Locomotive Idle Reduction: Technology Issues

Union Pacific Railroad Company

National Idling Reduction Planning Conference
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Diesel engines in perspective

(L) Typical auto injector

(R) Typical locomotive injector

Typical Loco. diesel engine … 1500-to-4400 HP
125-367 HP/cylinder
Weight 20+ tons
668 in³ per cylinder
9” bore x 10.5” stroke

World’s largest diesel engine … 89,640 HP marine engine
7,470 HP/cylinder
Weight 2,000 tons
111,144 in³ per cylinder
38” bore x 98” stroke
What a loco. diesel engine does

✔ Provides power for traction motors (ex: 4400 HP)
  ✔ Propulsion of train

✔ Provides auxiliary power (ex: ~110 additional HP)
  ✔ Cooling fans, blowers, controls, HVAC, etc.

✔ Enables use of “dynamic braking”
  ✔ Traction motors become generators
  ✔ DB energy dissipated thru resistance grids (not regen.)
  ✔ “Electric brake” to supplement train air brakes
Truck v Locomotive operation

Hypothetical regulatory engine duty cycles

% run time at idle & low-idle (typ. 4 & <4 gal/hr)

% run time at full load (typ. 180-200 gal/hr)
Key Loco. Issues: idling v shut-down

✗ No antifreeze used (only corrosion inhibitors)
✗ Evolutionary design of locos 1939-present
✗ Fixed infrastructure: tunnel clearances, etc.
✗ No volume onboard for larger glycol radiators
✗ “Onboard attendant”: Trucks 1:1, Locos. 1:3+ (and sometimes unattended rear- or mid-train)
✗ Large mass of engines, typ. 40K# 12~16 cyl.
✗ Extensive interchange of locos between RRss
4400 HP “AC” road locomotive

12~16 cylinder diesel engine weighs 40,000#
0-75 MPH capability
Can haul 3,300 tons up 2.2% grade at 10 MPH
Measures 76’ long x 10’ wide x 16.3’ high
Weighs 425,000 pounds
Carries 5,000 gallons fuel & 425 gallons coolant
N. American railroads & locomotives

✓ Class I RRs: 5 US, 2 Canada, 2 Mexico; Amtrak passenger; x00s “short lines” & commuter operators

✓ 26,000 locomotives in service today
  ✓ 2 OEMs … GM Electro-Motive Division & GE Rail
  ✓ Union Pacific RR: 5,000 road + 2,000 yard = 7,000 total

✓ 1972-2002 US production:
  ✓ 435,197,000+ automobiles (gasoline)
  ✓ 11,295,000+ heavy trucks (small-bore high-speed diesel)
  ✓ 22,089 locomotives (large-bore medium-speed diesel)
Diesel engine R&D funding

✓ $300+ million in *federal* funds for truck engine research past 5 years

✓ $225+ million in *railroad industry* funds (OEMs and railroad customers) for locomotive diesel research in past 5 years
Fuel efficiency factors ~ Railroads

✔ Technology
  ✔ Locomotives: diesel engines & transmission (AC v DC)
  ✔ Idle reduction procedures & technologies
  ✔ Other

✔ Human factors
  ✔ Train handling practices
  ✔ Train dispatching practices

✔ Geography (fixed) & weather (variable)
Locomotive idle reduction

✓ Reduces overall fuel consumption
✓ Reduces air emissions

✓ Idle time affected by operating parameters … train type, geographical area (west, midwest, east), weather

✓ Is one technology in a complex set of tools for fuel management
Loco fuel consumption rates

- **Idling:** ~4 US gallons/hour
- **Full throttle:** 180-200 US gallons/hour

- Estimated UP fuel consumption:
  - 95% over-the-road (**low** idle time potential)
  - 5% in-yard (**moderate** idle time potential)

- **UP:** 14% improvement in fuel efficiency since 1999 due to *all* combined initiatives
Typical 3-unit consist, crew on 1st unit

(right) single yard unit (with remote-control car)

135-car unit coal train (20,000 tons) with 2+2+2 locomotive configuration (below):

2 Distributed Power units on rear-end (unmanned)

2 Distributed Power units at mid-train (unmanned)

2 primary units on head-end of train (lead unit manned)

67 cars (3,571’) apart

68 cars (3,625’) apart
UP locomotive fleet

✓ 5,000 road units (3000-4000-4400-6000 HP/unit)
   ✓ 35% acquired new since EPA loco regulations 1-1-2000
   ✓ Auto stop-start on 500+ GM-EMD and 300+ GE (OEMs)

✓ 2,000 yard+switch units (1500-2300 HP/unit)
   ✓ Auto stop-start on 600+ low-HP units (retrofit)

✓ About 1,400 UP locos (20% of total fleet) now equipped with auto engine stop-start idle-reduction technology
Transcontinental & International operation of locomotives

60-day GPS movement track: UP road locomotive
UP stack train on BNSF, Cajon Pass (CA)

CSXT  Norfolk Southern  UP
Auto engine stop-start technologies

√ OEM auto stop-start on high-HP locomotives
√ Retrofit stop-start for older low-HP locos
√ “Plug-in” heaters used on Chicago commuter locos (owned by Reg. Transp. Authority)
  √ Locos stay overnight at same location repeatedly
√ Have reviewed APU (auxiliary power unit)
  √ Could power auxiliaries such as cab air conditioning
  √ Declining need: air conditioning on remote yard units
Loco operation in tunnels ... technical challenge re radiator design

Exhaust

Inlet air to radiators & engine

Waste heat from radiators

Loco. #1  Loco. #2  ... cars ...
Locos cannot get higher or wider ... nor much longer!

Maximum freight car height on special designated routes 20’3”

Unrestricted locomotive height on any AAR-member railroad 16’3”

10’3” wide
Yard loco technology under review

✔ Hybrid yard switcher

✔ Battery bank powers traction motors, truck-engine alternator recharges batteries

✔ Glycol+Water coolant (improved shut-down capability)

✔ Truck-engine yard switcher

✔ Truck-engine gen sets replace large-bore loco engine

✔ Glycol+Water coolant (improved shut-down capability)
"We live in a moment of history where change is so speeded up that we begin to see the present only when it is already disappearing."

R. D. Laing, "The Politics of Experience"
Questions & Comments