Refinery and Petrochemicals Hydrocarbon Mass Balance & Hydrocarbon Loss

Are you having a problem with your hydrocarbon mass balance? Coping with a relatively high hydrocarbon loss? There are several actions one can execute to get the mass balance 'closing' and minimizing the hydrocarbon loss.

A mass balance is an application of conservation of mass to the analysis of physical systems. It revolves around mass conservation, i.e., that matter cannot disappear or be created spontaneously. For many reasons, refineries and petrochemical plants need to have a good record on their feedstock intake, products exported and inventory changes.

This information is used for financial accounting purposes, tax obligations, safety & security (mass lost – whereto? – environment or theft?), blending, design, engineering, energy and CO2, monitoring, troubleshooting, project work, tuning planning models, strategy studies, and more.

A mass balance is per definition closing (accumulation = in – out, i.e. 100%m), but in practice some mass cannot be (easily) measured and is called 'hydrocarbon loss'. Part of it can be back-calculated ('Accounted HC loss') such as Flare emissions and the rest is called 'Unaccounted HC loss'. An Unaccounted Loss can be either a 'paper loss' (not correctly allocated in the financial books but molecules still physically present in refinery) or a 'physical loss' (molecules lost, e.g. miscalculated intake/export, spilled into the environment or theft).

For a typical refinery the 'hydrocarbon loss' is less than 1%m, but unlikely to be below 0.15%m. A hydrocarbon loss of 0.5%m represents for a throughput at 100,000 bbl/day (340 days/year), and a hydrocarbon price at 100 $/bbl, a potential value loss of about 17 M$/year. This underpins the importance of minimizing hydrocarbon loss. Theoretically, a calculated hydrocarbon 'gain' is possible as well requiring similar follow-up.

Key for good mass balancing and minimizing hydrocarbon loss expressly includes but is not limited to:

Feedstock intake and products export:
1. Correctly measure the intake and export by using recently calibrated measuring equipment.
2. Representative sampling.
3. Correction for water or other non-hydrocarbons incorporated (e.g. water/moisture in crude oil).
4. Use correct densities for conversion from volume flow to mass flow.
5. Flow measuring equipment should be properly sealed to avoid interference such as theft.

Inventory changes:
1. Feedstock, intermediate product and final product tank inventories are correctly measured (mind tank layering).
2. Correction for water and sediment.
3. A correct tank strapping chart (volume versus level) using calibrated gauging/dipping tapes or similar.
4. Correctly manage active tank pump-and-run situations.
5. Incorporate materials in transit (e.g. a pipeline).

Mass balance accounting practices:
1. Keep good monthly Finance Accounting records (including owned storage at Third Parties), consistent with (preferably) own measurements and Bill of Lading's (especially on amount and density).
2. Make sure slops, flares, purge gas, seepage, evaporation, G/L/S waste and spills are included.
3. Incorporate impact of utilities, such as refinery fuel and gas (own consumption).
4. Assure Finance Accounting tools (such as IT SAP) are correctly configured.
5. Make a daily balance and execute a monthly reconciliation including trend monitoring.

Management governance:
1. Clear and updated Roles and Responsibilities (GM, FM, E&S, Operations, Technology, …).
2. Clear, complete, specific/relevant, updated and used documentation, policies, and procedures.
3. Regular Management Reviews with efficient (follow-up) Key Performance Indicators (KPI's), action- and performance management.
4. Typically the Finance Manager is site process owner for Custody Transfer Measurement, Mass Balance and Hydrocarbon Loss.
5. People appropriately trained and motivated.

Calculations are typically executed on daily basis. An audit-type of investigation could be executed to solve any unacceptable hydrocarbon loss problems.

In a recent project for a client an on-site hydrocarbon loss workshop was held to reduce hydrocarbon losses from around 1.0%m to circa 0.15%m. Several ideas were listed that could lead to clarifying (part of) the observed losses.


FEDERAL RESERVE NOTE
THE UNITED STATES OF AMERICA
THIS NOTE IS LEGAL TENDER
FOR ALL DEBTS, PUBLIC AND PRIVATE
B 03542754 F
WASHINGTON, D.C.
B 03542754 F
SERIES 2009
Treasurer of the United States.
Secretary of the Treasury.
ONE DOLLAR
©EHP Wolff

Mitigating Refinery Hydrocarbon Loss by Reduction of Flaring

In ppPLUS Flyer 13 the (financial) impact of Refinery Hydrocarbon Loss was described. Part of the hydrocarbon loss can be accounted for (typically two-third of the hydrocarbon loss, but this varies widely), leaving the rest unaccounted.

The biggest accounted contributors of hydrocarbon loss is most likely flaring. Typically 25% of the hydrocarbon loss, but this varies considerably. Flares are first and foremost safety devices that must be available at all times for use in various situations to prevent accident, hazard, or release of refinery gas directly to the atmosphere.

However, minimizing flaring is of economic and environmental benefit and best-in-class refineries have almost no flaring (except of a purge to prevent air ingress and a pilot burner to provide a source of ignition in case flaring is indeed needed). Other main contributors for hydrocarbon loss are transfer/storage losses and all kinds of evaporation and diffusion.

To minimize flaring, several measures can be considered (but not always – economically – attractive):

1. Create a system evaluation to identify miscellaneous gas streams that are (erroneously) routinely routed to the Flare Gas Header (FGH) and determine if these streams can be eliminated, reduced or re-routed directly to the Fuel Gas Unit (FGU). Portable ultrasonic flow monitoring equipment is to be used to troubleshoot leaking valves to the Flare Header.
2. Upgrade condensers to improve performance, especially during hot weather periods. This improved performance reduces production of fuel gas and decreases the likelihood of fuel gas imbalance.
3. During unit shut-down:
   - hot strip reactors with H2 then N2; Recycle H2/N2 within reactors and minimize that quantity of gas that is purged to the FGH.
   - cool reactors (and purge downstream vessels) with N2; Recycle N2 within reactors and minimize that quantity of gas that is purged to the FGH.
   - route the low Btu gases (H2 and N2) to the FGU and add natural gas to meet Btu specifications for fuel gas.
   - segregate low Btu gases (H2 and N2) and routine base-load flare gases. Route the low Btu gases to the flare and the routine base-load flare gases to fuel gas recovery.
4. During unit start-up:
   - warm reactors with hot H2 and/or N2; Recycle H2 and/or N2 within reactors and minimize that quantity of gas that is purged to the FGH.
   - activate catalyst with H2/N2 (e.g. isomerisation); Recycle H2/N2 within reactors and minimize that quantity of gas that is purged to the FGH.
   - send off-spec products to the FGH. Utilize multiple compressors in a staged process to slowly start the units and minimize the production of off-spec products.
   - route the low Btu gases (H2 and N2) to the FGU and add natural gas to meet Btu specifications for fuel gas.
   - segregate low Btu gases (H2 and N2) and routine base-load flare gases. Route the low Btu gases to the flare and the routine base-load flare gases to fuel gas recovery.
5. Install or expand Flare Gas Recovery System.
6. Switch from fuel oil to fuel gas firing otherwise this gas being routed to the flare.
7. Purge the flare with (surplus) N2 rather fuel gas.
8. … and many more (operational, maintenance-, organisational-, and governance-wise, …).

In a recent project for a client in Asia, the above-mentioned options were taken into account and will lead to substantially less flaring (aiming for 75% reduction).


Source: https://www.scoopnest.com/user/KTLAnewsdesk/568103295140683776

Refinery Hydrocarbon Mass Balance and Loss, Get-It-Right!

Are you having a problem with your refinery (or petrochemicals) hydrocarbon mass balance? Struggling with a relatively high hydrocarbon loss? In Flyers 13 and 14 I described the necessity and key requirements for proper mass balancing and minimizing hydrocarbon loss.

This flyer helps you further to get it right! A mass balance is per definition closing, but in practice some mass cannot be (easily) measured and is called ‘hydrocarbon loss’. It should be noted that loss figures are generally derived as differences between comparatively large numbers (Intake – Export – Own Fuel Consumption, corrected for Inventory Changes). These large numbers need to be estimated very accurately to arrive at an accurate loss number.

Therefore, we need to look way beyond the ‘usual’ refinery intake (crude, other feedstocks, …) and export (LPG, mogas, diesel, fuel oil, …). In the attached figure, and below, is a more complete overview presented of the relevant intake and export. Elemental C, H, S, N, O, … mass balances have to be considered and also multiple – relatively small contributions – have to be included for an accurate mass balance.

Intake:

- Crudes & Condensates (calculated free from water, moisture and sediment).
- Other (chemical) feedstocks, such as VGO, platfeed, platformate, methanol, FAME, additives, slops, fuel, H2, …etcetera.
- Natural gas (typically fed to a steam reformer for hydrogen production).
- Steam fed to the steam reformer.

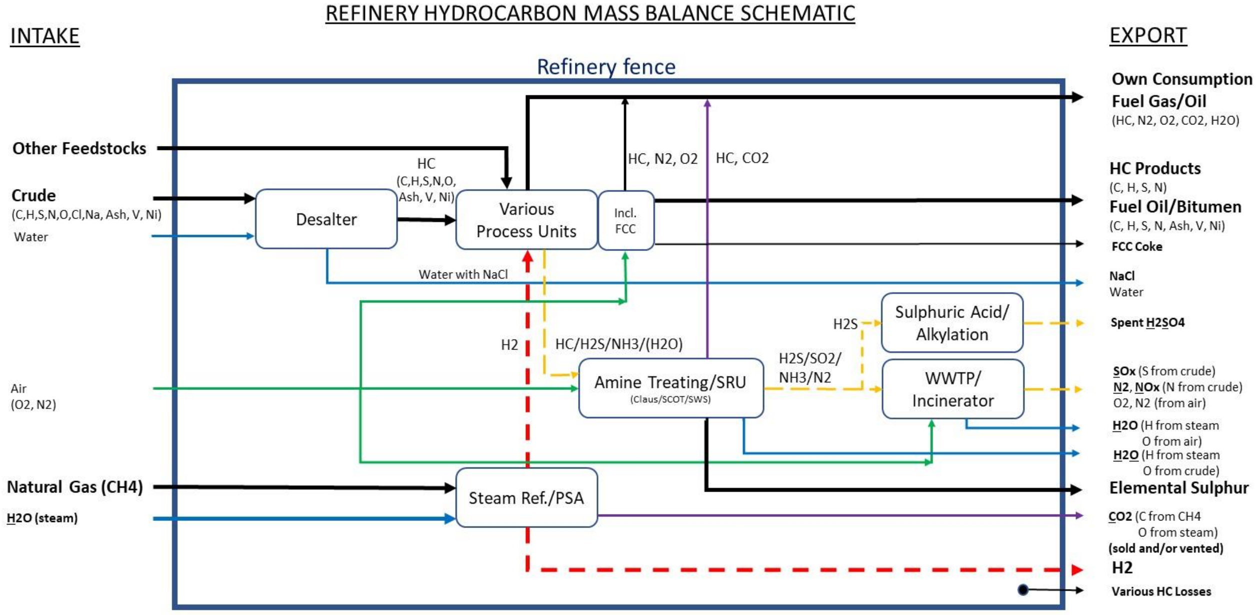
Export:

- The usual refinery hydrocarbon products.
- Own refinery fuel gas and fuel oil consumed.
- CO_2 (sold or vented) where the carbon originates from the natural gas feed to the steam reformer (the other CO_2 should already be accounted for in the refinery own fuel oil and gas production).
- Elemental sulphur.
- Hydrogen.
- SOx, NOx and H_2O where the sulphur, nitrogen and oxygen (in H_2O) originate from the feedstocks (i.e. not the nitrogen from combustion air), and the hydrogen from steam reformer steam intake.
- Spent catalyst containing carbon and/or hydrogen, such as FCC coke on catalyst and spent H_2SO_4 from an alkylation unit.
- Salts from crude oil.
- Various ‘accounted’ hydrocarbon losses such as flares, pilots, purges, HC in the excess air from a mercaptans oxidation process (such as MEROX), evaporation, fugitives, diffusion (especially H_2), vents, effluents, slops, sludge, spills, fires, and other G/L/S wastes.

The difference between all above mentioned Intake, Export and Own Fuel Consumption (all corrected for inventory changes) over a certain period of time is the ‘unaccounted loss’ (typically one-third of the total hydrocarbon loss, but this varies widely) and should be further investigated for identification. An unaccounted loss can be either a ‘paper loss’ (not correctly allocated in the financial books but molecules still physically present within the refinery fence) or a ‘physical loss’ (molecules lost, e.g. miscalculated intake/export, spilled into the environment or even theft).

In recent projects for clients in Italy and India, on-site hydrocarbon loss workshops were held to determine the mass balance correctly and reduce hydrocarbon loss from around 0.5%m - 1.0%m to circa 0.15%m which is best-in-class. Several new ideas were listed that could lead to clarifying (part of) the observed loss.

REFINERY HYDROCARBON MASS BALANCE SCHEMATIC



Note: This schematic only shows streams relevant for the hydrocarbon mass balance calculations and therefore does intend to show a complete refinery MB.