Mercury Removal in a Wet FGD

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April 18, 2013

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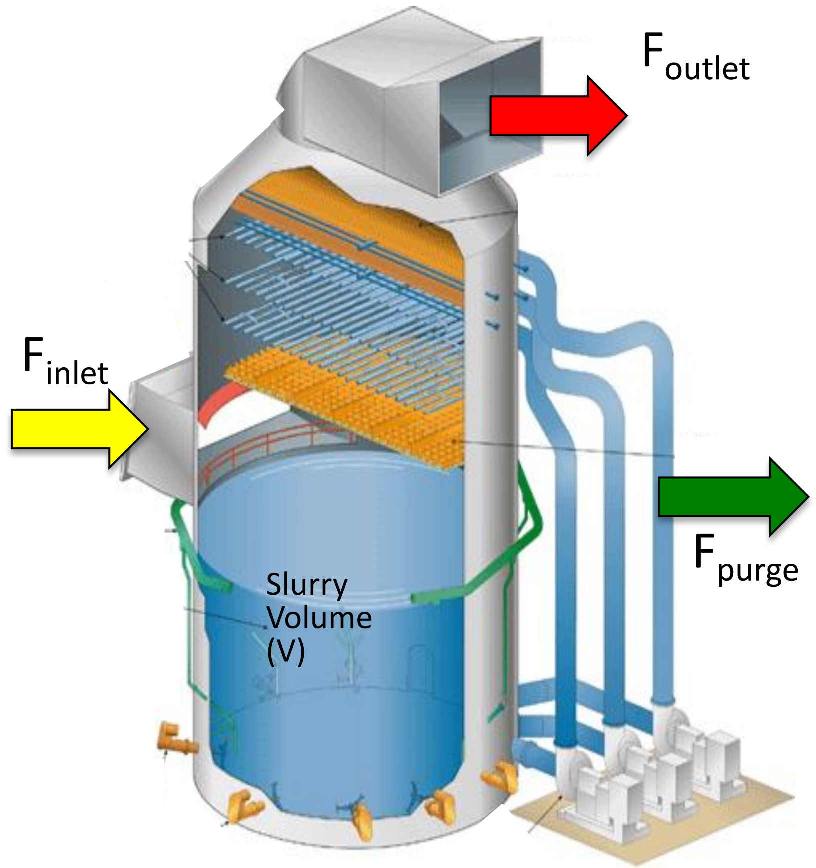
Apply the Scientific Method

- Problem statement
- Two competing hypotheses
  -- Suppress mercury re-emission.
  -- Satisfy the material balance.
- Testing the hypotheses in a trial
- Explanation of observations
- Revisit the competing hypotheses

Problem Statement

How to Achieve Reliable Removal of Mercury in a Wet FGD?



Problem:
How to Achieve Reliable Removal of Mercury in a Wet FGD?

Hypothesis A –

Suppress Mercury Re-emission.

- It is known that oxidized mercury is soluble in water and therefore can be removed from the flue gas by the presence of a w-FGD.
- However, for certain w-FGDs, when oxidized mercury enters the scrubber it is reduced to elemental mercury which is not soluble, resulting in lower mercury capture efficiency and increased stack emissions.
- This phenomenon has been coined Mercury Re-emission and is defined as an increase in elemental mercury across the w-FGD scrubber.
- Suppression of mercury re-emission in the w-FGD offers a low cost solution to reducing mercury emissions.

Hypothesis B –

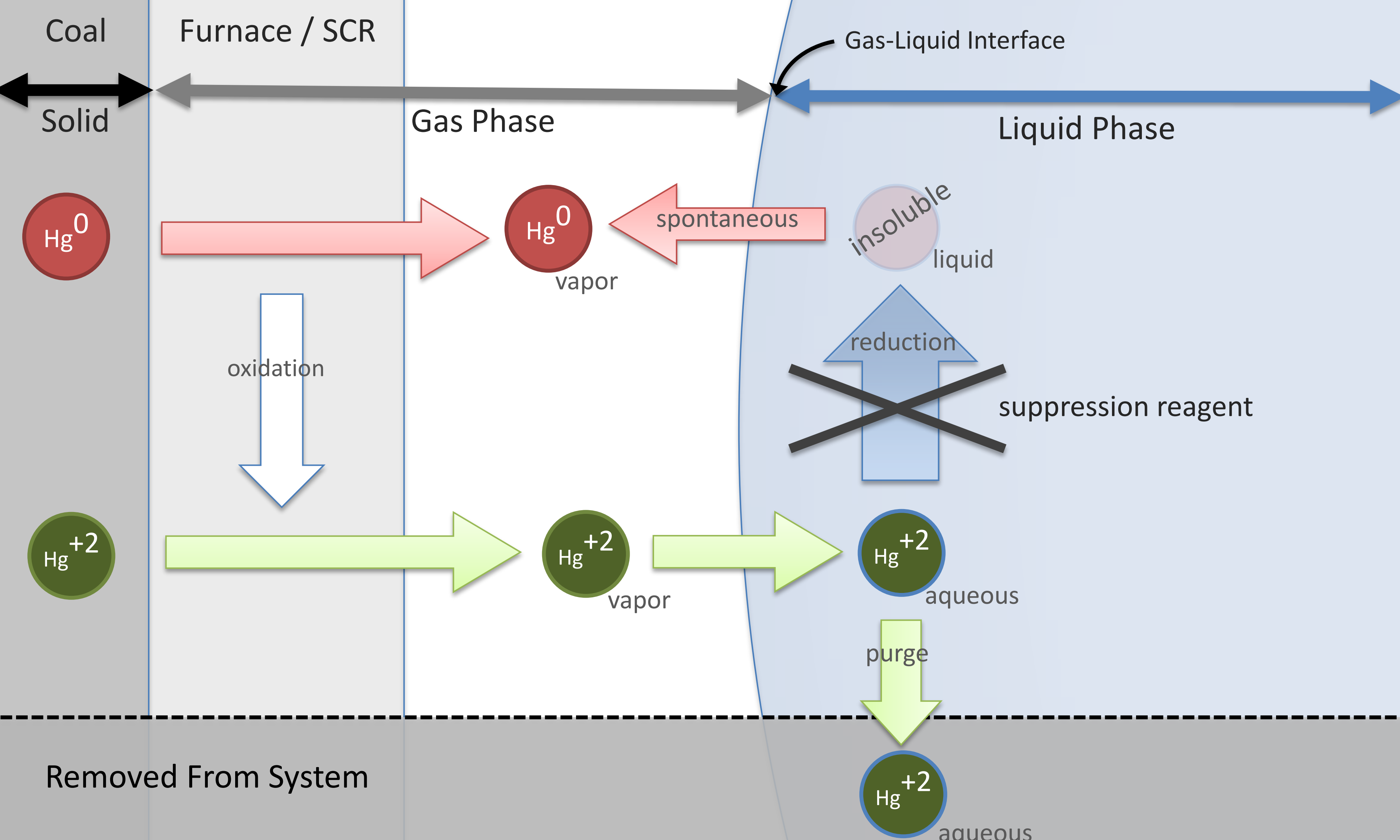
Satisfy the Material Balance.

Mercury is distributed into the streams leaving a wet FGD as determined by

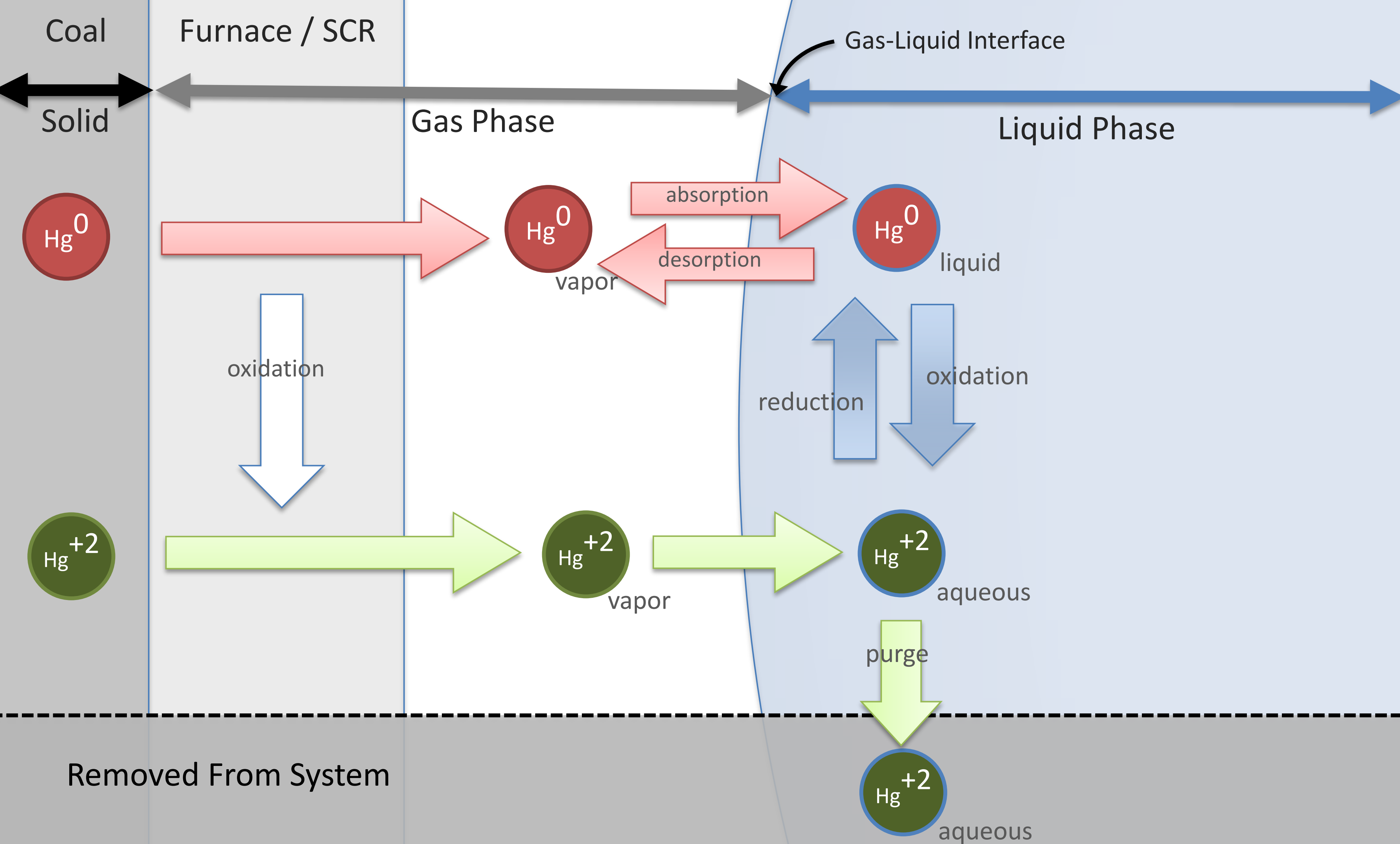
- the material balance around the FGD and
- the physical properties of mercury.

Use existing, accepted engineering principals to adjust the distribution of mercury between the streams leaving the FGD.

The Mercury Re-Emission Model



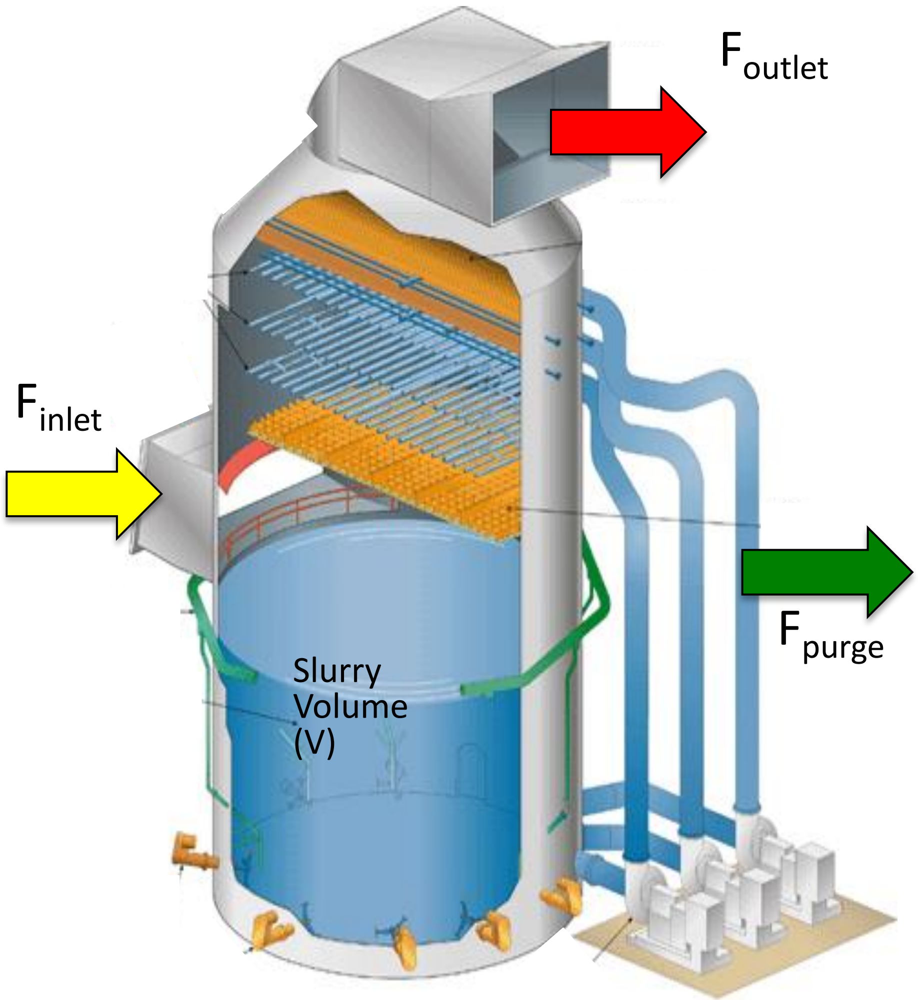
The Mercury Absorption Model



Absorbing Mercury In a WFGD

An absorber is

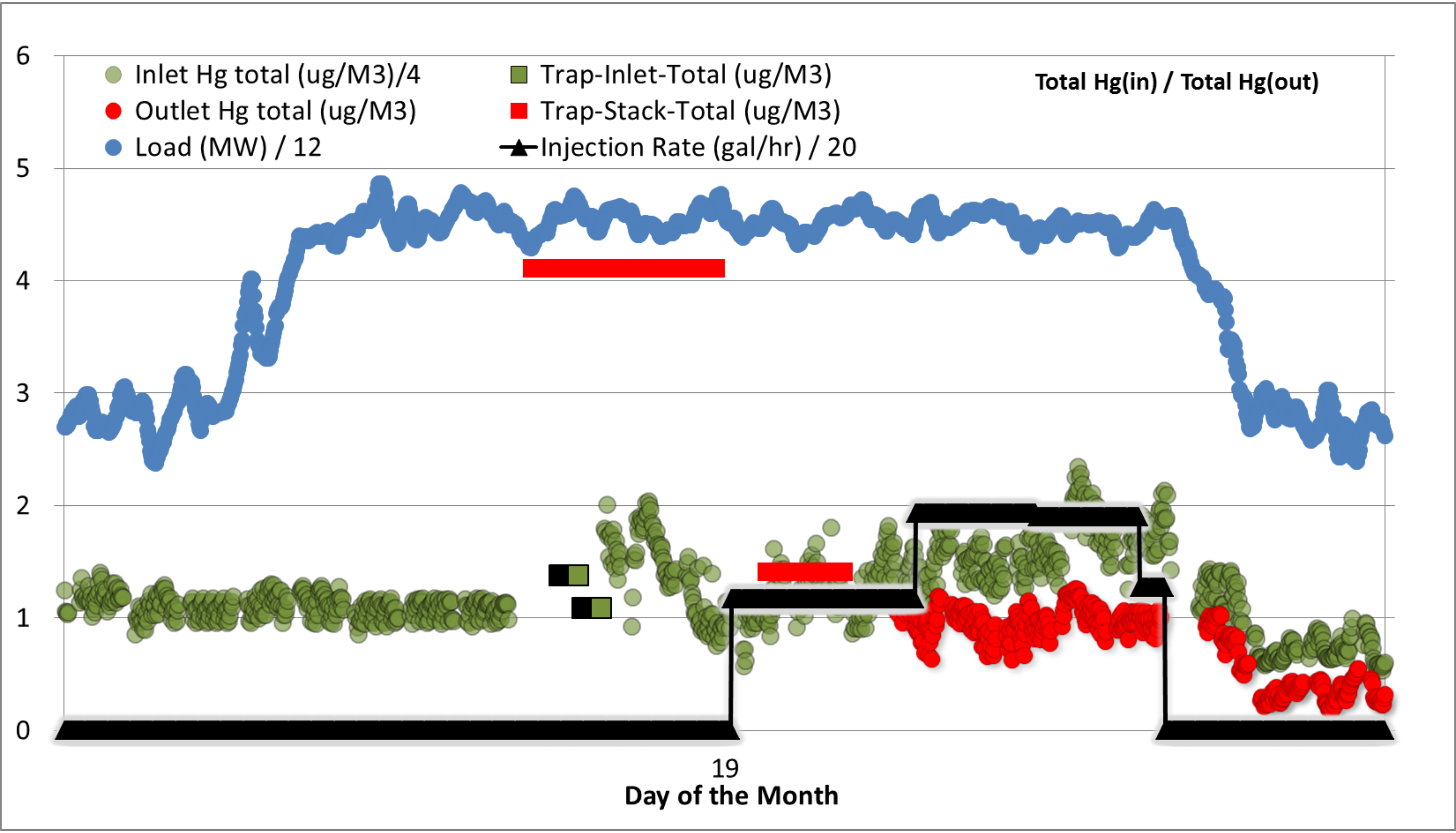
- a special case of distillation technology
- where components in the gas phase are preferentially transferred to the liquid phase as allowed by
- thermodynamic driving forces (concentration gradients) and
- mass transfer capacity (contact area).



A Trial to Test Our Hypotheses

- Two weeks of testing was done in March 2013 at Michigan South Central Power Agency's Endicott Power Station in Litchfield , MI.
- MSCPA was seeking a plan to achieve reliable mercury MATS compliance – less than 1.2 lb Hg emissions / TBTU heat input on a 30-day average – at minimum cost.
- Endicott is a 55 MW unit burning eastern bituminous coal. The unit is equipped with low NOx burners, over-fire air for nitrogen oxide controls, an electrostatic precipitator for particulate control, and wet flue gas desulfurization for sulfur dioxide control.
- Coal is sourced from the East Fairfield Mine located in North Lima, Ohio.
- Continuous mercury monitors on both the scrubber inlet and outlet were provided by Ohio Lumex.
- Data was collected at one-minute intervals.
- NaHS solution was injected into the suction of the scrubber recycle pumps as indicated to precipitate mercury as a solid compound.

Trial Results



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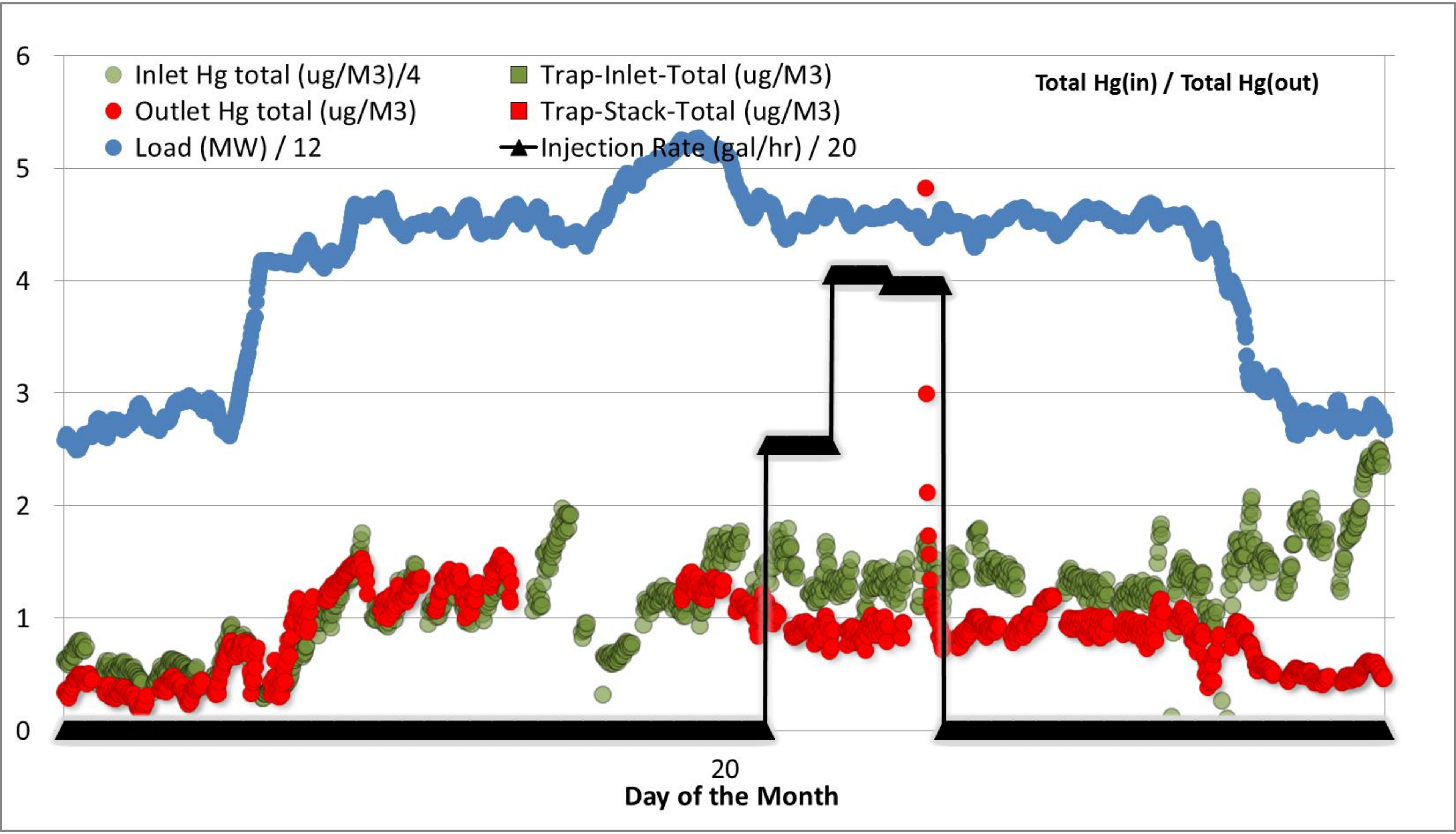

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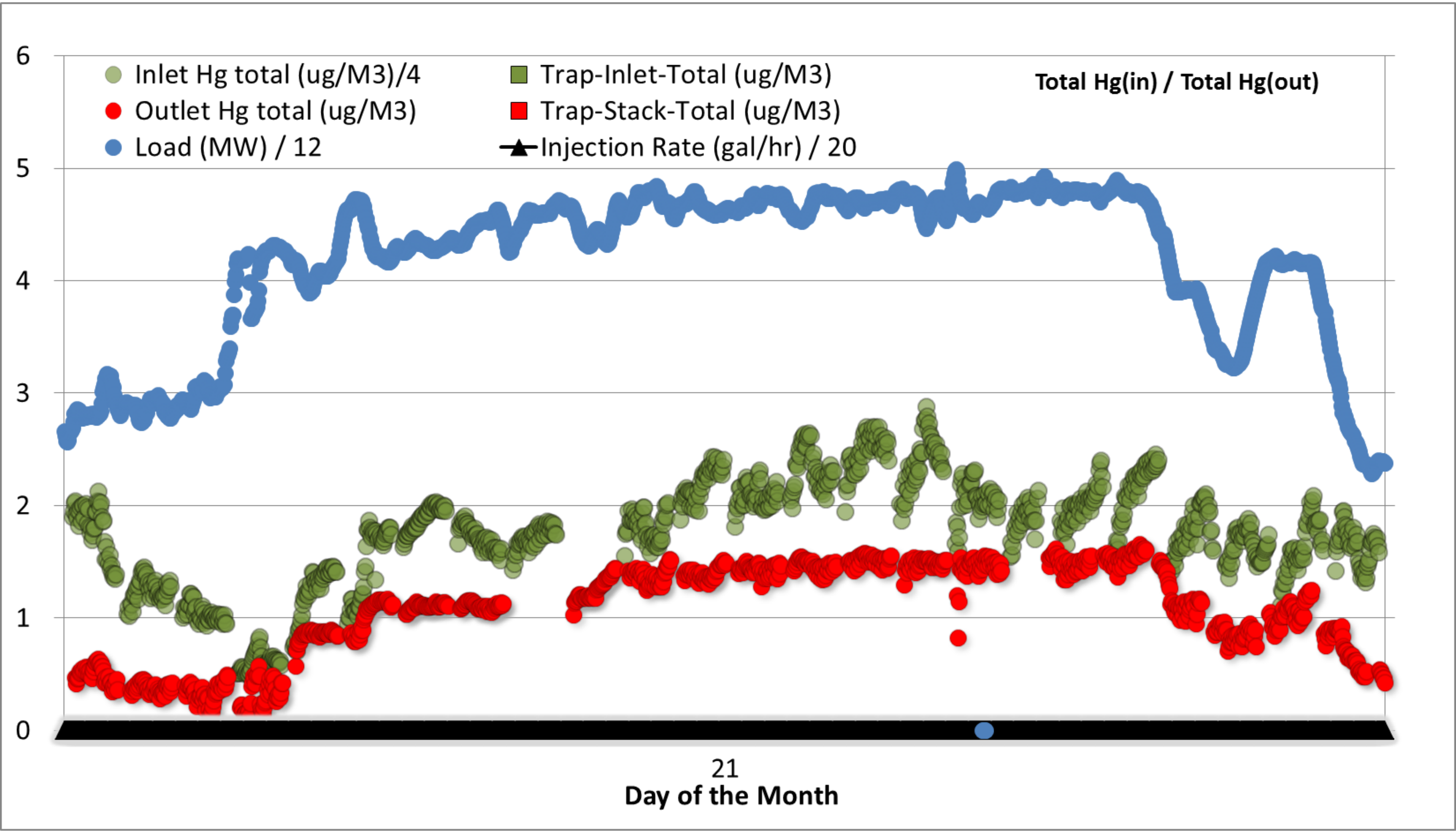

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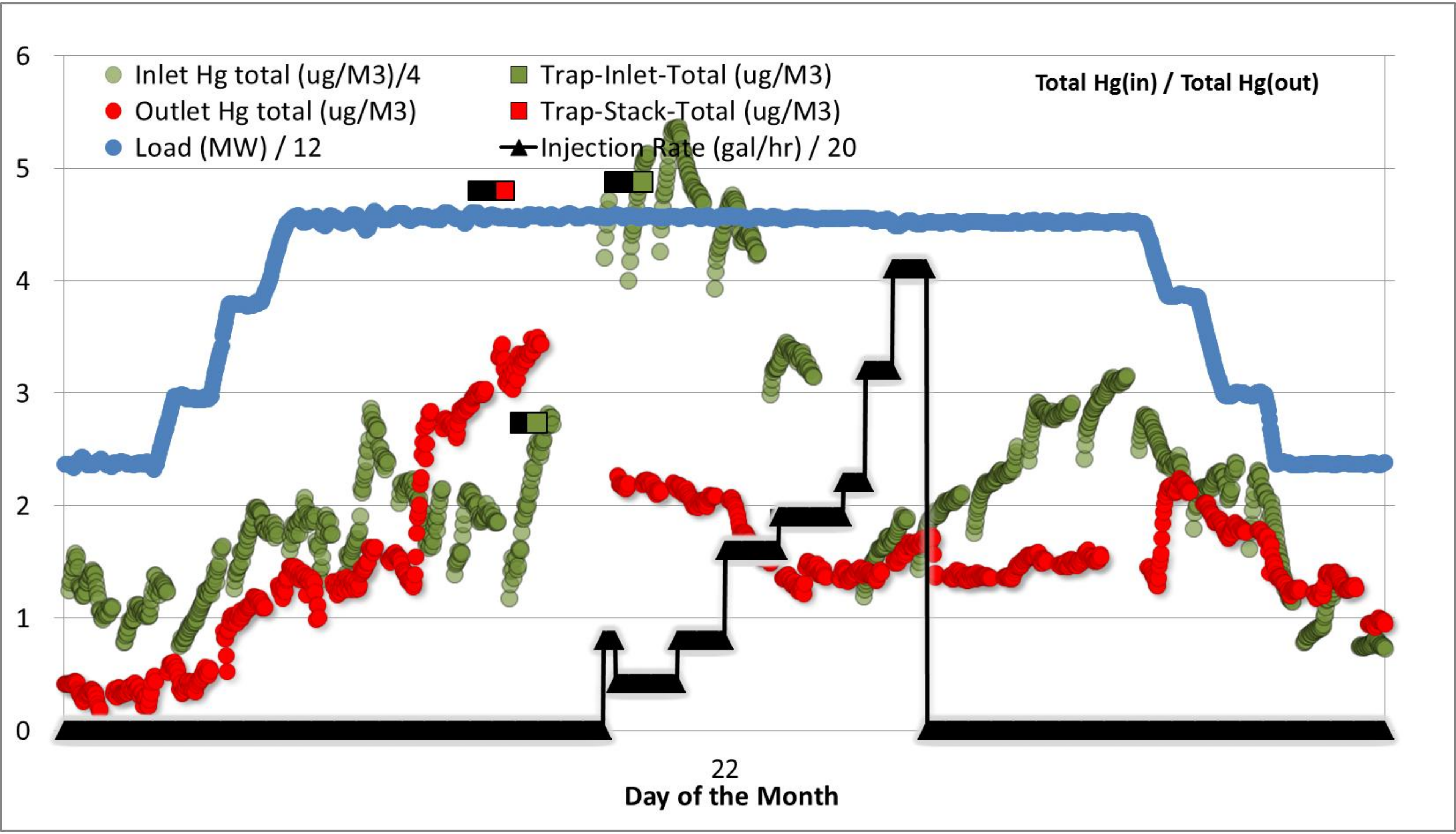

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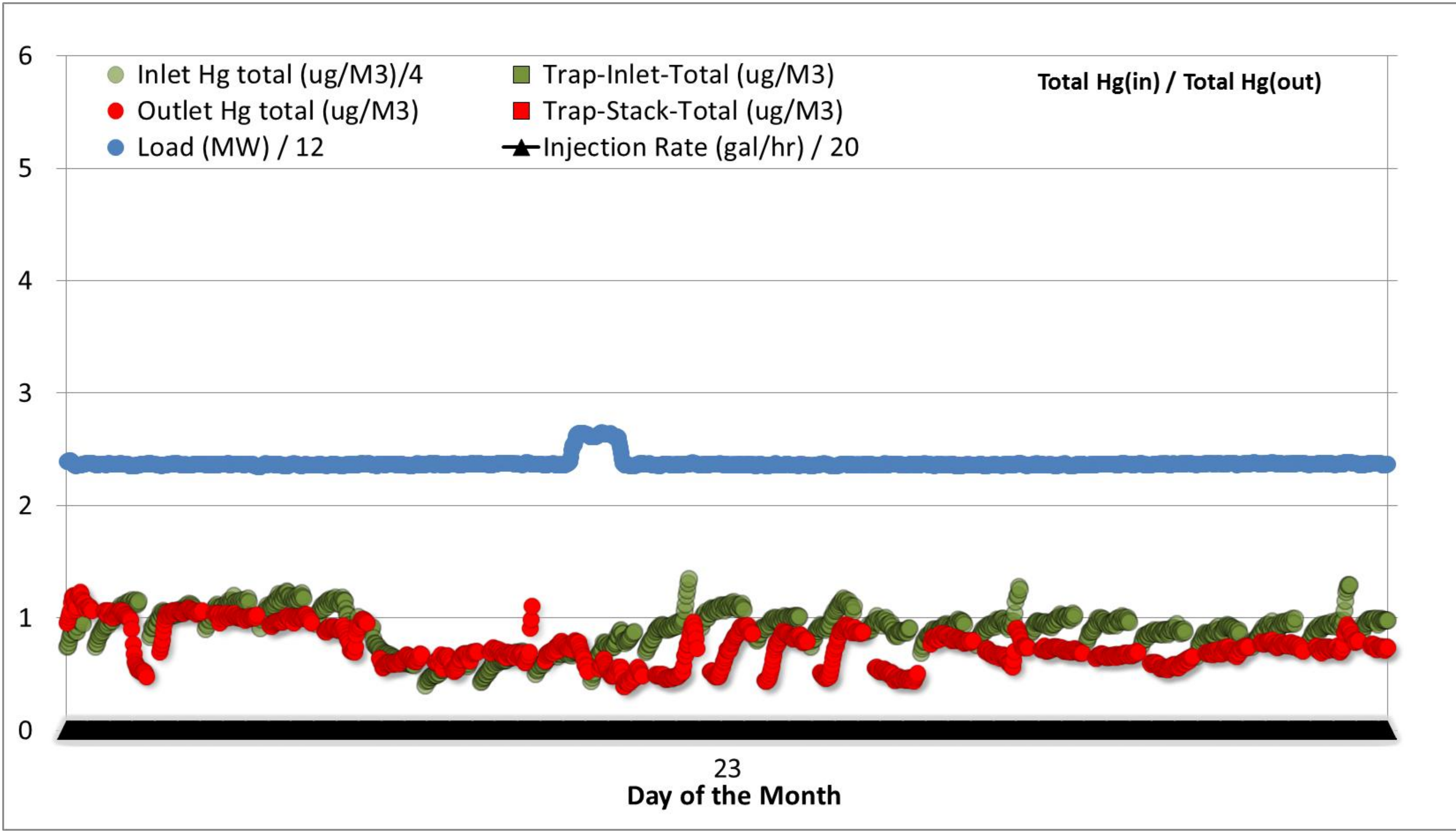

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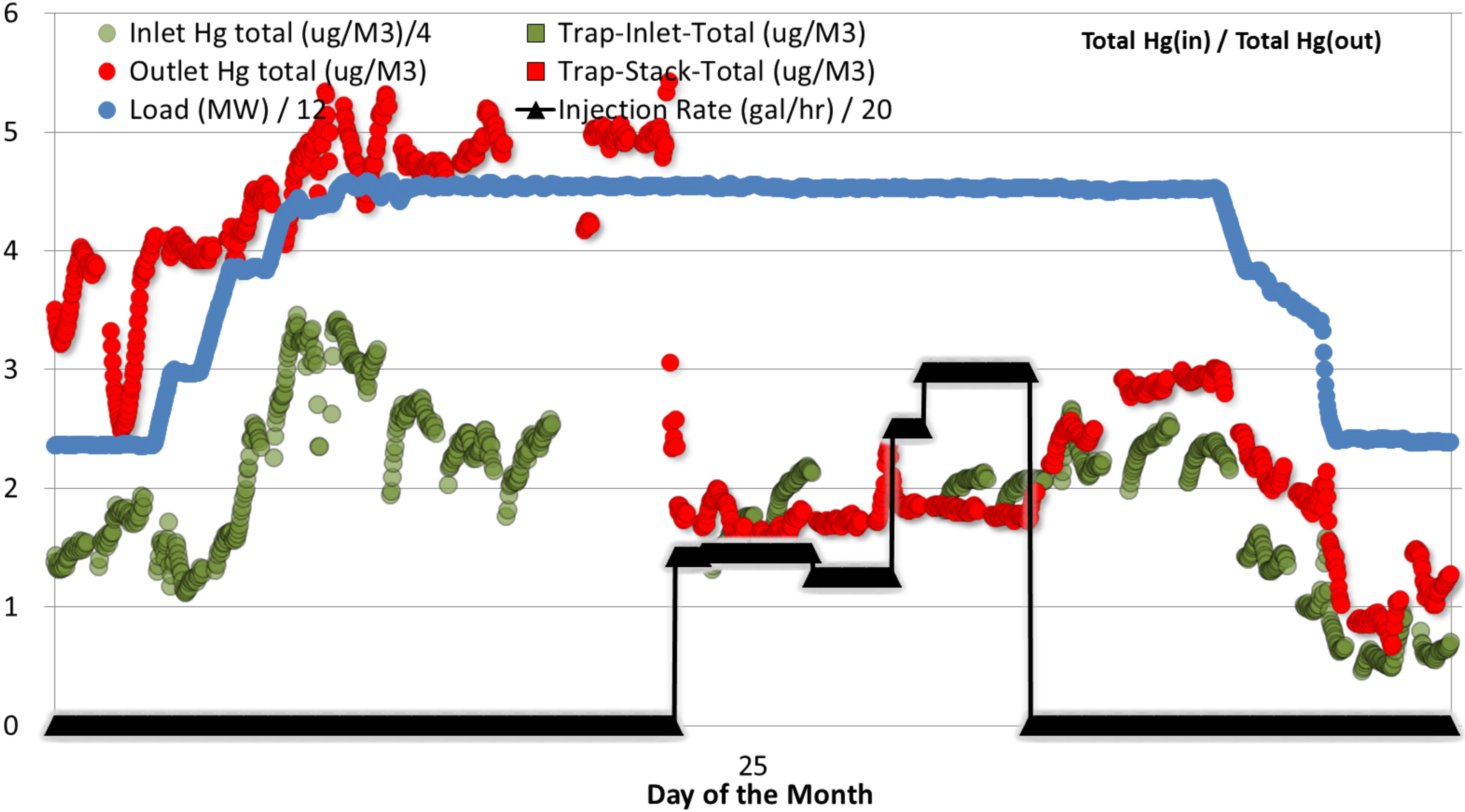

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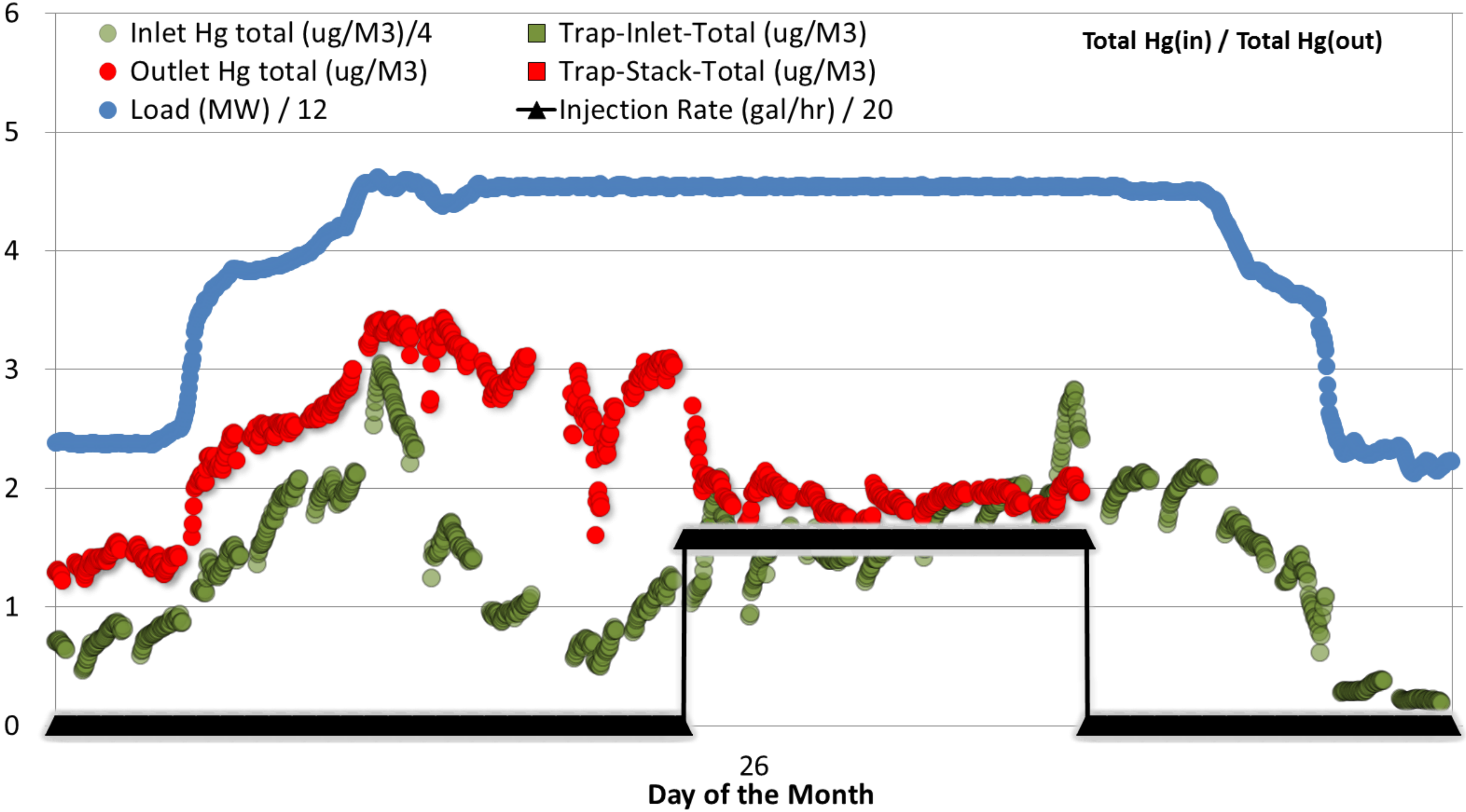

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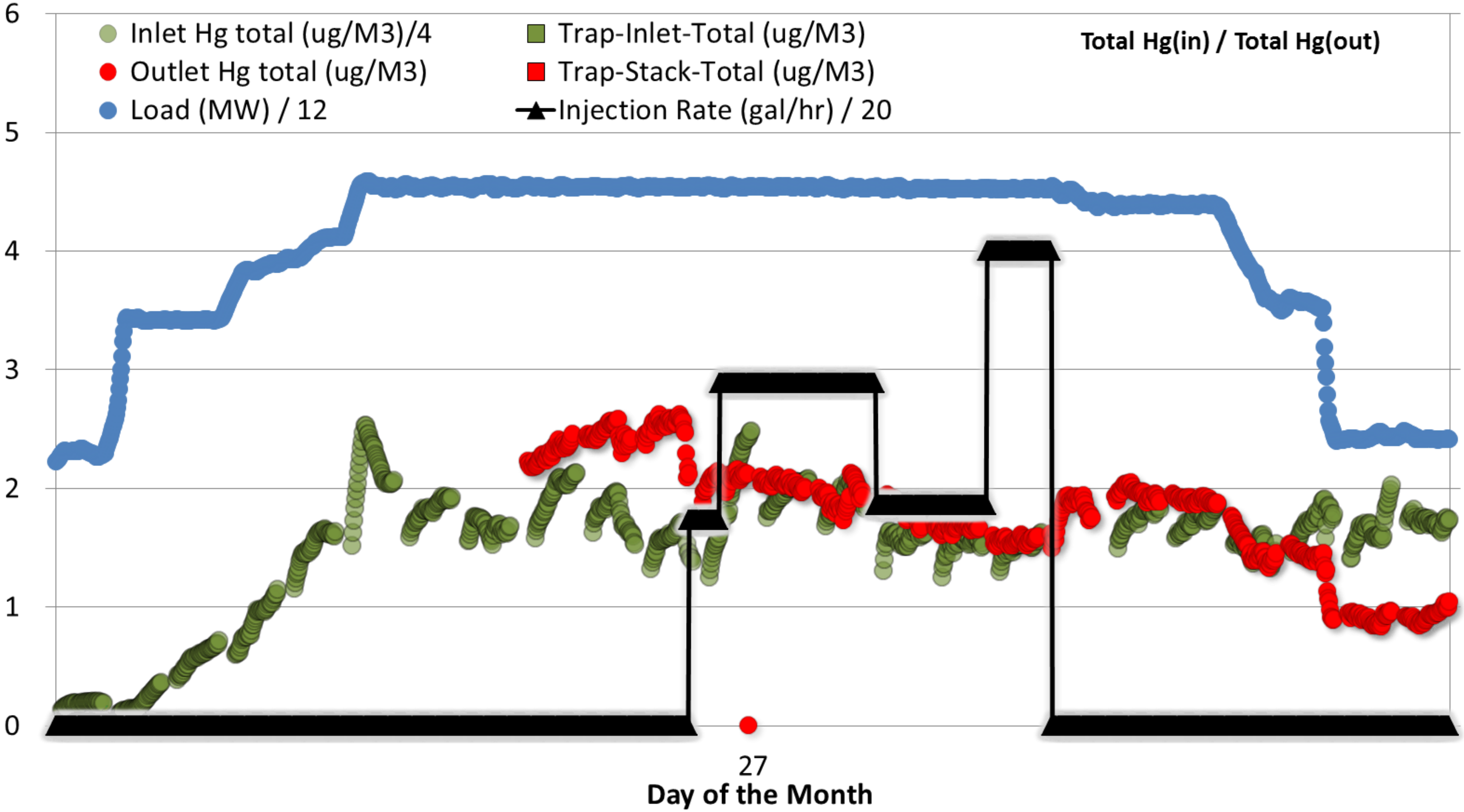

Explanation of Observations

- The mercury mass balance and physical properties appear to explain the results well.
- The first-order problem appears to be accumulation of mercury in the slurry liquid.
  - If saturated with both Hg^0 and Hg^{+2} then Hg(out) = Hg(in).
  - If saturated with Hg^0 but not Hg^{+2} ,then Hg^0 (out) > Hg^0 (in).
  - If sub-saturated in Hg^0 , then Hg(out) < Hg(in).
- Occurrence of the first-order problem appears dependent on the recent history of the system.
- One could expect that satisfying the steady-state material balance for mercury would reliably avoid the first-order problem.
- Mass-transfer limitations in absorbing Hg^0 can explain the observed second-order phenomena.
- Options exist for readily overcoming the mass-transfer limits by modest increases into the fraction of oxidized mercury in the inlet gas.

Revisit the Hypotheses in Light of Our Scientific Testing. Apply Occam's Razor to Make Your Own Decision

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Hg^0(liq)–Hg^0(solution) Equilibrium and Solubility of Elementary Mercury in Water

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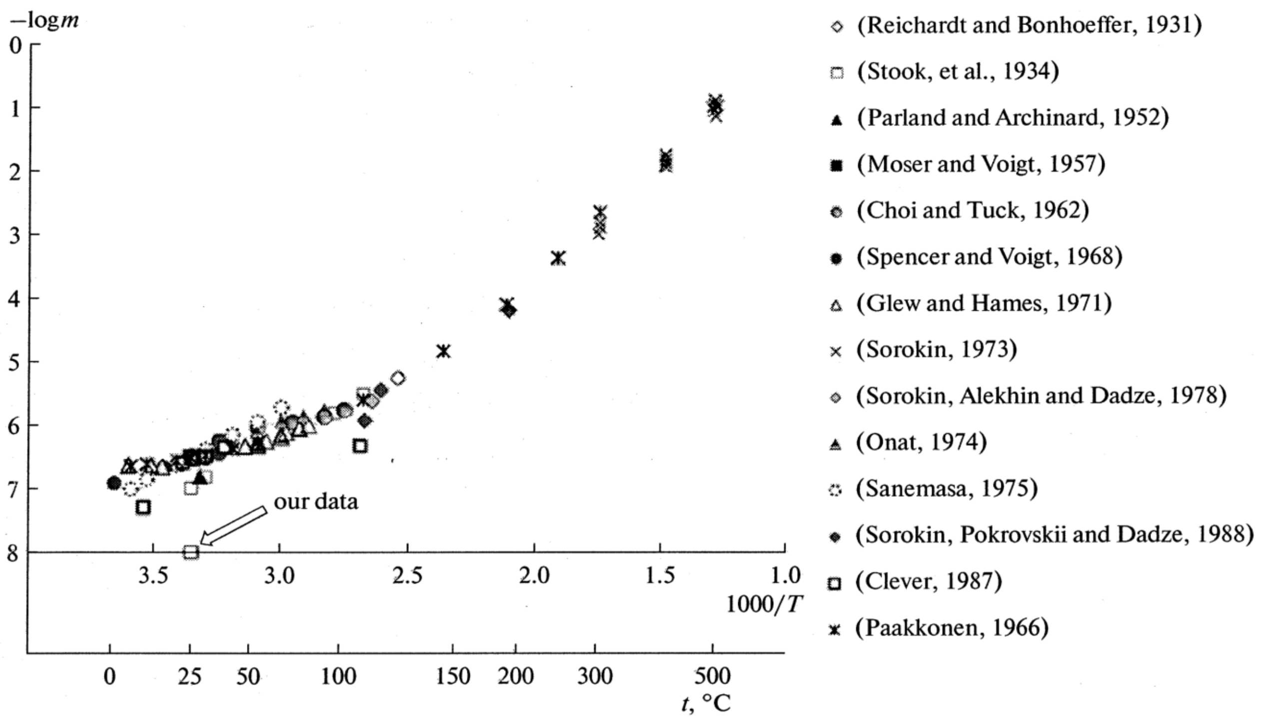
Received May 25, 2011

Abstract—The solubility metallic mercury in water and its dominating forms were studied. The prevalence of the Hg^0_{aq} form in the high-temperature range was confirmed and the reaction constant $Hg^0_{liq} \rightleftharpoons Hg^0_{aq}$ ($\log K = \log m = -8.01$) at 25°C with the predominance of oxidized forms of mercury for the 20–80°C area of low temperatures was found.



The solubility of mercury in water as an inverse temperature function. The initial experimental data of various authors are given from (Sorokin, Pokrovskii, and Dadze, 1988).