Back to Basics

RICE Compliance Through Basic Maintenance Practices

GCA Conference
March 2018

Presented By:
Pat Runnels
Service Manager – Emissions & Ignition
FW MURPHY PRODUCTION CONTROLS

Maintaining Emissions Compliance Using Basic Maintenance Practices

With ever-changing emissions requirements, maintaining emissions compliance on gas-fired engines has been thrown into the forefront of everyday operations. Staying compliant is easier than you think. All we need to do is:

GET BACK TO THE BASICS

WHAT EVERYONE WANTS

- Maximize Run Time
- Maintain Unit Reliability – engines available when needed and keeping downtime to a minimum
- Keep Cost Of Operations Down ($ per HP)
- Maintain Emissions Compliance

UNCONTROLLABLE CIRCUMSTANCES

These circumstances have forced us to change how we operate and caused unintentional outcomes

- Downturn In Economy
- Price Of Oil And Gas

Outcome -

- Doing More With Less
- Budgets Being Cut Or Restrained

We Can't Let These Changes Get Too Entrenched In Our Business Long Term

EPA Designates All Reciprocating Internal Combustion Engines Into 3 Groups

- 2 Stroke
- 4 Stroke Lean Burn
- 4 Stroke Rich Burn

2 Stroke Engines

Produces HP Quickly

2 Strokes Of The Piston Required To Make 1 Power Cycle

- Intake/Compression
- Power/Exhaust

Small and Light for Their Power Output Compared to 4 Stroke Engines

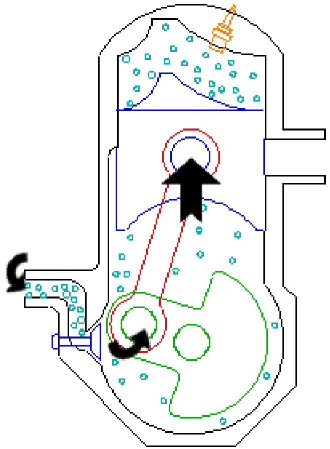
Dirty Exhaust Emissions – harder to control

Excess O2 Levels >10%

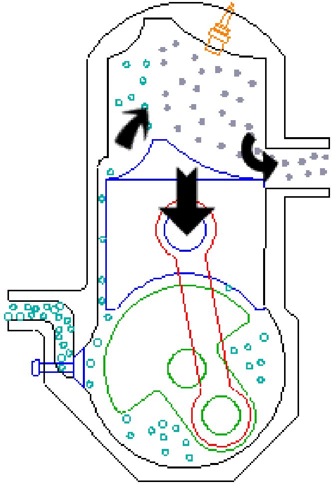
Losing Favor in US Due To Emissions

Limited After-treatment Options

Still Common In Home And Recreational Use



Intake/Compression



Power/Exhaust

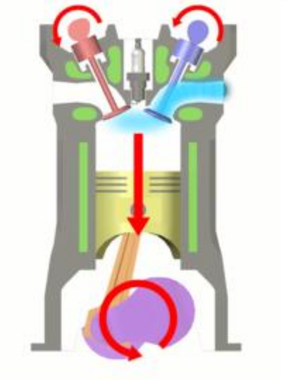
4 Stroke Engines

Most Commonly Used Engines

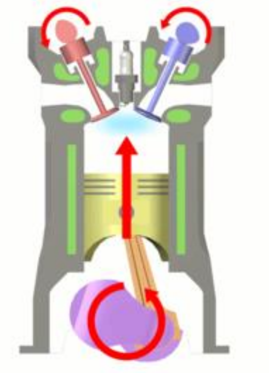
4 Strokes of Piston Required to Produce 1 Power Cycle

- Intake
- Compression/Ignition
- Power
- Exhaust

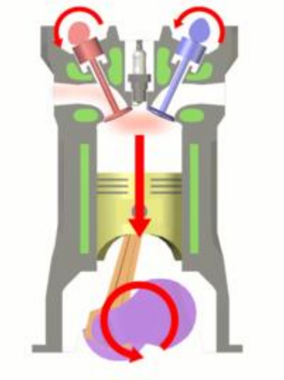
Slower HP Production Due to Extra Strokes



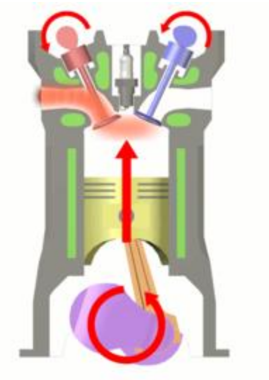
(1) Intake



(2) Compression



(3) Power



(4) Exhaust

4 Stroke Lean Burn

Higher AFR (varying ranges – 18:1 to 50:1); commonly around 24:1

Less HP for Same Size as Rich Burn

Better Fuel Economy than Rich Burn

Higher Maintenance Cost

Lower General CO/NOx Emissions, Higher CH2O Levels

Excess O2 Levels >2% - Typically Between 6 – 15%

More Expensive After Treatment to Eliminate NOx – SCR Systems

4 Stroke Rich Burn

Low Air Fuel Ratio, (Typically Around 16:1)

More HP Size

High Fuel Consumption

Lower Overall Maintenance Cost

Higher CO/NOx Levels

Excess Exhaust O2 =< 2%

More Economical Exhaust After Treatment – NSCR Catalyst w/AFR

Catalytic Converter Types

Rich Burn (aka – 3-way; NSCR, Dirty Burn)

- Simultaneously reduces NOx, CO and HC levels
- Minimum operating temperature of 750°F

Lean Burn Oxidation

- Designed for operation on a “Lean Burn” natural gas engine only
- Will not reduce NOx
- Minimum operating temperature of 550°F

Diesel Oxidation

- Designed for operation on a “Lean Burn” natural gas engine only
- Will not reduce NOx
- Minimum operating temperature of 550°F

SCR (Selective Catalyst Reduction)

- Designed to target only selected exhaust pollutants.
- Designed to work on Lean Burn engines only
- Most common application is to reduce NOx levels by injecting a reactant into the exhaust stream to assist the catalyst element.

Maintenance Types

Preventative – Used by Most Everyone

- Head off future issues, therefore PREVENTING failures
- Triggered by a predetermined time line based on known variables and set by user and/or OEM

Types –

  - Oil changes
  - Spark plug changes
  - Valve adjustments
  - Filter replacement
  - Cylinder compression check

Maintenance Types

Predictive

- Used to predict a component failure by recording and analyzing variables over time and knowing life expectancies of components
- Can be used to budget costs, allocate downtime and manpower resources

Types

- Cylinder compression checks
- Cylinder temperatures
- Oil analysis
- Catalyst differential temperature
- Catalyst differential pressure

Engine Maintenance

Areas of Concern

High workloads on service personnel – Work to balance between maintenance and emergencies!

- Time pressure and constraints may impact regular maintenance intervals

"This is how we always did it!"

- Old school practices no longer apply. We must adapt!

Training is needed –

- Experienced technicians can learn new tricks!
- New or less experienced technicians need to be taught by the experienced technicians!

Corporate standards are relevant and must be adhered to!

- Consistency is the key

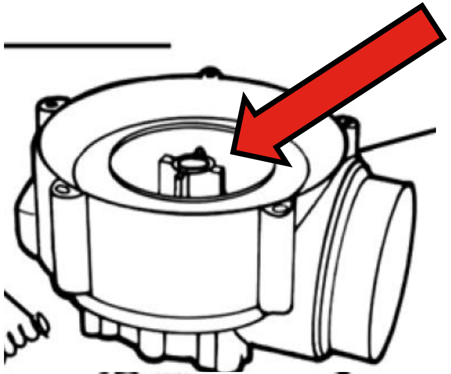
Fuel Systems

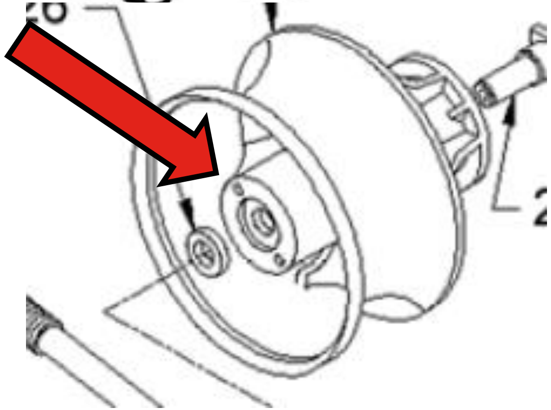
Fuel System Maintenance

Easily overlooked during typical maintenance periods

Areas of concern include:

- Carburetor/Mixer Air Valve Assembly. Should be considered a high wear item
- Inspect semi-annually for wear
- When worn sticking occurs and causes emissions to oscillate rich and lean
- Diaphragm inspection – stretched, worn, dirty





Fuel System Maintenance

Areas of concern include:

- Fuel Pressure Regulators should also be considered a high wear item
- Fuel pressure should be checked every maintenance period
  - First cut regulators and final cut regulators
  - Adjust when necessary to OEM recommendations
  - Rebuild or replace every 16,000 hours of operation
- Know the right way to measure fuel pressure
  - Final cut regulator inlet pressure within OEM's specification
  - Final cut outlet pressure within OEM's recommendation and always measured in Inches of Water differential (Fuel/Air)
- Naturally Aspirated (NA) engines should have a balance line added between the regulator and the air inlet pipe.

Ignition Systems

The ignition system plays one of the most important rolls in the operation of the engine and maintaining emissions compliance

Many times the ignition is overlooked in maintenance as long as the engine is running and is making horsepower.

When considering your ignition system and components the old adage kicks in

“YOU GET WHAT YOU PAY FOR”

Ignition Systems

A few things to consider about your ignition system, engine reliability and emissions compliance

- Igniting the gas in the cylinder at the right time is essential to a clean, complete combustion.
- Clean, complete combustion is essential to maintaining engine reliability and emissions compliance.

What should your ignition timing be?

How does the engine manufacturer determine when the combustion should start (ignition timing point)?

- Speed of the engine – related as piston speed
- Fuel quality – All of the gas constituents need to be known, methane, propanes, pentanes, etc. Not just the BTUs

Ignition Systems

DETERMINING IGNITION TIMING (in mechanic's terms)

- City or Pipeline quality gas burns at a very specific rate (measured in micro-seconds per inch)
- Propane also burns at a very specific rate (mS/inch)
- Different mixtures of all of the gas constituents burn at their own rate
- For a clean burn, the peak firing pressure in the cylinder MUST occur at a very particular point in the crankshaft rotation. Typically between 10° & 15° ATDC
- To achieve the peak firing pressure at the right time the gas quality must be known in order to determine how fast it burns
- Knowing how fast it burns and where the peak firing pressure should occur, the ignition timing point can be determined
- A fuel gas analysis and the OEM's software are needed to determine ignition timing point
- Fuel should be analyzed at least every 6 months or as required by permit

Ignition Systems - Systems

Magnetos vs. Electronic Ignition Systems – Old School vs. New School

- Magnetos have served us well but have inherent drawbacks
- Magneto firing patterns are not as accurate as we need today
- Timing can vary from cylinder to cylinder as much as ±3° with a new magneto and as much as ±12° with a worn-out magneto
- When repaired, not all of the worn gears are replaced carrying over some of the combustion issues from previous engines

Electronic Ignitions

- No moving parts so with the right electronics inside the timing can be held as close ±0.1° cylinder to cylinder

Ignition Systems – Spark Plugs

Spark plug types and designs vary greatly depending on needs of the engine and life expectancy desired by the user

Installation is key to combustion stability – combustion stability is key to longer plug life

Areas Of Concern:

- Incorrect gapping – Proper spark plug gaps are dictated by the air/fuel ratio. Improper gap will cause misfires and shorter spark plug life
- Threads and seats – Threads and seating areas of the head must be clean and dry to ensure proper grounding and correct heat dissipation
- Torque – All plugs should be torqued to manufacture's specification – Too loose, the plug can back out; Too tight, seizing, thread stretch, breaking of internal seals in plug
- Thread lubricant – Only use OEM recommended thread lubricant. NEVER use metallic anti-seize

Ignition Systems – Coils & Wires

Ignition Coils

- Ignition coils should be expected to have a life expectancy of 50,000 hours in most cases and should be replaced during an overhaul
- Dielectric grease should be used in coil towers to minimize corrosion
- Coil block grounds are critical – Only a metal-to-metal contact is acceptable
- Coils should never be painted – Shortens life by holding in heat and causes grounding on the primary connections

Spark Plug Wires

- Plug wires have a life expectancy of 16,000 hours and should be replaced on a regular bases
- Tight connections are needed on both the coil side and plug side
- Never paint the plug wires – Shortens life of wires and causes shorting to ground

Ignition Systems – Spark Timing

"What's the big deal about ignition timing?"

Firing too far advanced –

- Increases chances of detonation
- Increases NOx and CH2O production
- Increases cylinder pressures and temperatures
- Shortens cylinder life

Firing too far retarded (de-advanced)

- Increases CO production
- Steals horsepower
- Increases chances of burning valves
- Shorten cylinder life

Air Fuel Ratio Controllers

Proper operation of the engine is contingent on maintaining the proper air to fuel ratio delivered to the engine

Rich Burn Engines

- Too rich – High CO and HC emissions; Loss of horsepower; Engine misfires; etc.
- Too lean – High NOx emissions; Loss of horsepower; Engine misfires; Detonation

Lean Burn Engines

- ALL Lean Burn engines must have an AFRC to maintain engine efficiency
- Too lean – Loss of horsepower
- Too rich – High NOx, CO and HC emissions; Detonation

Periodic Maintenance Required – Changing out sensors, cleaning valves

Catalytic Converters

Period maintenance, testing and record keeping is recommended

Maintenance:

- Inspect the AFRC's oxygen sensors during replacement – Note ash content and other contaminates The oxygen sensors are the window to the inside of the catalyst
- Inspect the element, at minimum every 8,000 hours on removable elements, rely on O2 sensor inspection for sealed catalyst
- Chemically clean removable elements, every 12,000 to 16,000 hours
- With removable element housings, clean the inside of the housing any time it is opened
- Replace any disturbed gaskets whenever inspecting or replacing catalyst elements or housings

Testing and Record Keeping:

- Test and record emissions reduction rate: pre-catalyst emissions & post cat emissions
    - Reduction Rate = (Pre Cat – Post Cat) ÷ Pre Cat x 100
- Test and record differential pressures (ΔP)
- Test and record differential temperatures (ΔT)

When in doubt, contact the manufacturer.

Back to Basics
RICE Compliance Through Basic Maintenance Practices

QUESTIONS?