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# **Suggestions for HVAC Efficiency Improvements for the 2008 California Building Energy Efficiency Standards**

***March 28, 2006***

***901 P Street, Sacramento, Hearing Room 102-A***

**Robert Mowris & Associates**



# Overview of Suggestions

The following suggestions are provided to improve HVAC efficiency for the 2008 Building Energy Efficiency Standards.

- 1) Verification of proper RCA and proper TXV installation by HVAC installers working under third-party verification service providers working with HERS Providers and HERS raters.
- 2) Automatic alarm when air conditioner air filters are dirty, third-party quality control registration, permanent labels, and locking Schrader caps to maintain proper RCA.
- 3) Eliminate the TXV as a substitute for proper RCA.
- 4) Proper evaporator airflow (cross-sectional area) required by the manufacturer and rated efficiency for multi-zone damper systems.
- 5) ARI matching evaporator and condenser coils to provide rated capacity and efficiency for split-system air conditioners

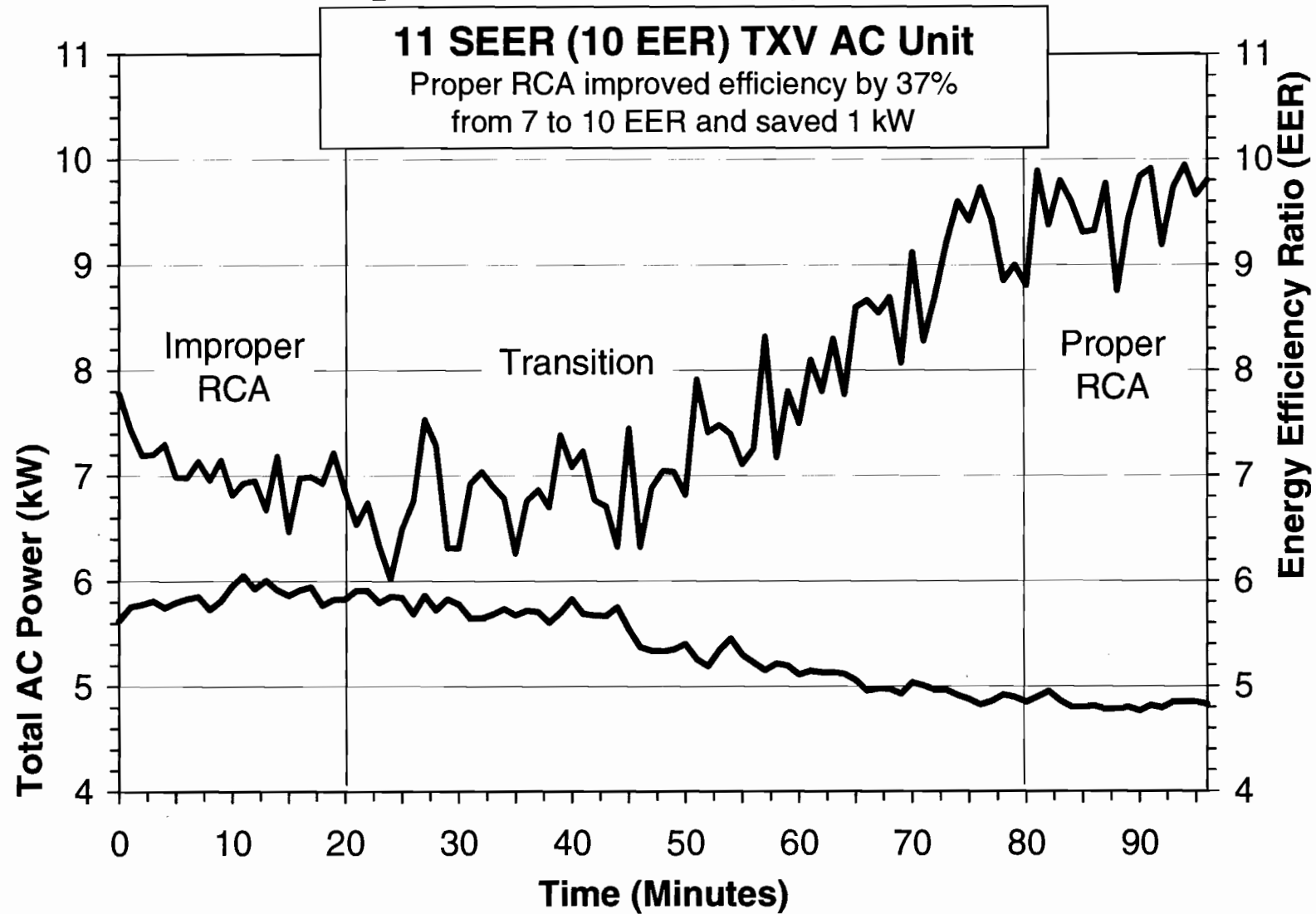


# Refrigerant Charge and Airflow

- The CEC should consider requiring proper RCA for all air conditioners under the 2008 Building Energy Efficiency Standards.
- Field measurements indicate TXV and non-TXV air conditioners have comparable efficiency gains due to proper RCA irrespective of whether they are over- or under charged (Mowris 2004).
  - TXV sensing bulbs are often improperly installed and current Standards don't address installation quality (insulation, contact, orientation).
  - Laboratory studies indicate improved performance for TXVs, but only when undercharged, but the studies lack similitude to field conditions, and did not consider TXV "hunting" issues with improper RCA.
- Current Title 24 building efficiency standards allow a TXV to substitute for proper RCA to receive the same compliance credit.
- Manufacturers provide the same warranty irrespective of whether an air conditioner has proper RCA.
- Therefore, most people do not understand the value of proper RCA.



# Proper RCA (cont'd)





# Proper RCA (cont'd)

- The CEC standards should promote HERS providers/raters to work with Verification Service Providers to recruit, train, and equip local HVAC dealers to deliver RCA consistent with third-party quality control included within the CEC standards.
- HERS raters haven't historically trained and equipped HVAC dealers to provide proper RCA and HERS raters do not generally verify proper RCA.
- Research studies show HVAC dealers lack interest, training, equipment, and methods to install proper refrigerant charge/airflow (RCA) and duct testing/sealing measures.
- Instead, technicians rely on rules of thumb such as:
  - "Add refrigerant until suction line is 6-pack cold," or
  - "Suction pressure is 70 psig and less than 250 psig on liquid line."



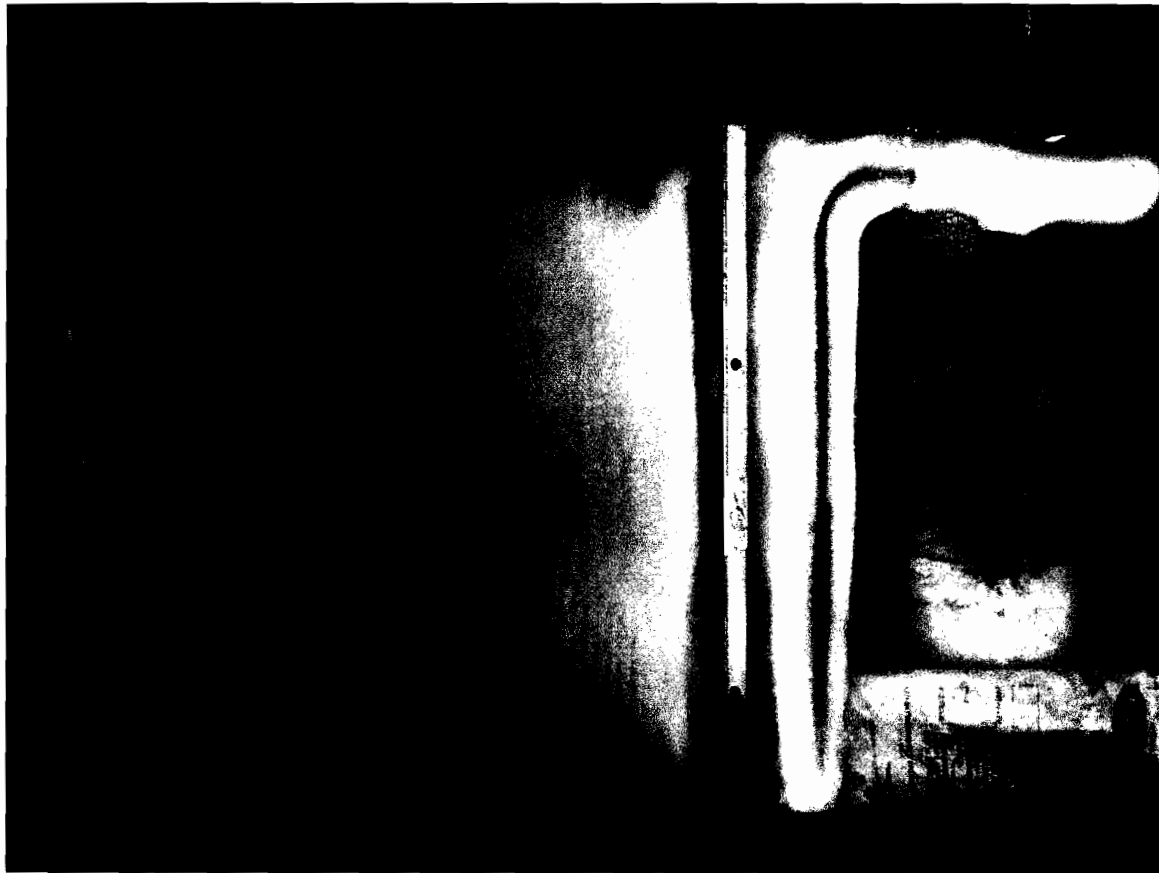
# Maintaining Proper RCA

- To maintain proper RCA, the CEC should consider requiring:
  - Automatic alarm when air conditioner air filters are dirty,
  - Third-party VSP quality-control registration,
  - Permanent labels, and
  - Locking Schrader caps.
- This will help maintain efficiency and help prevent refrigerant leakage, tampering, injury, and future mal-adjustments.
- Without these measures the EUL for proper RCA will be reduced and the savings assumed by the standards will be reduced.
- Field studies show that mal-adjustments of proper refrigerant charge by untrained and ill-equipped AC technicians can occur within 1 to 3 years without permanent labels and locking Schrader caps.



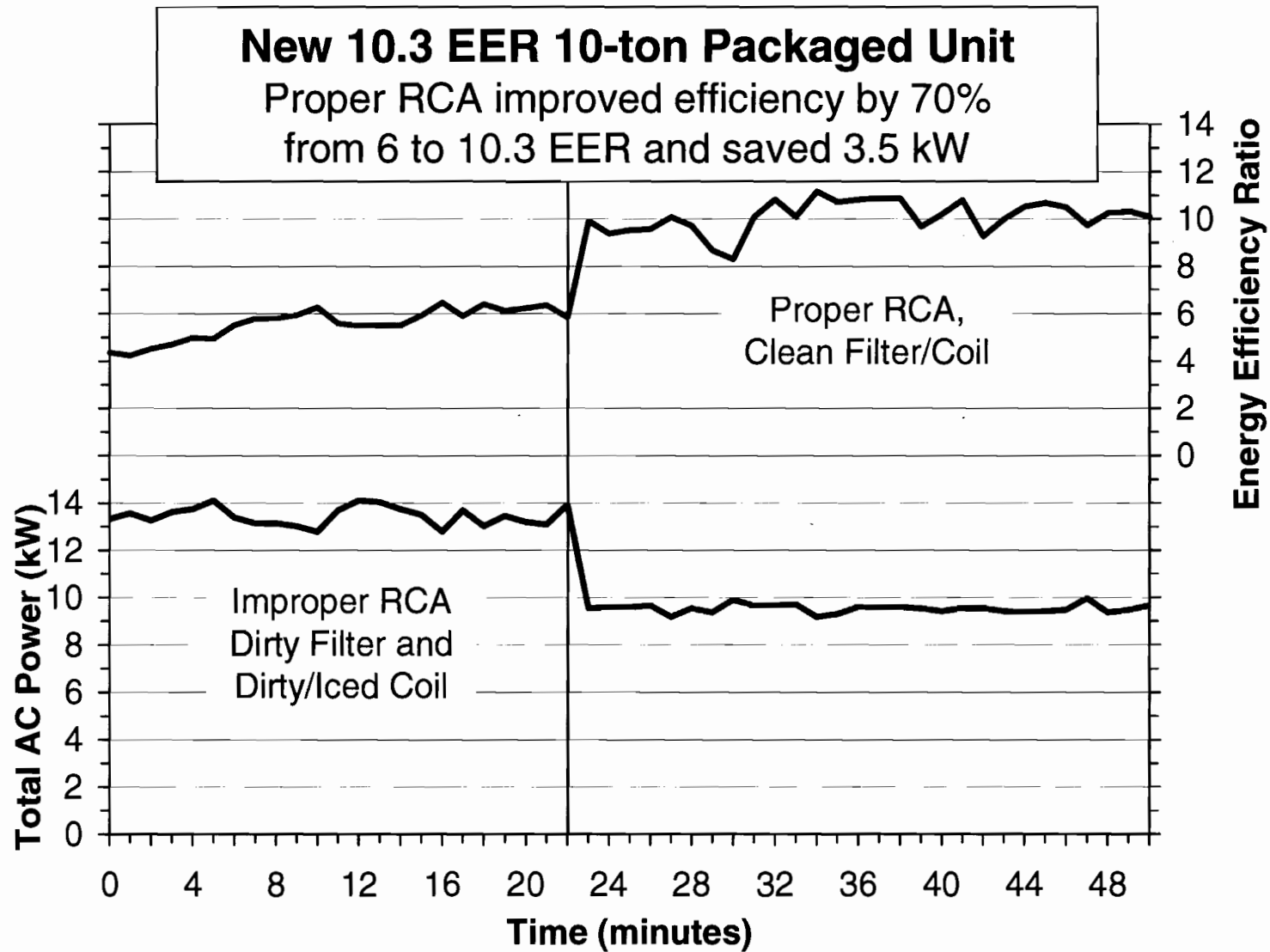
# Maintaining Proper RCA

- Improper RCA can cause ice to form on packaged units and this lowers efficiency and damages the compressor.





# Maintaining Proper RCA



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# Maintaining Proper RCA

- The CEC should require locking Schrader caps to maintain proper RCA, promote public health and safety, and encourage proper refrigerant management practices to prevent stratospheric ozone depletion consistent with section 608 of the Federal Clean Air Act regulated by the US EPA.
- A study from the Global Environment & Technology Foundation “The State of Stratospheric Ozone Depletion,” provided the following recommendations ([www.getf.org/cecs/Ozone\\_Study.pdf](http://www.getf.org/cecs/Ozone_Study.pdf)).
  - “Governments, industry, and environmental groups must create distinct and separate messages on stratospheric ozone depletion and the importance of the ozone layer, in addition to climate change.”
  - Diligence and technological innovation are necessary well into the future to achieve our goals of repairing and maintaining a healthy ozone layer.
  - Most importantly, the public needs to be more effectively engaged and prevent further stratospheric ozone depletion.”

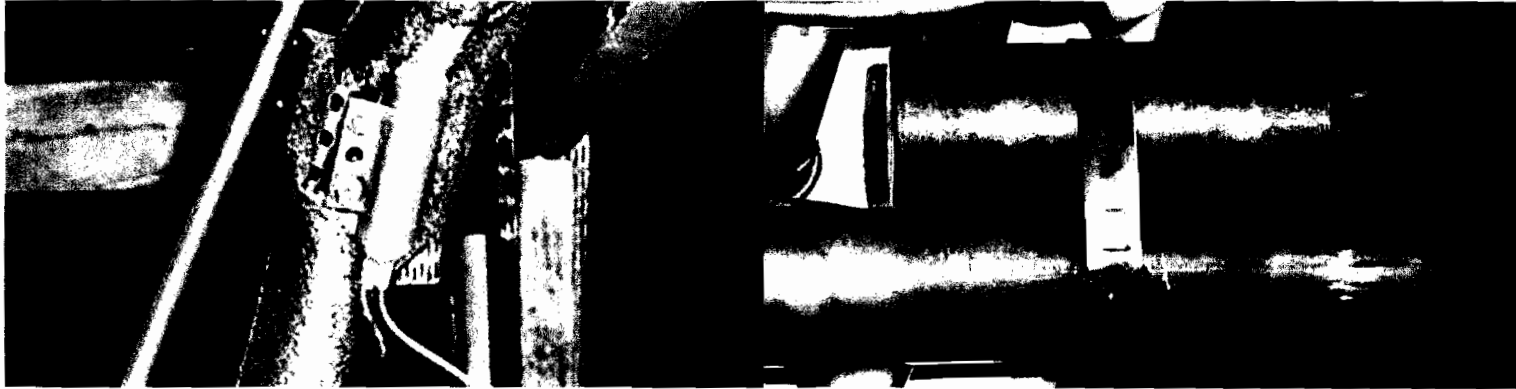


# Thermostatic Expansion Valves

- The CEC should consider eliminating the TXV as a substitute for proper RCA.
- Laboratory and field studies show that TXV-equipped air conditioners have no efficiency advantage compared to non-TXV-equipped air conditioners when units are overcharged.
- TXV equipped air conditioners “hunt” when evaporator coils have reduced heat loads caused by low airflow, dirty or icy coils, and low refrigerant charge (Tomczyk 1995). “Hunting” TXV can lose control and successively overfeed and then underfeed refrigerant to the evaporator while attempting to stabilize control causing reduced capacity and efficiency. Overfeeding liquid can damage compressors.
- The tendency for hunting can be reduced by: 1) Correcting RCA, 2) Relocating TXV sensing bulb inside the evaporator coil box, and 3) Insulating the sensing bulb.



# TXV Installations



- Uninsulated factory TXV sensing bulbs inside evaporator coil boxes are influenced by supply-air temperatures which are 10-20°F higher than vapor line temperatures.
- Uninsulated field-installed TXV sensing bulbs are influenced by attic temperatures which are 50 to 80°F higher than vapor line temperatures.
- Manufacturers' recommend: 1) tightly clamp sensing bulb to vapor line with good thermal contact at recommended orientation to guard against false readings due to air or liquid in suction line; and 2) insulate sensing bulbs to prevent ambient air causing false readings.



# Multi-Zone AC Systems

- The CEC should consider Standards requiring multi-zone damper systems installed on conventional constant-speed single-stage split-system air conditioners to not reduce the rated efficiency or the evaporator airflow cross-sectional area required by manufacturer.
- Most multi-zone systems use dampers and damper assemblies that reduce the cross-sectional area by 50% to 75%.
- Multi-zone systems should be required to have bypass ducts when the dampers are actuated to reduce and eliminate low airflow which can cause:
  - Icing of the evaporator coil,
  - Slugging (i.e., liquid refrigerant entering the compressor),
  - Reduced efficiency, and
  - Premature compressor failure.



# Multi-Zone AC Systems

- Field measurements of multi-zone damper systems show 10 to 14% lower capacity and 20 to 30% lower Energy Efficiency Ratio (EER).
- HVAC dealers install larger indoor fans (i.e., 1 to 1½ tons larger) to overcome larger static pressure when dampers are engaged.
- This causes greater total kW (i.e., indoor fan, condenser fan, and compressor).
- This lowers the field-measured EER compared to rated EER.
- Based on field measurements, the multi-zone damper systems reduce capacity and EER compared to units without dampers.
- Multi-zone damper systems can cause icing of the evaporator, slugging, reduced efficiency, and premature compressor failure.
- Additional field testing should be performed to better understand performance with and without the multi-zone damper systems.



# Proper Sized HVAC Systems

- The CEC should consider Standards requiring proper sized HVAC systems (per ACCA Manual J) to improve the capacity and efficiency of split-system air conditioners.
- Energy and peak demand savings for proper sized evaporator/condenser coils per ACCA Manual J are 10 to 20%.
- Field studies show most units are significantly oversized by at least ½ to 1 ton or more.
- This causes inefficient operation, reduced reliability due to frequent cycling of compressors, and poor humidity control.
- Oversized systems waste capital invested in both the HVAC unit and distribution system.
- Oversized commercial units affect the ability of the system to provide simultaneous economizer and compressor operation, and exacerbates problems with distribution system fan power, since larger units are supplied with larger fans.



# ARI Matching Coils

- The CEC should consider Standards requiring ARI matching evaporator and condenser coils to provide rated capacity and efficiency for split-system air conditioners.
- Even with correct RCA, many split-system air conditioners do not perform at their rated efficiency due to improperly matching evaporator and condenser coils.
- Field measurements of new split-system units indicate 10 to 35% lower EER values due to improper matching coils.
- Original Equipment Manufacturers (OEM) of condensing coils cannot guarantee the rated efficiency per the Air-Conditioning and Refrigeration Institute (ARI) SEER/EER ratings with evaporator coils manufactured by Independent Coil Manufacturers (ICM) that are not listed in the ARI directory as a proper match for the condensing coil.
- ARI doesn't require laboratory testing of ICM evaporator coils with OEM condenser coils (simulations are used).



# Conclusions

- The estimated potential savings in California from proper RCA/TXV, RCA maintenance, multi-zone damper systems, proper-sized coils, and ARI matching coils are  $2 \pm 0.4$  TWh/yr and  $1 \pm 0.2$  GW.
- The CEC should consider the following standards to achieve these savings through improved HVAC efficiency and useful life.
  - Verification of proper RCA and proper TXV installation by HVAC installers working under third-party verification service providers working with HERS Providers and HERS raters.
  - Automatic alarm when air conditioner air filters are dirty, third-party quality control registration, permanent labels, and locking Schrader caps to maintain proper RCA.
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