





Cylinder Head Gasket with Integrated Combustion Pressure Sensors

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Advanced Engine Controls Enabled by Combustion Pressure Sensor (CPS)



- Balancing of large bore gas & diesel engines
- Closed loop control of light duty diesel engine: 50%MFB, IMEP-balancing, peak pressure, fuel quality correction
- Real time (in-cycle) fuel injection & ignition control
- Combustion control of diesel LTC/PCCI engines
- Control of gasoline, natural gas HCCI & lean burn engines
- Control of hybrid combustion engine & powertrain
- Knock & air-fuel control in aviation SI engines
- Advanced OBD, engine monitoring & diagnostics
- Virtual in-cylinder MAF, NOx, and EGR sensing
- High accuracy CPS could eliminate: knock, misfire, cam shaft, position, Mass Air Flow, & NOx sensors



Cylinder Head Gasket with Integrated CPS (CHGICPS)









- Sensor front section diameter: 1.8mm
- Conical pressure seal 60 degrees
- Sensor back section diameter: 2.5mm

- Signal conditioner dimensions: W=10mm, H= 5mm, L= 20mm
- FO cable length: 30-60mm



Schematic Diagram of Optrand CPS









- Closed-loop LED current control based on low pass filtered photodiode output
- Compensates for effects of under hood temperature changes on opto-electronics & light transmission
- Corrects for effects of sensor head & diaphragm temperature changes on sensor offset & gain





CPS Head Components & Assembly







Hat Shape CPS Inconel 718







- Pressure Range: 0-150, 0-250(350) bar
- Over Pressure: > 1.5 r
- Accuracy:
- Accuracy:

- > 1.5 range
- +/-1.2% of reading for p > 5 bar +/-0.1 bar for p < 5 bar, before SOC
 - +/- 0.2-0.4 bar for p<5 bar, after SOC
- Temp. coeff. Sens.: +/- 0.002 %/°C
- Non-linearity: <+/-0.2% (@80% FS)





- Sensor tip temp.:
- Conditioner temp.:
- Frequency range:
- SNR:
- Power supply:
- Output:
- Switch on delay:
- Service life:
- Diaphragm dia.:

-40°C to 380°C or 450°C -40°C to 150°C 0.1(1) Hz to 15(30) kHz ~1500:1 @20kHz 3.0V-5.5V, 10mA max 0.05 V_{cc} to 0.95 V_{cc} ; 0.25V to 4.75V @ V_{cc} =5V; ratio-metric < 20ms after V_{cc} on 0.5 -5 Billion cycles, 10k-30k h 1.7mm, 1.0mm to be offered



Removable CPS Prototype



- Signal conditioner dimensions: Dia.=25mm, L= 75mm
- FO cable length: 1.5 m





- Sensor front section diameter: 1.8mm
- Sensor back section diameter: 2.5mm



CHGICPS Prototype with Removable CPS in Diesel Engine





CHGICPS Performance @ 2000 RPM, Different Loads





Technology / PTSB



CHGICPS Performance @ 2000 RPM, All Loads







CHGICPS Performance @ 2900 RPM, Full Load







CHGICPS Performance IMEP Comparison







CHGICPS Performance Process Variability







- Cylinder Head Gasket with integrated miniature cylinder pressure sensor has removable transducers having 1.8mm in diameter front section and 2.5mm diameter, 50mm long cylindrical body
- Prototype CHGICPS has 3.2mm thick distance layer and sensors having their signal conditioners outside CHG, connected to sensors by 1.5m-long fiber optic cables
- Increased CHG thickness compared to production version compensated by increased piston height
- Production intent CHGICPS to come with 2.5mm thick distance layer, sensors' miniature signal conditioners attached to CHG flange, ~30mm long f.o. cables & single connector to connect all sensors to ECU



- Optrand Cylinder Pressure Sensor operates on principle of changing light intensity reflected from Inconel diaphragm deflecting under effect of pressure
- Sensor design is based on 2 optical fibers, one LED, one photodiode, & miniature signal conditioner electronics
- Current CGHICPS sensors use Φ1.7mm diaphragms;
 Φ1.0mm diaphragm to be offered in the future
- All welded fiber optic construction & metal to glass bonding allow sensor head temperatures up to 450°C
- Accuracy ranging from 1.0% to 3% & thermal shock error of 0.3 bar to 1 bar reported for prototype CHGICPS mounted in 6-cylinder diesel engine against water-cooled quartz reference at different load and RPM conditions





- Long term endurance and soot tests
- CHGICPS prototype to be built based on 2.5mm thick distance layer for automotive diesel & gasoline HCCI and medium/heavy duty diesel & natural gas engines
- Prototype CHGICPS with 1.5mm thick distance layer to be developed based on 1mm dia. sensor
- Accuracy better than 1.5% to be met under all engine operating conditions
- B-level CHGICPS prototype to be developed with miniature signal conditioner attached to CHG flange
- B-level CHGICPS prototypes to be tested in vehicle and under automotive vibration, temperature, EMI/EMP, salt spray etc. conditions