops using concentrated hydrogen fluoride, we will have virtually eliminated the potential for a catastrophic accidental release of this compound in our region." Barry Wallerstein, former AQMD Executive Officer
- **Wilmington Refinery Alkylation Improvement Project, Final EIR Ch. 2, p. 2-7,**

  "The modified HF catalyst reduces acid vapor pressure sufficiently to suppress the usual flash atomization process of hydrofluoric acid, causing most of the acid to fall to the ground as an easily controlled liquid and reduces the potential for off-site consequences of an accidental HF release."
- **February 7, 2003, Governing Board Letter, Agenda No. 25**

  "To further minimize public exposure to potential HF releases, the refinery is proposing to use modified HF in the alkylation process and upgrade its mitigation system to include deflector barriers for HF pumps and flanges. This proposed change meets the intent of the former Rule 1410 and will significantly reduce the potential for public exposure to this hazardous chemical in the event of an emergency release."

ADDENDUM:

GLOSSARY OF TERMS

Glossary of Terms

- **Acid strength / acid concentration:** The weight percent of acid in the alkylation unit main acid stream
- **Additive:** A heavy liquid component added to anhydrous hydrofluoric acid (AHF), which reduces aerosol properties of AHF through hydrogen bonding; additive is the “M” in “MHF” or “modified” HF. Additive is one of the five components of the main acid stream in the MHF alkylation process
- **Acid detecting paint:** Yellow paint that is painted on flanges and other surfaces in the alky unit, which turns red in the presence of hydrofluoric acid (HF)
- **Aerosol / aerosoling:** Dispersing a substance into fine particles or a “mist” suspended in the air; examples of aerosoling are fog or hair spray
- **AES / Acid Evacuation System / Rapid Acid Dump (RAD) System:** A process in which the acid contained in an alkylation unit is rapidly moved to a safe location; typical de-inventory is 5-7 minutes
- **AHF**: Anhydrous hydrogen fluoride / hydrofluoric acid. Anhydrous HF contains no water or other components besides HF (>99% pure HF)
- **Alkylate:** The main product in the alkylation process; alkylate is a high octane, low sulfur component required to blend cleaner-burning CARB gasoline
- **Alkylation:** A refining process in which light olefins (propylene, butylene) are upgraded to a high octane, low sulfur gasoline blendstock. Gasoline regulations in the United States favor alkylate blendstock due to its lower emissions.
- **AQMD** / **SCAQMD**: South Coast Air Quality Management District - the air pollution control agency for Orange County, Los Angeles, Riverside, and San Bernardino counties
- **API:** American Petroleum Institute - The only national trade association that represents all aspects of America’s oil and natural gas industry. API’s mission is to promote safety across the industry globally and to influence public policy in support of a strong, viable U.S. oil and natural gas industry.

Glossary of Terms

- **API 751 /API RP 751:** American Petroleum Institute Recommended Practices for safe operations of HF Alkylation units. RP 751 is an industry document that communicates proven industry practices to support the safe operation of an HF acid alkylation unit
- **ARF: Airborne Reduction Factor - t**he percent reduction in airborne HF as compared to an unmitigated AHF release. Larger ARF = less HF released to atmosphere. ARF is calculated using acid strength, water, additive, and reactor temperature. The ARF calculation was developed from extensive lab testing at varying percentages of each component. The refinery reports ARF values monthly to TFD.
- **ASO: Acid soluble oil -** a polymer and byproduct of the alkylation process and one of the five components of the main acid stream in the MHF alkylation process
- **Barrel / bbl:** A barrel of oil; one barrel of oil is equivalent to 42 US gallons
- **Barrier:** An enclosure which intercepts / captures a released jet of MHF which enables it to rainout instead of aerosoling; there are multiple types of barriers at Torrance including flange shrouds, pump enclosures, or barrier or “belly” pans under acid settlers
- **Belly Pan:** A barrier or enclosure surrounding the bottom area of the settler, which contains a large portion of the unit’s MHF. The belly pan captures MHF in the event of a release.
- **Blast wall:** A physical wall surrounding the acid storage and rapid acid dump vessel in the alkylation unit in order to protect both vessels from a major process upset
- **BOL: Bill of Lading** - The certificate a truck must present to the refinery in order to enter and make a delivery; a BOL shows the composition and quantity in the truck from the manufacturer
- **BPD:** Barrels per day
- **Cal/OSHA: California Division of Occupational Safety and Health (DOSH) -** a government agency which protects and improves the health and safety of employees working in California

Glossary of Terms

- **Catalyst:** A chemical which enhances or enables a reaction to occur without being destroyed or consumed in the reaction; HF is the catalyst in the HF alkylation process
- **CCPS: Center for Chemical Process Safety** - an organization within the American Institute of Chemical Engineers (AIChE) that identifies and addresses process safety needs within the chemical, pharmaceutical, and petroleum industries
- **CD / Consent Decree / City of Torrance Consent Decree:** Ordered by the Superior Court for the County of Los Angeles and developed in the 1990s based on recommendations by the City of Torrance, Mobil, and a court-appointed Safety Advisor (SA) to phase out anhydrous HF by 1997 and ensure the refinery operates in a safe manner. There are multiple post-decree obligatory items including reporting and communication protocols with TFD that were approved by the Superior Court
- **CSB: Chemical Safety Board** - an independent U.S. federal agency charged with investigating industrial chemical accidents. Headquartered in Washington, D.C., the agency's board members are appointed by the president and confirmed by the United States Senate. The CSB conducts root cause investigations of chemical accidents at fixed industrial facilities.
- **Desert Test / Nevada Desert test :** Testing conducted in 1986 to determine release properties of anhydrous HF
- **EPA: Environmental Protection Agency** - an agency of the Federal government of the United States that has the purpose of protecting human health and the environment by writing and enforcing regulations based on laws passed by Congress.
- **EPA Worst Case Scenario:** A component of the EPA's Risk Management Program or RMP which aims to understand potential offsite impacts in the event of a release of a toxic substance
- **ERPG-2: Emergency Response Planning Guidelines Tier 2** - part of the EPA's RMP; the maximum airborne concentration below which nearly all individuals could be exposed for up to 1 hour without experiencing or developing life-threatening health effects.
- **ESP: Electrostatic Precipitator** - a pollution control device on the back-end of the FCC unit which collects FCC catalyst particles, preventing them from being released to the atmosphere
- **ExxonMobil:** The owner and operator of the Torrance Refinery from 1999-2016

Glossary of Terms

- **FCC/FCCU: Fluidized Catalytic Cracking Unit** - makes feedstock for the alkylation unit and other gasoline components used to blend CARB gasoline
- **First Principles:** Scientific theoretical work is said to be from first principles if it starts directly at the level of established science and does not make assumptions such as empirical model and fitting parameters.
- **Flange barrier / flange shroud:** One of the MHF barriers at Torrance which fully wrap around pipe flanges and enclose the flange. Shrouds are tested annually for integrity and efficacy with the Torrance Fire Department
- **Flash Atomization:** The act of a substance disintegrating into small droplets when a pressurized liquid is released into the atmosphere. Modified HF eliminates the ability for flash atomization of HF to occur.
- **Flash Vaporization:** A liquid stream partially vaporizing under certain pressure and temperatures. Flash vaporization typically occurs from a large drop in pressure which causes the fluid to rapidly vaporize or "flash"
- **HC / light ASO: Hydrocarbon / light acid soluble oil** - a component of the main acid stream which has a lower boiling point than "normal" ASO
- **HF alkylation:** Alkylation process which uses hydrogen fluoride as the reaction catalyst
- **Honeywell / UOP:** Honeywell manufactures modified HF which is sold to the Torrance Refinery; UOP owns the ReVAP and HF alkylation technologies
- **Hydrogen bonding:** An attraction between a hydrogen atom and another atom or molecule, such as water. Water's high boiling point can be attributed to its strong hydrogen bonding relative to its low molecular weight.
- **IARC: International Agency for Research on Cancer –** specialized inter-disciplinary cancer agency of the World Health Organization that promotes international collaboration in cancer research so that preventive measures may be adopted
- **Ionic liquid Alkylation/ILA:** A new alkylation technology developed by Chevron licensed to UOP which has only been tested on a small scale. A small scale plant is planned to be developed and implemented by 2020 at Chevron's Salt Lake City refinery

Glossary of Terms

- **Isobutane:** One of the main feedstocks for the alkylation unit
- **Jet Release:** The act of a substance disintegrating into small droplets when a pressurized liquid is released into the atmosphere.
- **KB:** Thousand barrels
- **Mobil:** The Torrance Refinery's owner and operator until 1999 when Exxon and Mobil merged
- **MHF**: "Modified" hydrogen fluoride / hydrofluoric acid – hydrofluoric acid with an additive depressant to prevent flash atomization
- **MHF Alkylation / ReVAP:** Reduced Volatility Alkylation Process which uses a heavy liquid additive to suppress aerosolization properties of hydrogen fluoride
- **MHF-AUA:** Modified Hydrogen Fluoride Alkylation Unit Acid
- **Naphtha:** A product made from the FCC which is a key blendstock for CARB gasoline
- **Norton Study / Norton Alkylation Technology Study:** A study commissioned by the South Coast Air Quality Management District assessing the different options of alkylation technologies issues in September 2016
- **Olefin / PBB:** Main feedstock for the alkylation unit which is produced from the FCC – (PBB –propylene, butylenes, butanes)
- **Passive mitigation:** A mitigation system which requires no human or mechanical interaction
- **PBF: PBF Energy** - the current owner and operator of the Torrance Refinery since July 2016
- **TORC: Torrance Refining Company, a subsidiary of PBF Energy,** the current owner and operator of the Torrance Refinery since July 2016
- **PSM**: Process safety management

Glossary of Terms

- **QRA:** Quantitative Risk Assessment - an industry standard methodology that considers a broad range of scenarios, applies probability of likelihood, and highlights most effective risk mitigation options.
- **Rainout:** The act of a substance forming a liquid and dropping or "raining" to the ground. "Rainout percent" refers to the percentage of released liquid HF which remains as a liquid due to rainout.
- **Reactor:** Vessel in which alkylation reaction takes place. Olefin, isobutane, and acid are combined in reactor to make alkylate
- **Regeneration / acid regeneration:** The process in which byproducts / contaminants produced in the alkylation reaction are removed from the acid stream so the acid can be reused
- **RMP** / **EPA RMP: Risk Management Plan -** part of the Clean Air Act, which requires EPA to publish regulations and guidance for chemical accident prevention at facilities which use hazardous substances.
- **SA / Safety Advisor:** A Superior Court-appointed safety advisor responsible for reviewing, investigating, and developing recommendations around modified HF and overall safe operation of the refinery including the MHF unit at the Torrance refinery; recommendations were documented in the Safety Advisor Report and implemented in the Torrance Consent Decree, which bound the Torrance refinery to adhere to these recommendations
- **Settler / acid settler:** A horizontal vessel in the alkylation unit that separates acid from hydrocarbon / alkylate (based on density) after the alkylation reaction has occurred
- **Solid Acid Catalyst (SAC) alkylation:** An alkylation process not yet commercially viable which uses a zeolite catalyst to produce alkylate. One plant (<3 kbd) has been in operation in China since 2015.
- **SRI: Societal Risk Index** - a measure of risk to the general public which accounts for all safety factors affecting the alkylation unit; lower SRI = lower risk. SRI is affected by multiple factors including ARF, number of acid truck deliveries, and the availability of critical safety systems such as barriers, AES, HF detectors, fire monitors / deluge. The refinery stewards and reports SRI quarterly to the Torrance Fire Department

Glossary of Terms

- **Stratco Alkysafe:** The process in which an HF unit is converted to sulfuric acid; process is a patent and has never been implemented in an actual refinery
- **Sulfuric Acid alkylation:** Alkylation process which uses sulfuric acid (H_2SO_4) as the reaction catalyst
- **TFD:** Torrance Fire Department
- **TRAA: Torrance Refinery Action Alliance** - grassroots organization of South Bay residents and business owners against MHF
- **Vapor pressure:** The pressure exerted by a vapor that is in equilibrium with its solid or liquid form - volatility is directly related to vapor pressure. A substance with a high vapor pressure is considered volatile.
- **Water:** One component in the main acid stream which acts as an HF vapor suppressant (via hydrogen bonding), reducing aerosoling of HF. Water concentration is limited to 3 wt% due to corrosion issues
- **Water Cannon:** A water mitigation system which suppresses HF vapors in the event of a release