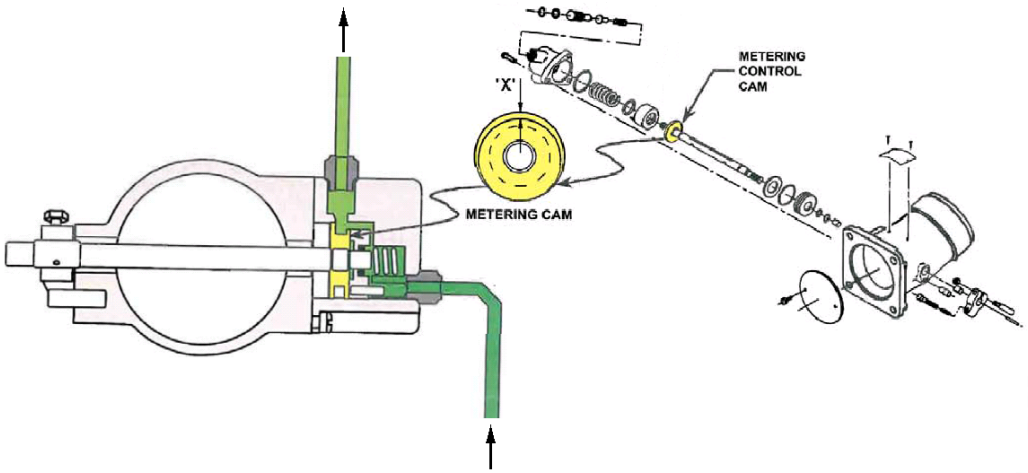
Engine Management

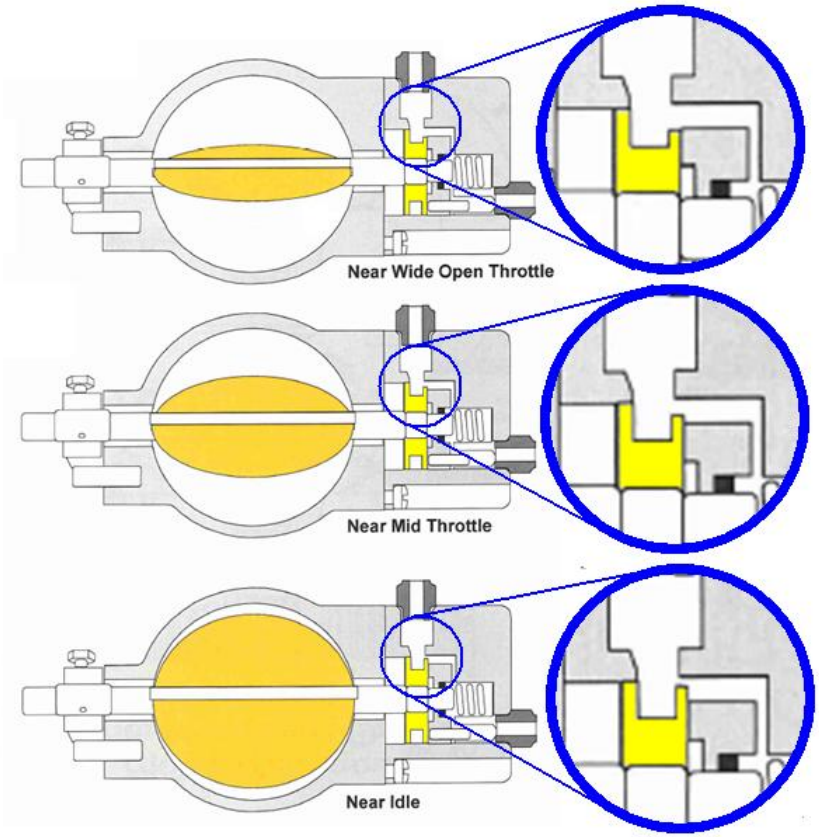
Agenda

- Common Design Features
- Unique Design Features
- Normal Combustion, Detonation and Preignition
- Engine Power
- Operational Practices/Techniques

Common Design Features

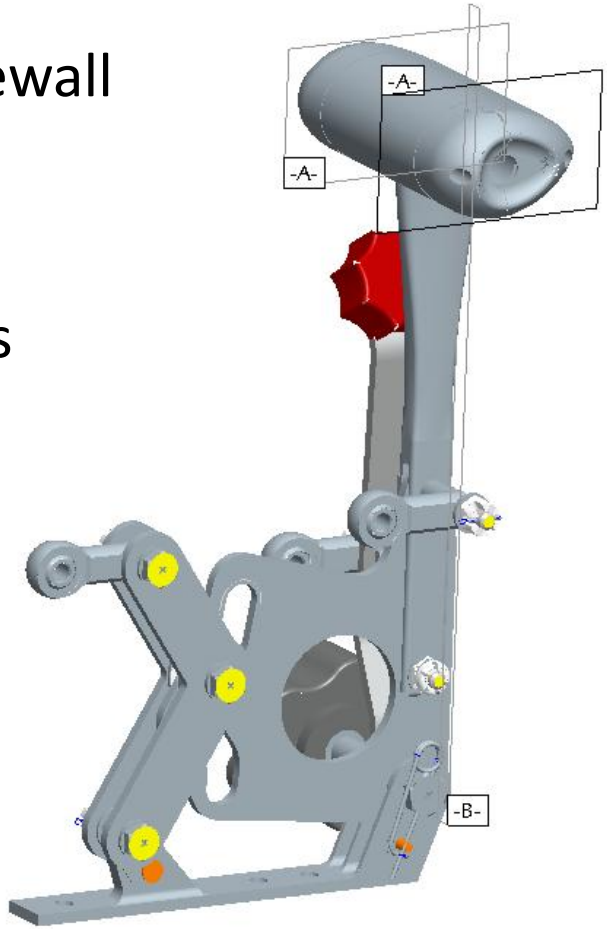
- Positive Displacement Fuel Pump
  - Flow proportional to engine RPM
- Throttle Body Fuel Metering Cam
  - Progressively restricts fuel flow as throttle plate closes





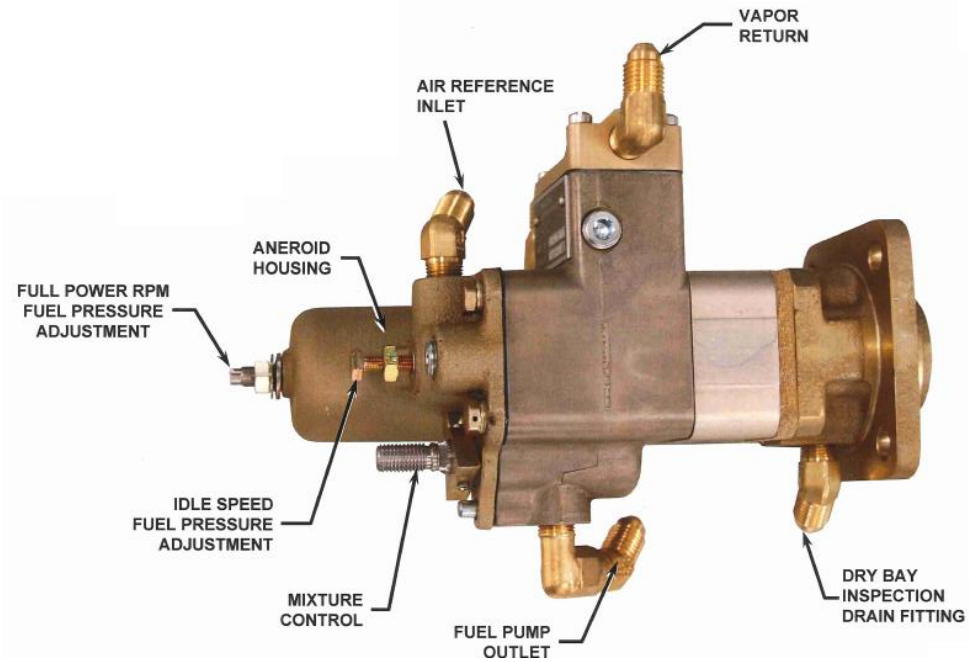
SR20 Unique Features

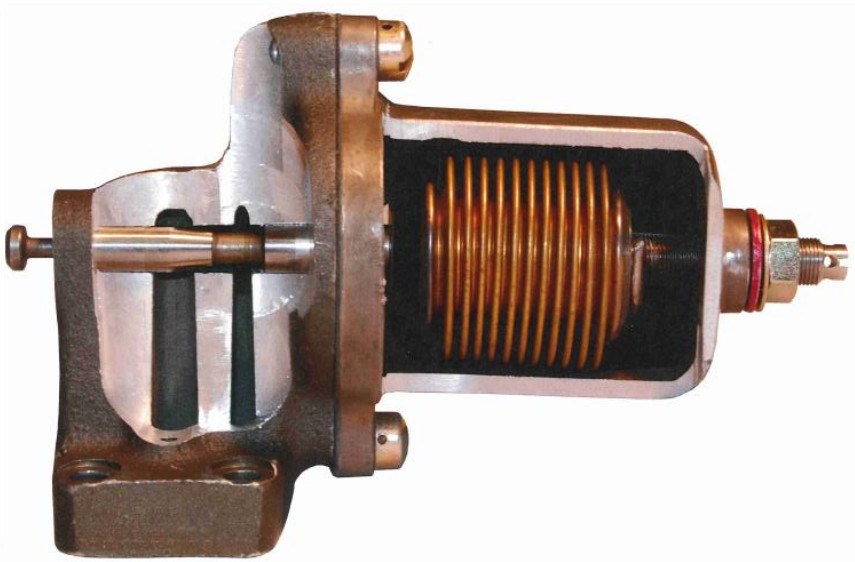
– Single Power Lever Control
  - Conventional governor and throttle firewall forward
  - Blended in power lever
  - Some RPM hysteresis due to clearances (“free play”)



SR20 Unique Features

- Altitude Compensating Fuel Pump
  - Pressure sensing aneroid referenced to ambient (cowl) pressure
  - As altitude increased, ambient pressure drops and results in auto-leaned mixture
  - Alleviates mixture leaning in full rich/full power climb





SR22 Unique Features

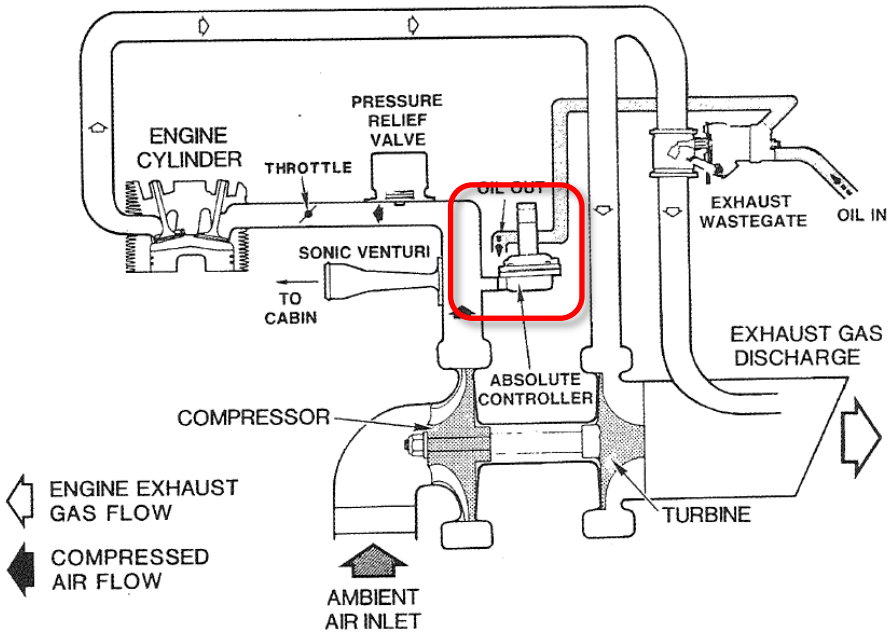
- Single power lever control
  - Identical to SR20
- No aneroid on fuel pump
  - No Altitude compensating
  - Requires manual leaning in climb
    - Perspective aircraft: indicated by top of green arc
    - Non-Perspective: Leaning Placard

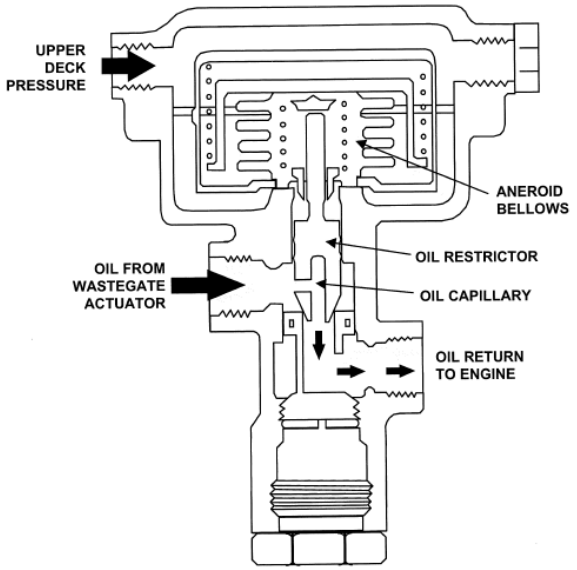
ST22TN Unique Features

- Base model SR22
- Dual Turbochargers / Dual Wastegate
- Manifold Pressure Sensing Fuel Pump
  - Similar concept to SR20, but referenced to upper deck pressure (before throttle plate) instead of ambient pressure
  - Will lean FF if sudden loss of upper deck pressure
- Turbo GAMIjector® fuel injectors
  - Positioned tuned injectors to closely match mixture in all cylinders
  - Facilitates better lean of peak engine operation

SR22TN Unique Features

- Absolute Pressure Controller
  - Controls master waste gate to maintain <u>constant</u> upper deck pressure





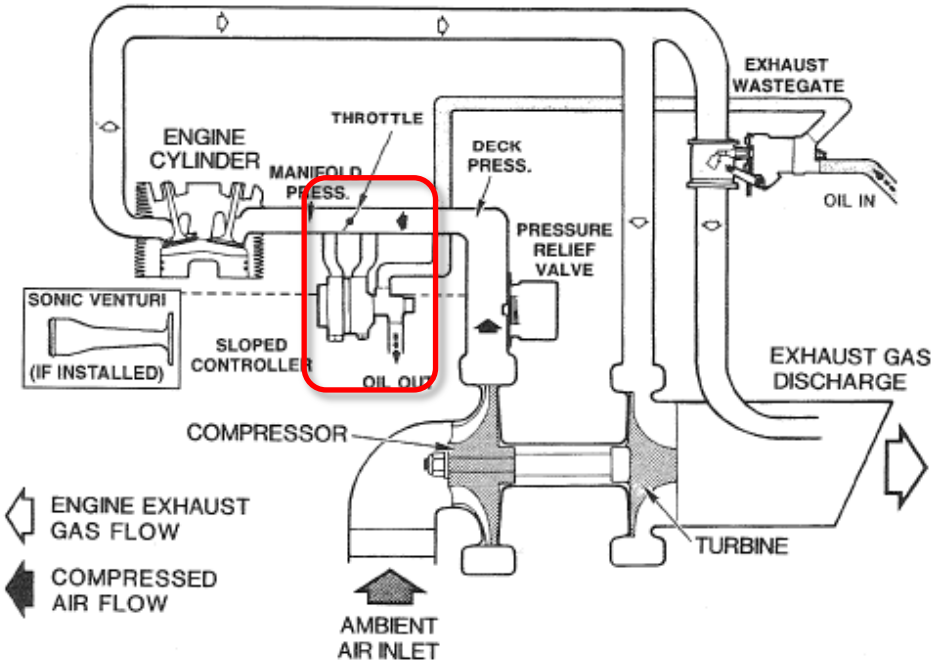
  - Slave waste gate mechanically linked to master

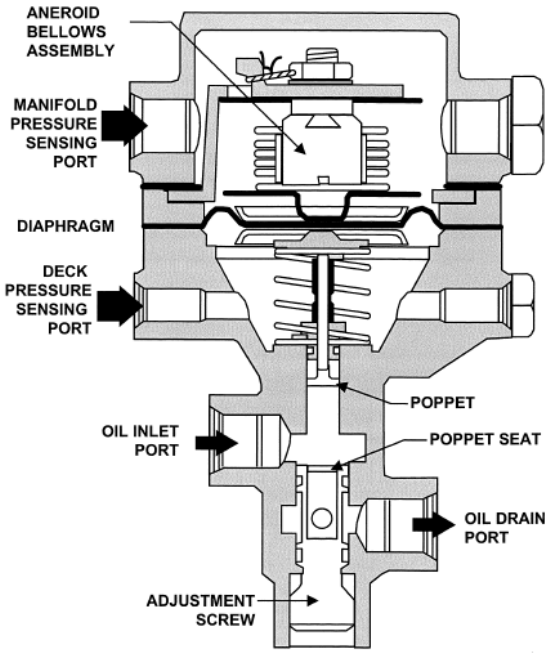
SR22T Unique Features

- Dual Turbo charged / single waste gate
  - Boosted (WOT MAP > 29.92”)
- Constant RPM
  - No Governor connection to power lever
- Manifold Pressure reference to fuel pump

SR22T Unique Features

- Slope Pressure Controller
  - Unlike Absolute Pressure Controller, reduces upper deck pressure when high pressures not required





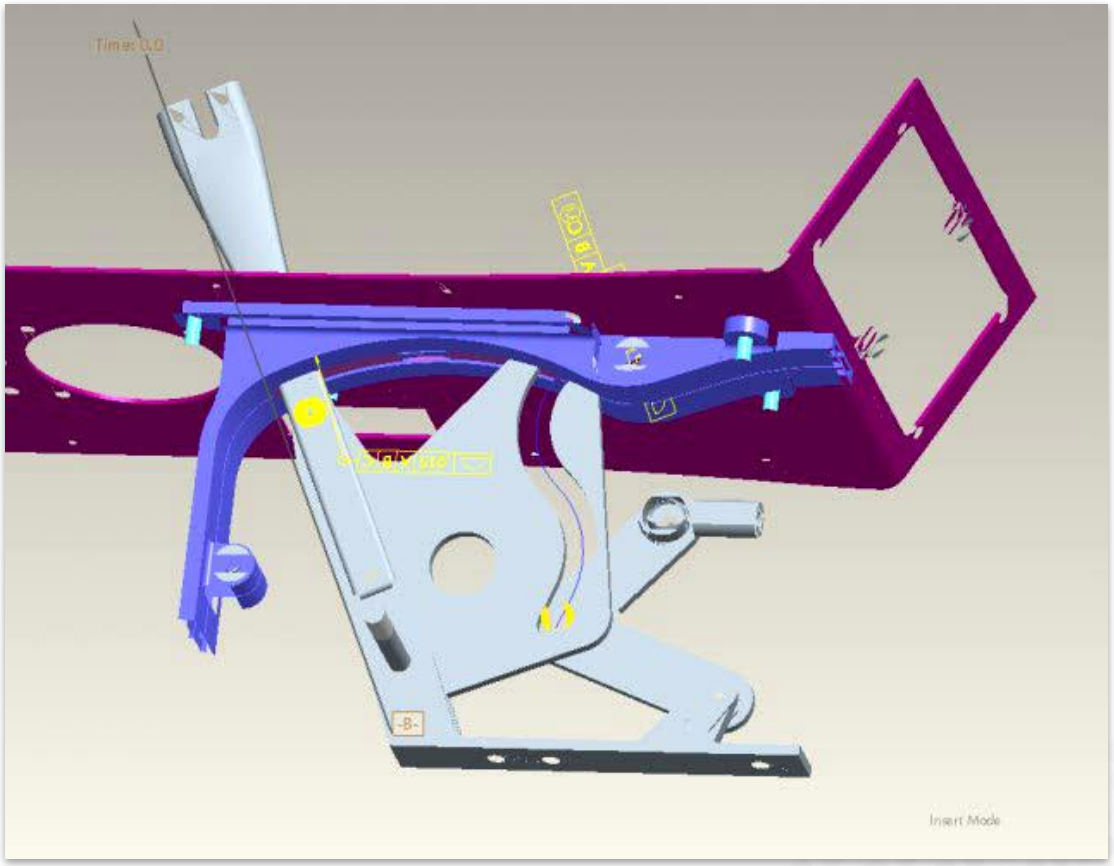
  - Introduces functional differences
    - Manifold Pressure Management
    - Mixture Management

SR22T Unique Features

- Manifold Pressure Management
  - With constant pressure upstream of throttle plate (as with normally aspirated or absolute pressure controlled aircraft), normal rotation of throttle plate has familiar and manageable affect on manifold pressure
  - With introduction of slope control, secondary influence on manifold pressure
  - Result is that in some positions, small changes in throttle lever position have large changes in Manifold Pressure…difficult to make refined MAP adjustments

SR22T Unique Features

- Design Solution: Power Lever Mechanism
  - Throttle cable “slowed” in cruise power range



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Combustion – Normal and Abnormal

Normal Combustion Event

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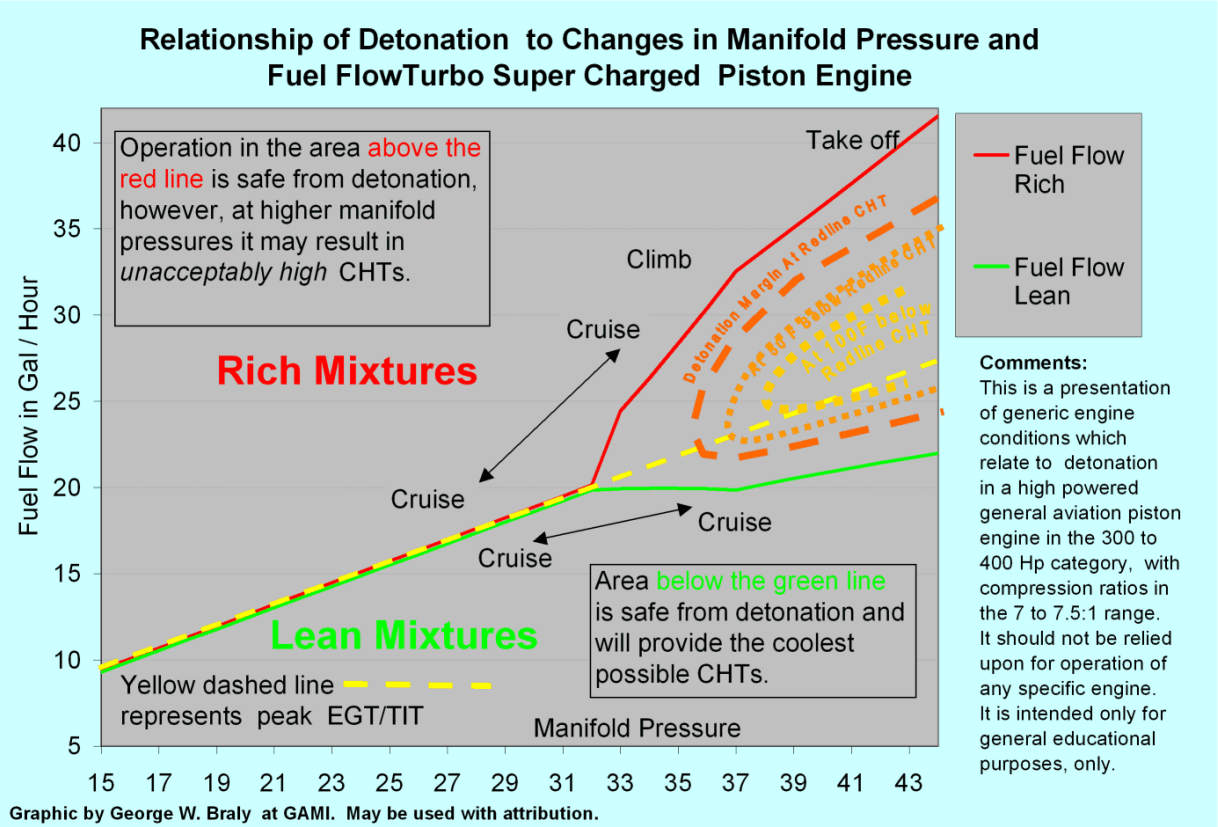
Detonation and Mixture Sensitivity



- SR22T:
  - In engine certification, with CHT at 460°F, and Manifold Air Temp >120°F (obstructions on intercoolers), detonation was observed at 31.5” Manifold Pressure

SR22T Leaning Limitation

- Leaning prohibited if MAP > 30.5”
  - Detonation margin

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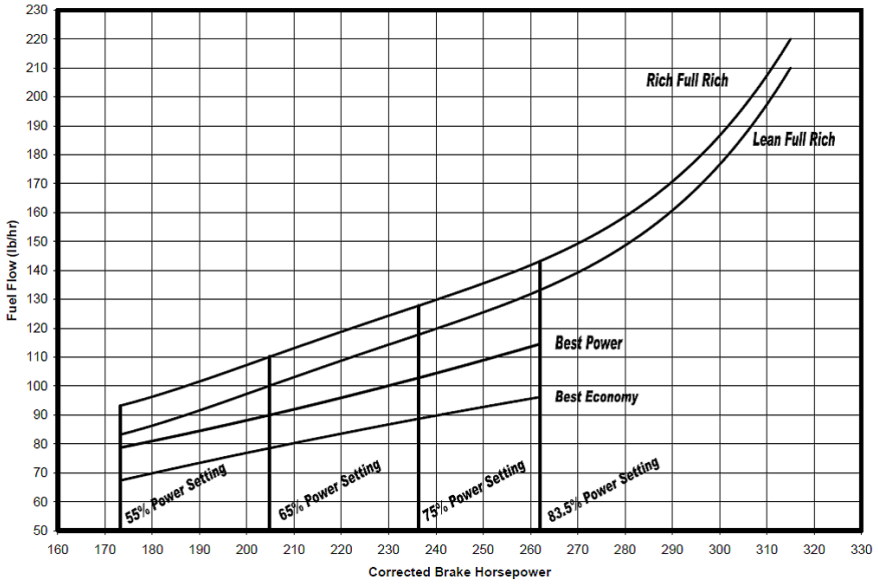
SR22T

Section 4
Normal Procedures

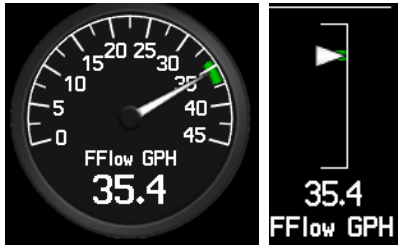
Maximum Power Fuel Flow

For maximum power operations (Power Lever full forward - 2500 RPM, 36.0 in.Hg manifold pressure) fuel flow should be in the green arc.

For any power setting greater than 30.5 in.Hg (cruise power) fuel flow is indicated by a dynamically calculated green arc displayed on the fuel gage. Fuel flow should be maintained within this arc by use of the mixture lever.



- Indicated by green arc
  - Reduced if MAP > 30.7”
  - Wide if MAP ≤30.7”
  - Target Fuel Flow only provided when MAP ≤ 30.7”



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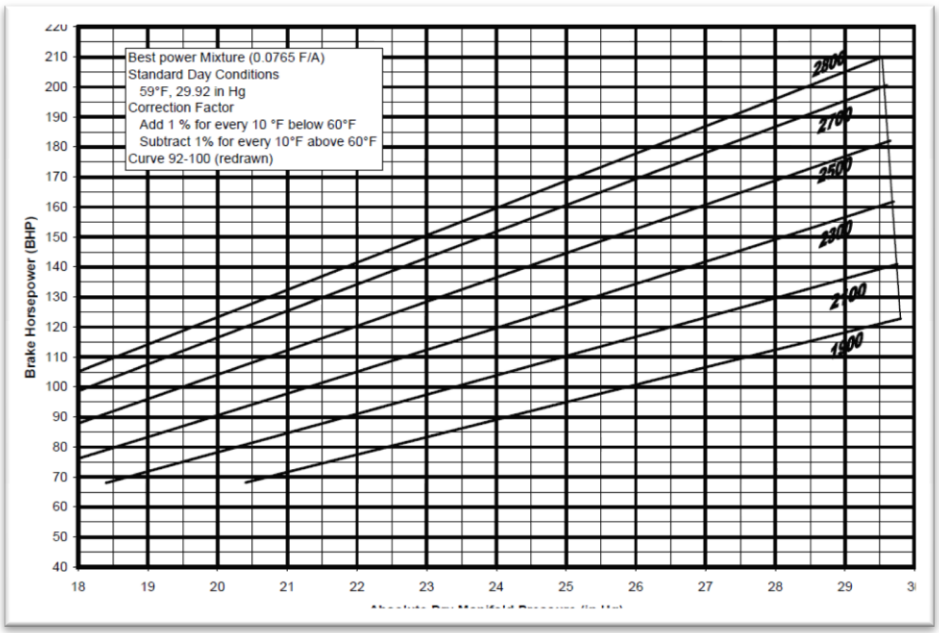
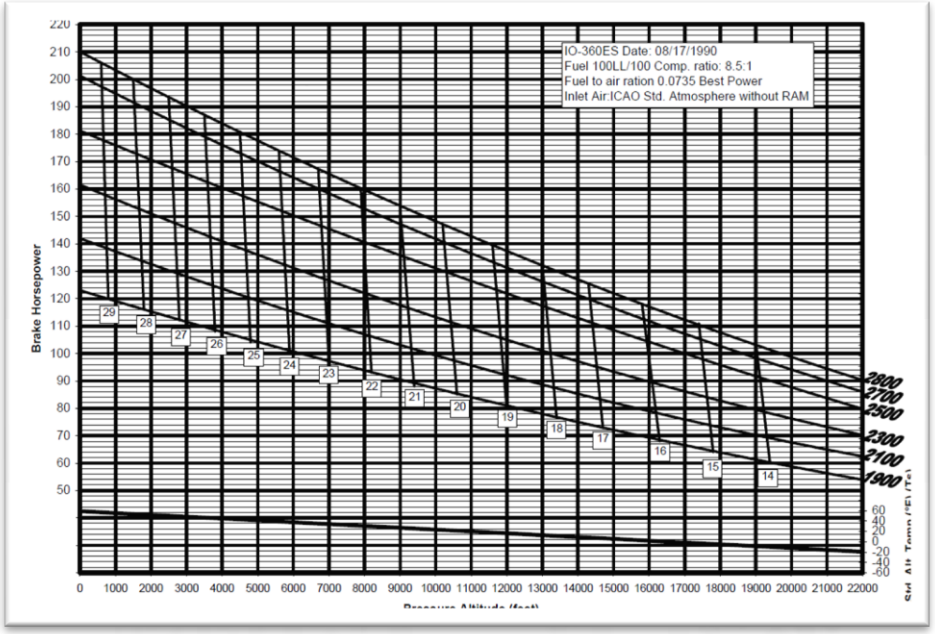
Engine Power Determination

- Performance Tables
  - Engine Manufacturer
  - Generally Provides Best Power





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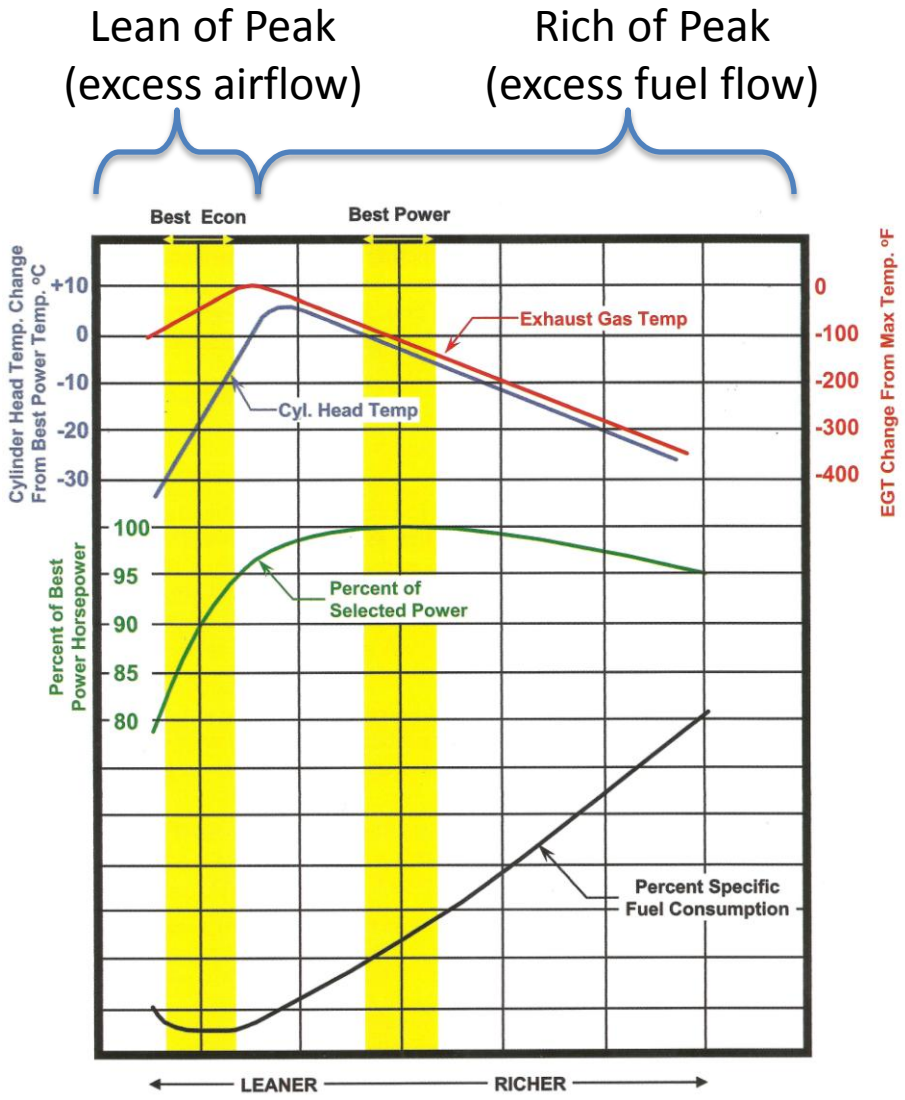
Mixture Influence

- Peak EGT
  - "Stochiometric mixture"
  - All fuel and oxygen consumed
  - Air:Fuel ratio of 14.7
- Rich of Peak
  - Power limited by oxygen quantity
  - Excess fuel flow (fuel not consumed) provides cooling
  - Rich mixtures will have slight degrade on power
  - Excessively rich will flood engine (large power degrade or flameout)
- Lean of Peak
  - Power limited by fuel quantity
  - Excess airflow (oxygen not completely consumed) provides cooling
  - Excessively lean → lean misfire



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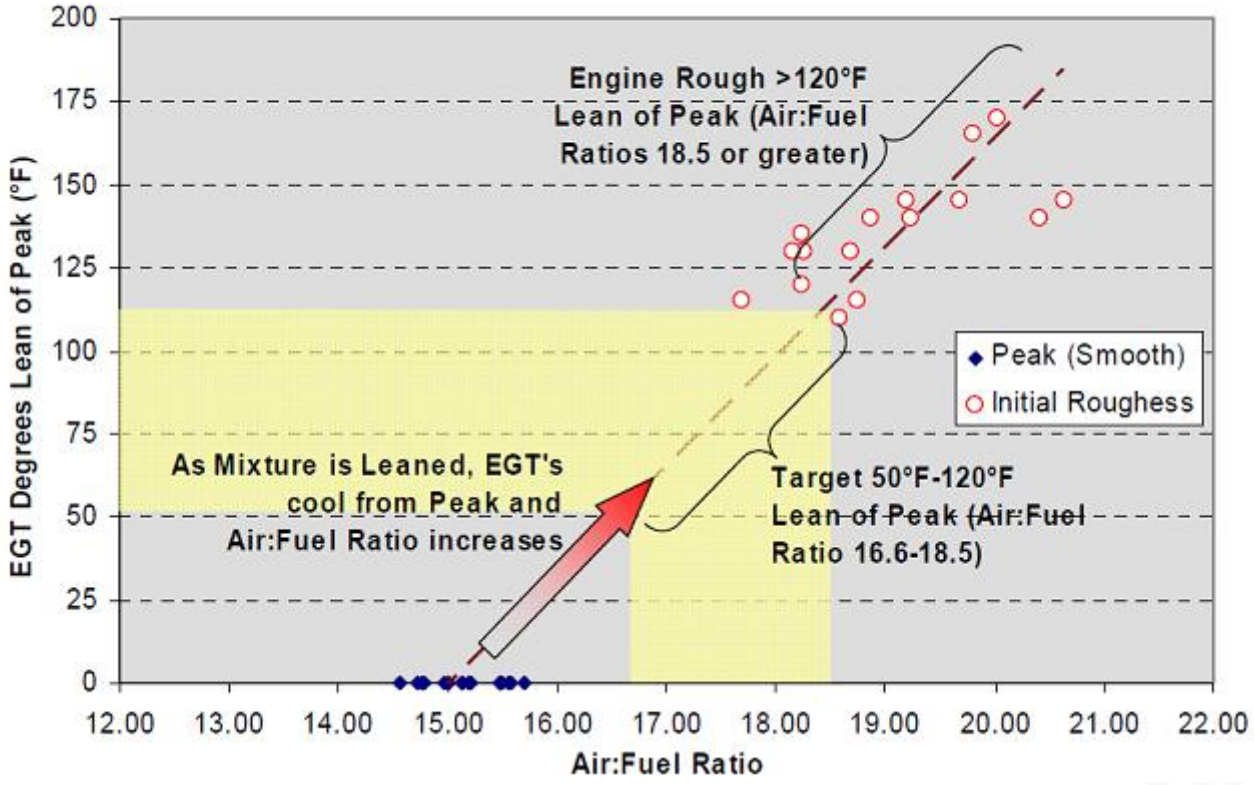
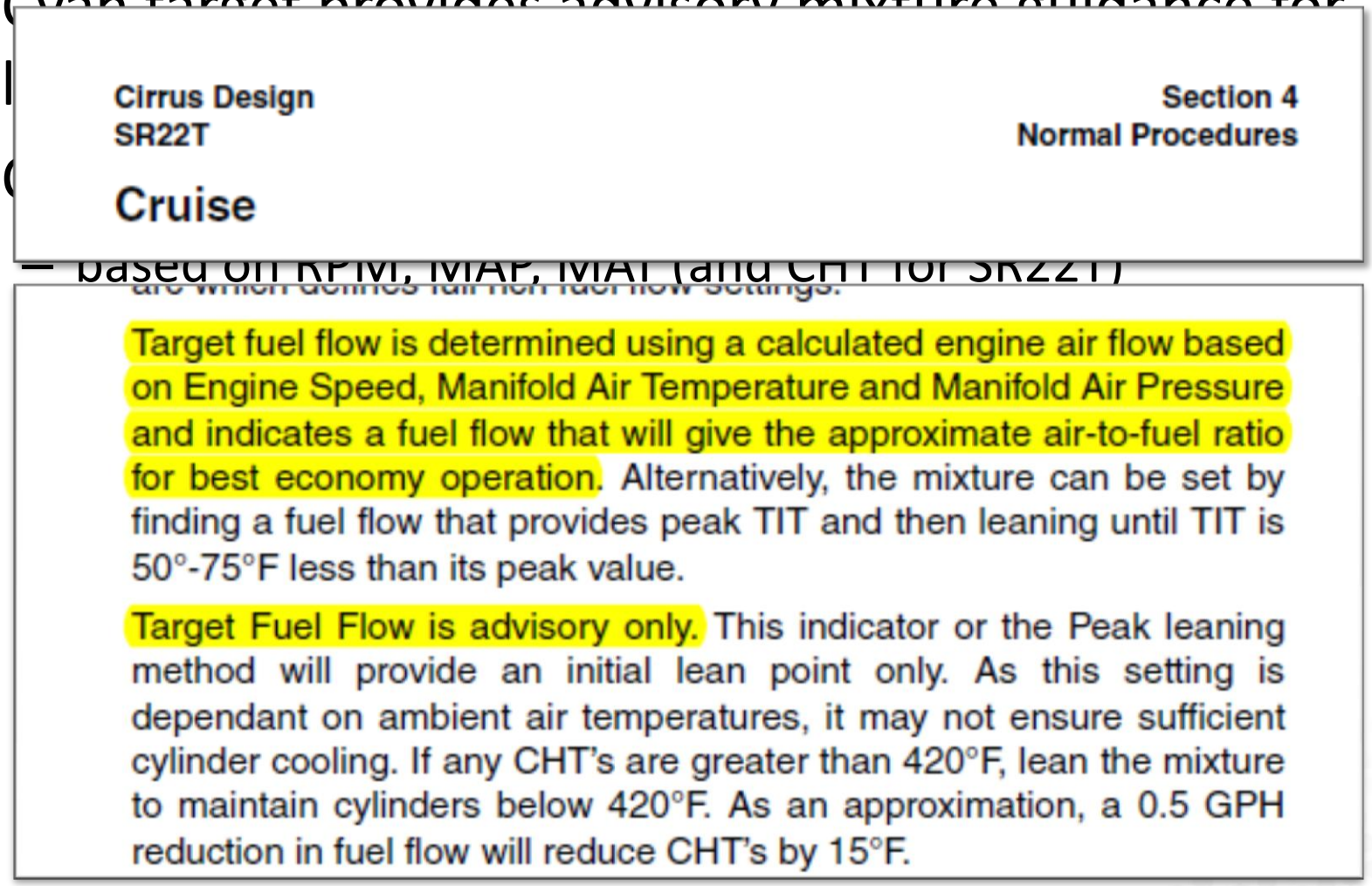
Lean Misfire

- Generally observed/characterized by sudden engine roughness
- Typically occurs at air:fuel ratio's > 18.5 (approximately corresponds to 120°F lean of peak)



Target Fuel Flow (SR22TN and SR22T)

- Cyan target provides advisory mixture guidance for
- C
  - based on RPM, MAP, MAT (and CHT for SR22T)



Cirrus Design
SR22T

Section 4
Normal Procedures

Cruise

are which defines full rich fuel flow settings.

Target fuel flow is determined using a calculated engine air flow based on Engine Speed, Manifold Air Temperature and Manifold Air Pressure and indicates a fuel flow that will give the approximate air-to-fuel ratio for best economy operation. Alternatively, the mixture can be set by finding a fuel flow that provides peak TIT and then leaning until TIT is 50°-75°F less than its peak value.

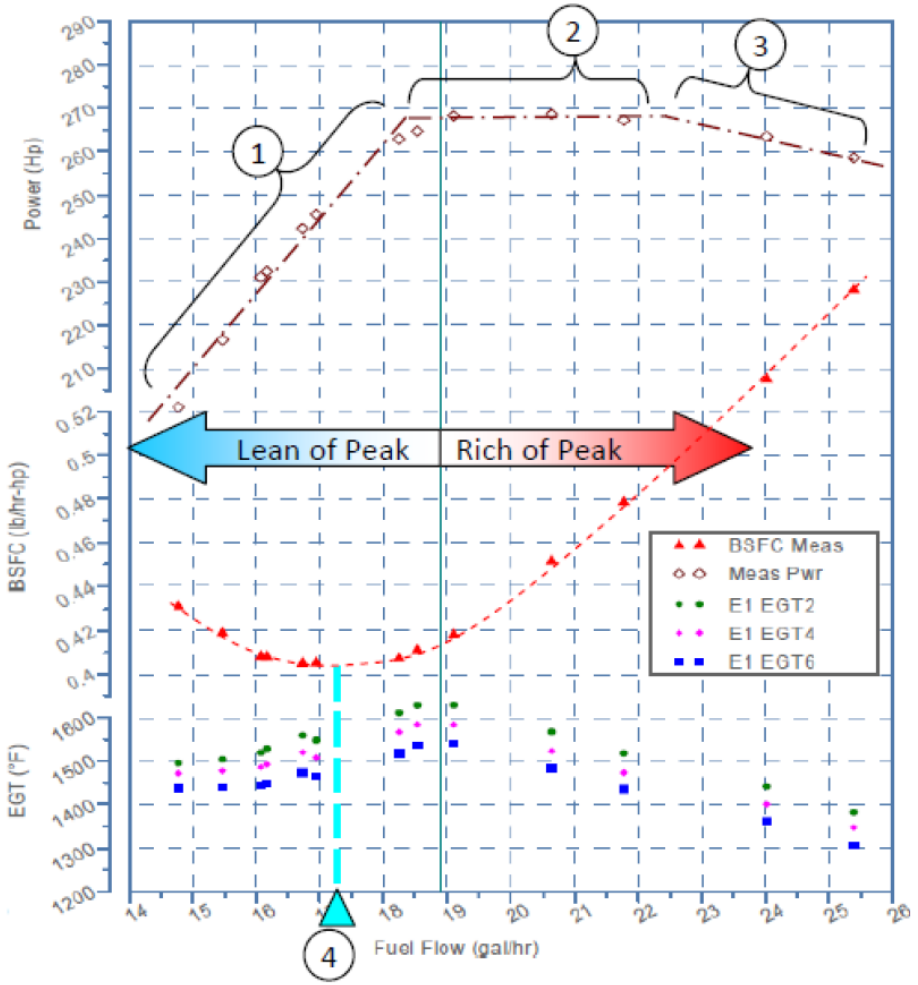
Target Fuel Flow is advisory only. This indicator or the Peak leaning method will provide an initial lean point only. As this setting is dependant on ambient air temperatures, it may not ensure sufficient cylinder cooling. If any CHT's are greater than 420°F, lean the mixture to maintain cylinders below 420°F. As an approximation, a 0.5 GPH reduction in fuel flow will reduce CHT's by 15°F.

% Power Model (Displayed Power)

- Calculation
  - f(MAP, RPM, MAT, FF)
  - SR20/22
    - Simplified 2 states (LOP/ROP)
    - LOP assumes constant BFSC 0.39

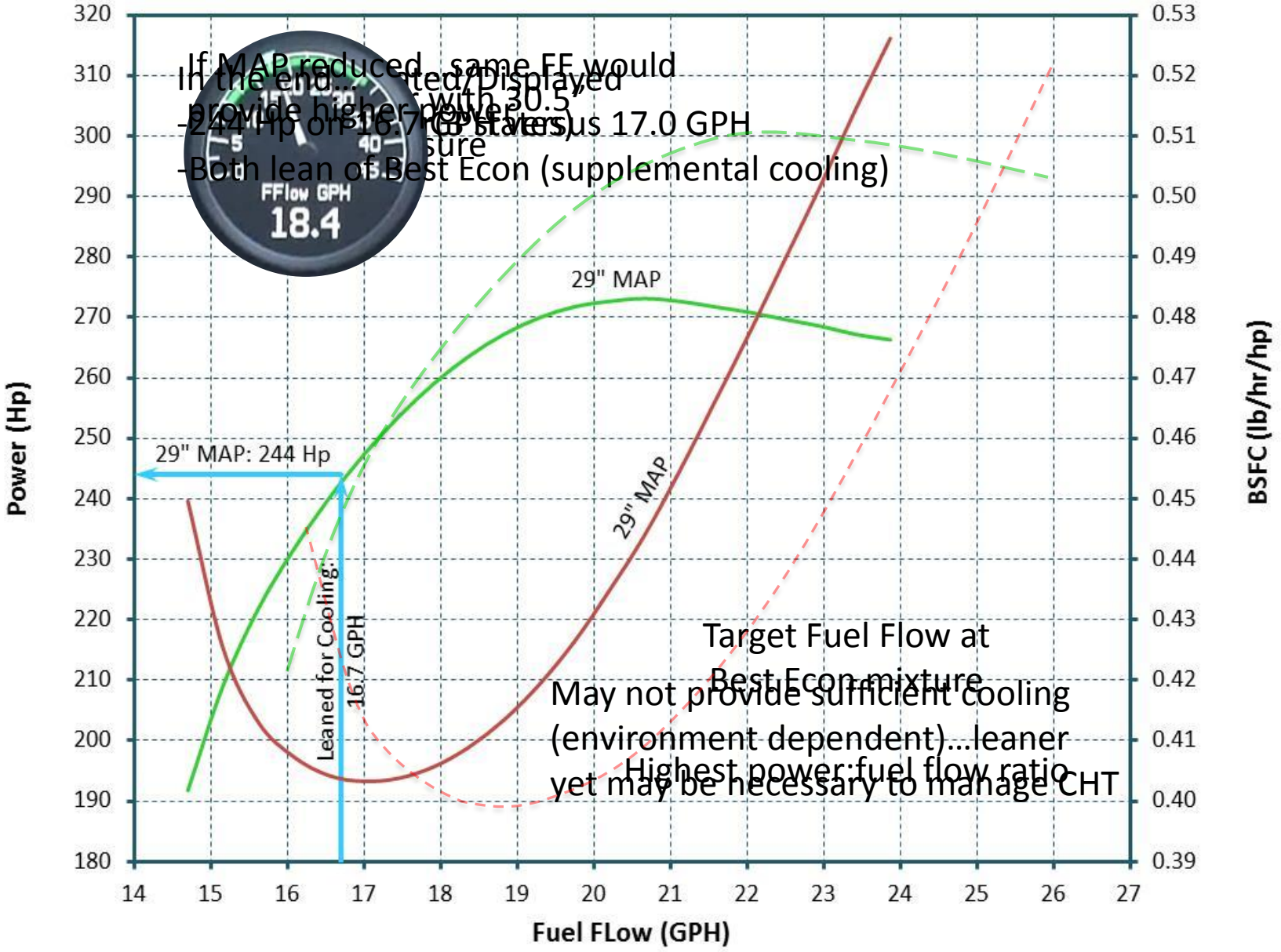
$$Pwr = 15 \times FF$$

  - SR22TN and SR22T
    - Simplified 3 states (LOP/ROP/>>ROP)
  - No “LOP Roll-off” modeled



Fuel Management Differences

- SR20:
  - Power Lever Δ: fuel metering cam + RPM (governor interconnect)
  - Aneroid only influences on climb or descent
  - Cruise leaning only (mixture remains stable if power lever changed thereafter)
  - No leaning limitations
- SR22:
  - Power Lever Δ: Fuel metering cam + RPM (governor interconnect)
  - Manual leaning required in climb and for cruise (mixture remains stable if power lever changed thereafter)
  - No leaning limitations
- SR22TN:
  - Similar to SR22 (aneroid only influences if loss of upper deck pressure)
  - No leaning limitations
- SR22T:
  - Power Lever Δ: Fuel metering cam + aneroid influence (slope controller reduces upper deck pressure)
  - No RPM induced “boost” with full power, but compensated with cam geometry
  - Mixture requires re-set if cruise power changed substantially (more than 1”)
  - Leaning limitation: cruise leaning only permitted ≤30.5” (detonation)



In the end…

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“Rules of Thumb”

- Lean of Peak mixtures approved for cruise and climb
  - 30.5” MAP requirement for SR22T
- Target FF advisory guidance for initial LOP fuel flow
- Further lean as necessary if supplemental cooling required
  - 0.5 GPH ≈ 15°F CHT reduction
  - Some efficiency loss (% Power will overestimate power by 1-2% if more than 1 GPH leaner than target)
  - Lean misfire will eventually begin if excessive leaning necessary
- If it is necessary to lean more than 1 gallon/hour, consider MAP reduction of 1” instead and lean for cruise

- Questions?