# Modeling Evaporative Emissions in MOVES2010b

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## Overview

This presentation is an overview intended to provide context for subsequent more detailed presentations. This presentation addresses:

- Definition of “evaporative” emissions.
- How MOVES2010b accounts for “evap”.
- The major factors affecting evap emissions.

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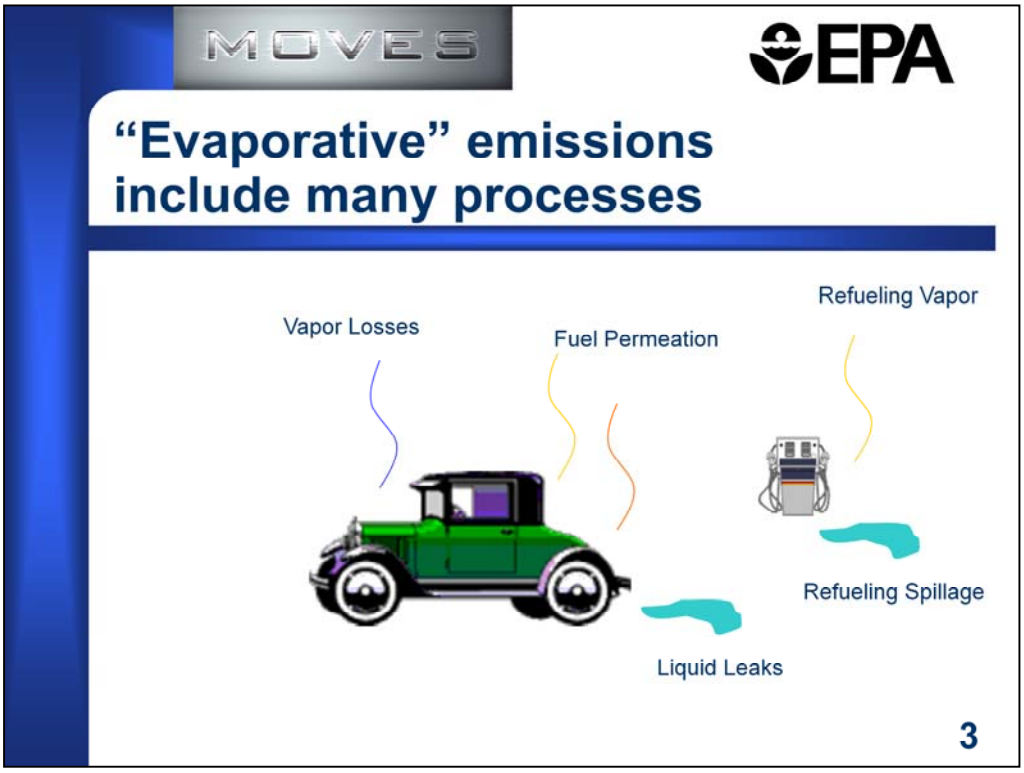
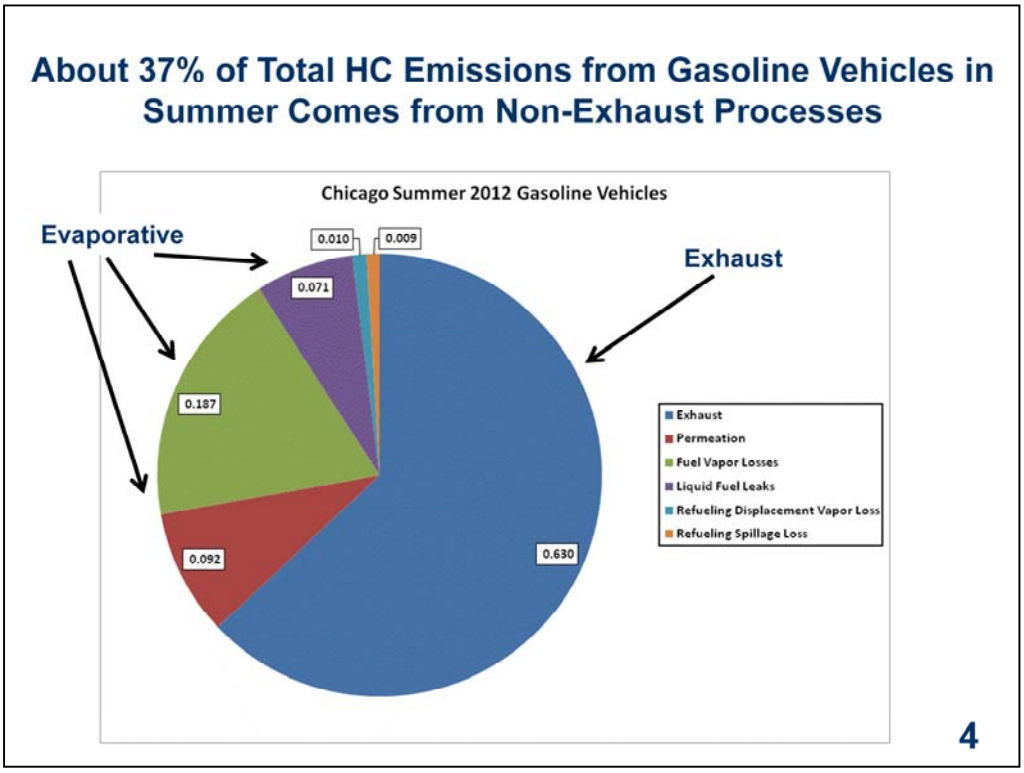



There are five basic non-exhaust processes which are included in the estimate for what is commonly called "evaporative" emissions. All of these sources involve fuel (hydrocarbons) that escape from the system and vaporize (evaporate) into the atmosphere. MOVES addresses each of these sources and makes an estimate of their impact on vehicle emissions.




Results are from a MOVES2010b run for Cook County, IL, in July 2012 using default temperatures and fuels.

Subsequent slides will explain the sources of the various evaporative losses.

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## Basic Evaporative Mechanisms

- Permeation is the migration of hydrocarbons through the various elastomers in a vehicle fuel system.
- Fuel vapor losses are any evaporated fuel in the fuel system that escapes to the atmosphere.
- Liquid leaks are any liquid fuel that escapes to the environment.

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# Vapor Losses

- **Vapor losses are vaporized fuel within the system that find their way out.**
- **Vapor losses are divided into three modes:**
  - Cold Soak
    - Losses that occur while the engine is off (excluding hot soak).
  - Running Loss
    - Losses that occur while the engine is running.
  - Hot Soak
    - Losses that occur immediately after the engine is turned off until the vehicle reaches ambient temperature.

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# Vapor Losses: Cold Soak

- **Cold soak (diurnal) emissions calculation:**
  1. Compute tank temperature.
  2. Estimate total vapor generated.
  3. Calculate vapor losses.
- **Vapor leaks account for much of the vapor losses on modern vehicles.**
  - Vapor leak rates are affected by I/M programs
  - In MOVES2010b, vapor leak rates effect Cold Soak emissions.

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# Vapor Losses: Hot Soak & Running Losses

- **In MOVES2010b, hot soak and running losses are not adjusted for fuel properties or temperature.**
- **Vapor leak rates are not applied to hot soak or running loss rates in MOVES2010b.**
  - Without vapor leaks, I/M has no effect on hot soak or running losses.

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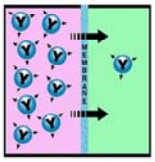
## Fuel Permeation

- **Gasoline permeates through tank/hoses and then evaporates.**
  - Diesel fuel permeation is negligible.




- **Emission rates vary significantly with temperature.**
- **Permeation increases due to ethanol in gasoline.**
- **Permeation is not affected by I/M programs.**

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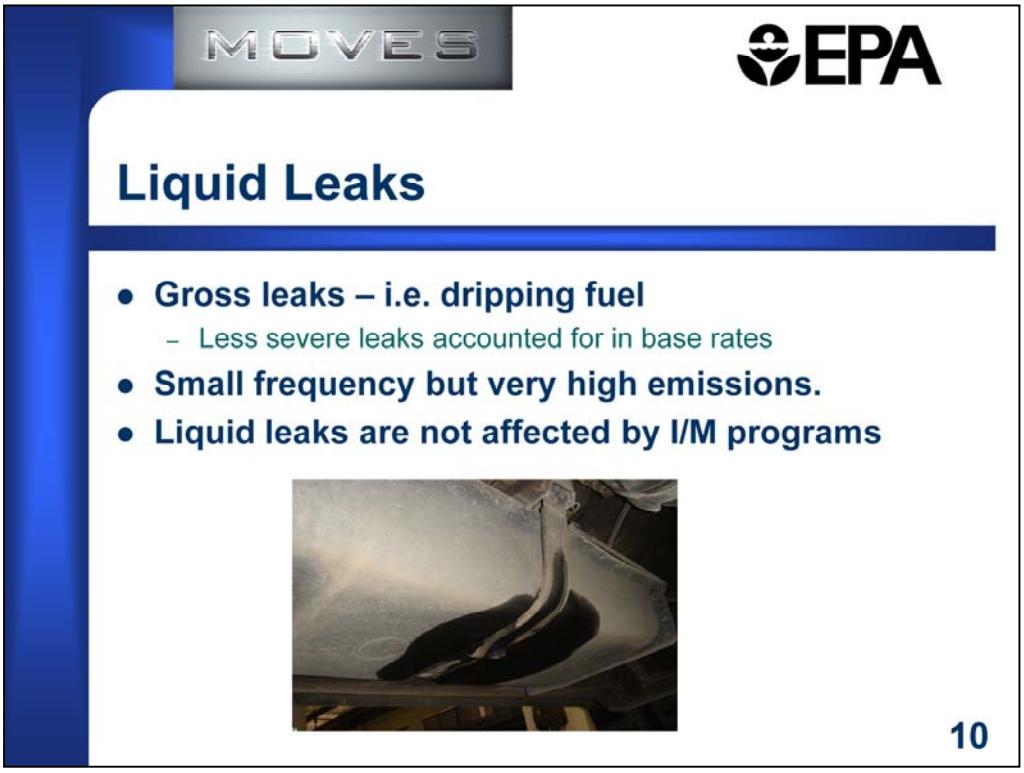


Measurements of permeation and vapor losses include some small amount of liquid leaking. Gross leaks are accounted for separately using an estimate of leak frequency and leak rate (grams per hour).

EPA does not provide Inspection and Maintenance (I/M) program benefit for the detection of liquid leaks.

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## Refueling Losses

- **Split into spillage and vapor losses.**
- **Diesel vehicles have spillage, but not vapor losses.**
- **Calculated as**

  **g/gallon emission rates * fuel consumption**

  - Gallons calculated from energy consumption and fuel energy content.
  - Refueling emissions will reflect changes in fuel consumption.

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# Refueling Losses

- **Losses affected by:**
  - Ambient temperature.
  - Fuel volatility (RVP).
  - Model year (Onboard Refueling Vapor Recovery (ORVR) systems).
  - Location (state run Stage II Programs).

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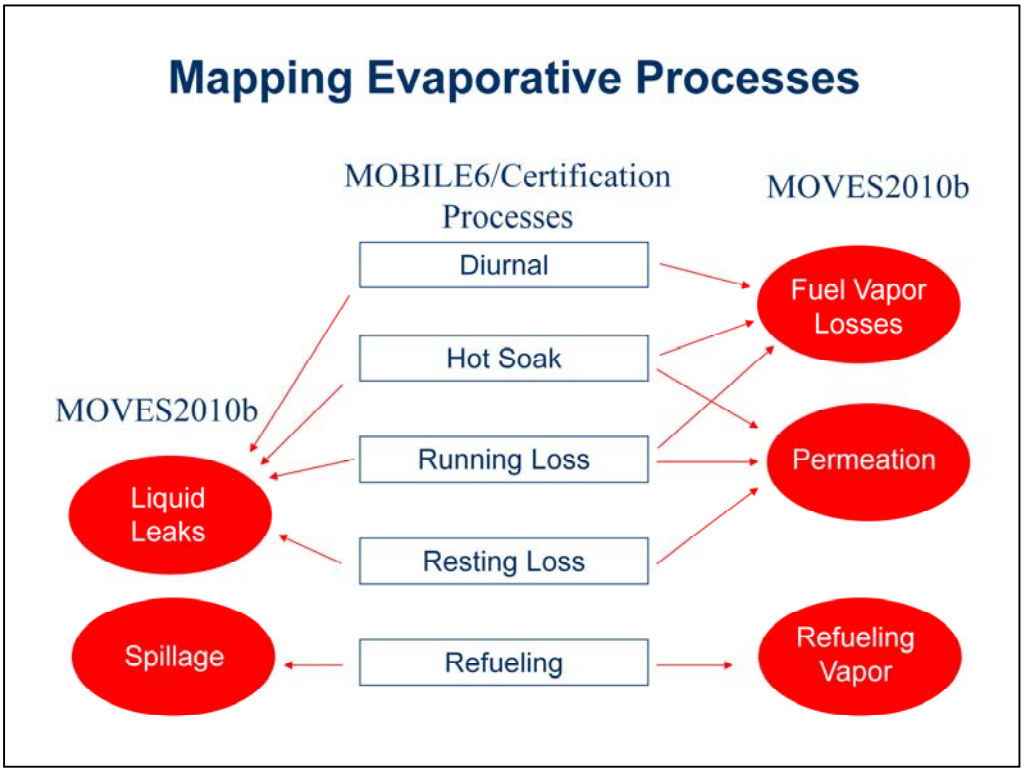
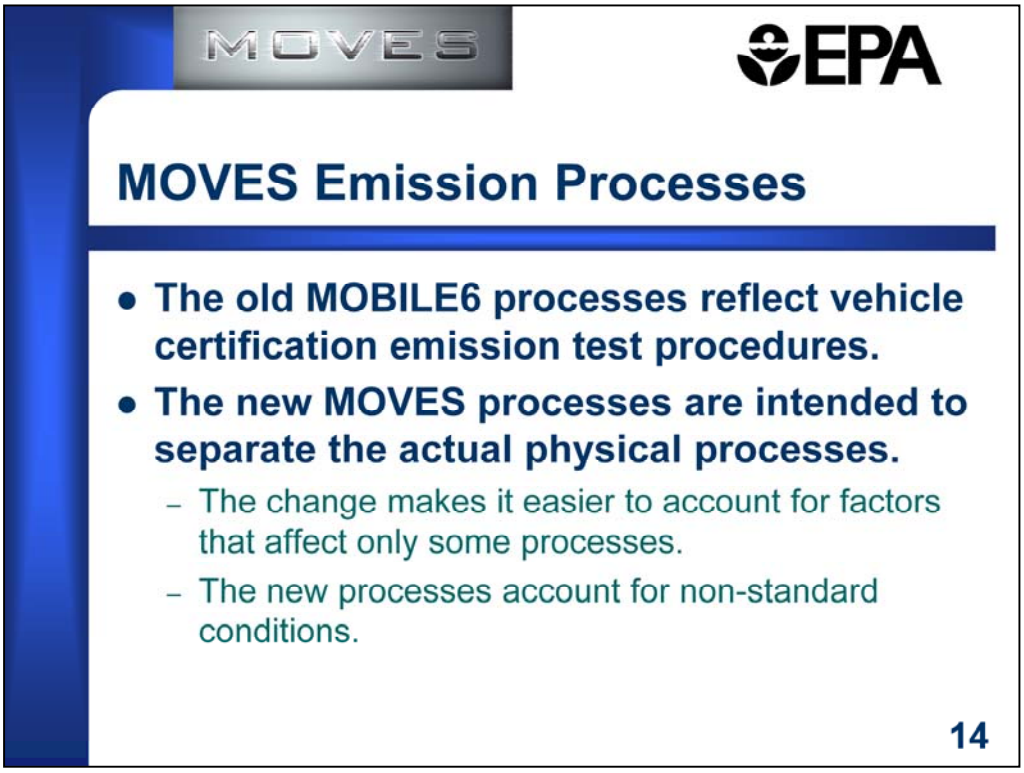



EPA's previous model (MOBILE6) accounted for evaporative emissions using results from specific vehicle emission certification procedures. MOVES accounts for these same emissions using processes that overlap the certification procedures. New test procedures developed specifically to measure these new processes have been developed for use with MOVES.




Factors, such and temperature, do not affect the physical processes found in evaporative emissions in the same way. This made it difficult to come up with adjustment factors for the results obtained in “certification” style measurements that often include multiple physical processes.

Vehicle certification procedures do not account for the full variety of temperatures and vehicle activity (soak times) that can affect emissions in extreme conditions.

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# Fuel Tank Temperature

- Fuel temperature main driver for permeation and cold soak vapor losses.
- Depends on day-to-day vehicle operating pattern and vehicle type.
- MOVES2010b estimates fuel temperature based on ambient temperature and trip information.
- Hourly fuel tank temperature averages are used to calculate cold soak and permeation emissions.

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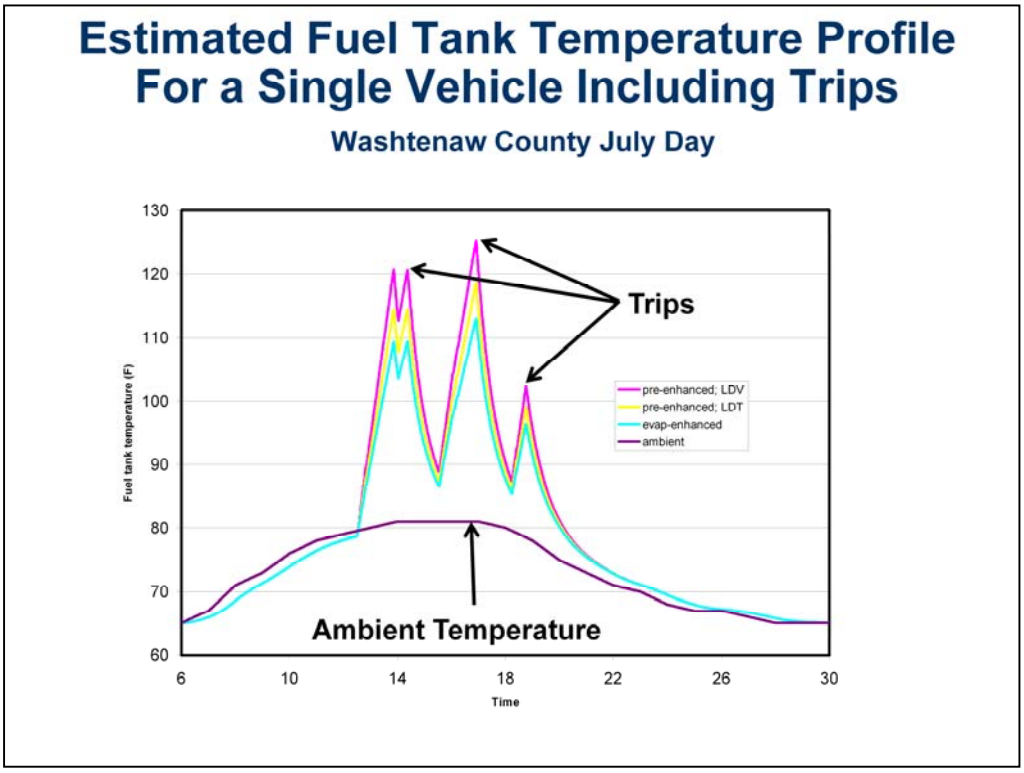


This figure illustrates how fuel tank temperature lags the ambient temperature during cold soak, rises when the vehicle is driven, peaks at the end of each trip, and declines during the Hot Soak period. The estimate of tank temperature is affected by vehicle type and technology.

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# Activity Basis for Evap Losses

- **Activity calculated from trips.**
  - Distribution of hours parked (when, how long) calculated using sample trip data.
  - Source hours parked (SHP).
    - Split into "cold soak", "hot soak" modes.
  - Source hours operating (SHO).
    - For calculating "running" mode losses.
- **Fuel consumption (gallons of fuel).**
    - Determines refueling losses.

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## Sample Vehicles & Trips

- MOVES2010b database includes a log of daily trips from a group of "sample vehicles".
- Values are used to estimate fractions of vehicles that are operating, hot soaking & cold soaking for each hour, on weekends and weekdays and how long they have been soaking.
- Data was obtained from instrumented vehicles.

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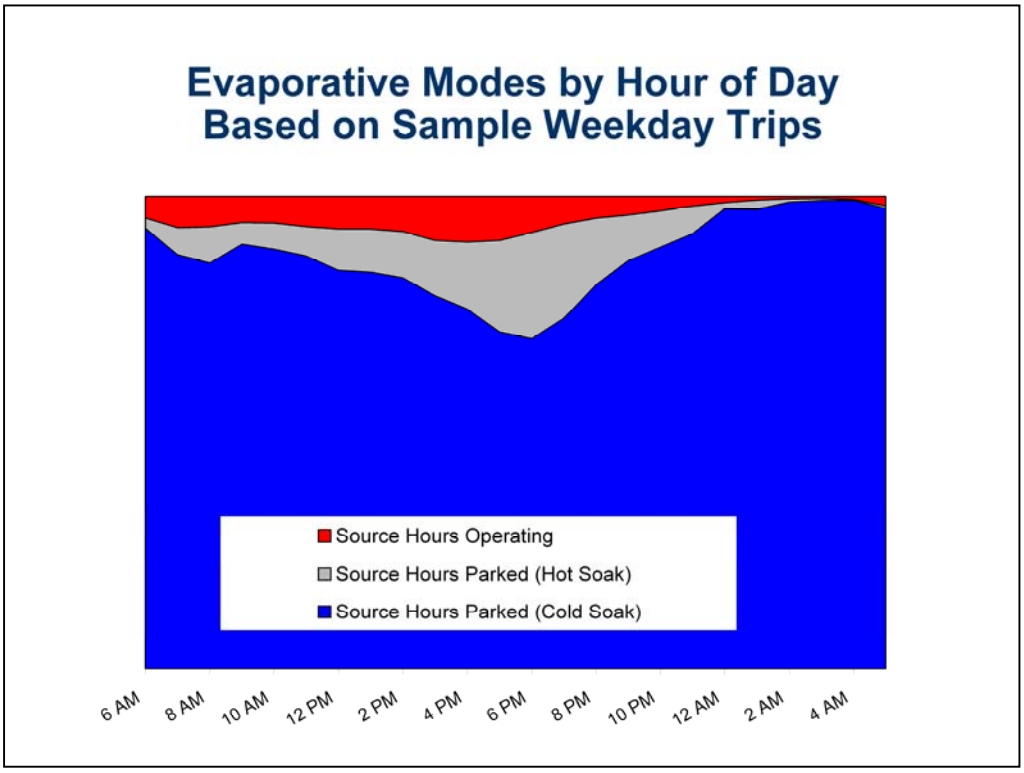


This figure shows an example distribution of the amount of time spent in the various modes where evaporative emissions occur. By far, parking (cold soak) represents the most time. However, emissions during cold soak are caused by temperature rising, which occurs only in certain parts of the day. Evaporative emissions during vehicle operation and hot soak are less dependent on ambient temperature.

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# Questions?

**"Development of Evaporative Emissions Calculations for the Motor Vehicle Emissions Simulator MOVES2010"**

**(EPA-420-R-12-027, September 2012)**

http://epa.gov/otaq/models/moves/movesback.htm

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