COMBUSTION DYNAMICS INSTRUMENTATION

IMI SENSORS
A PCB DIVISION

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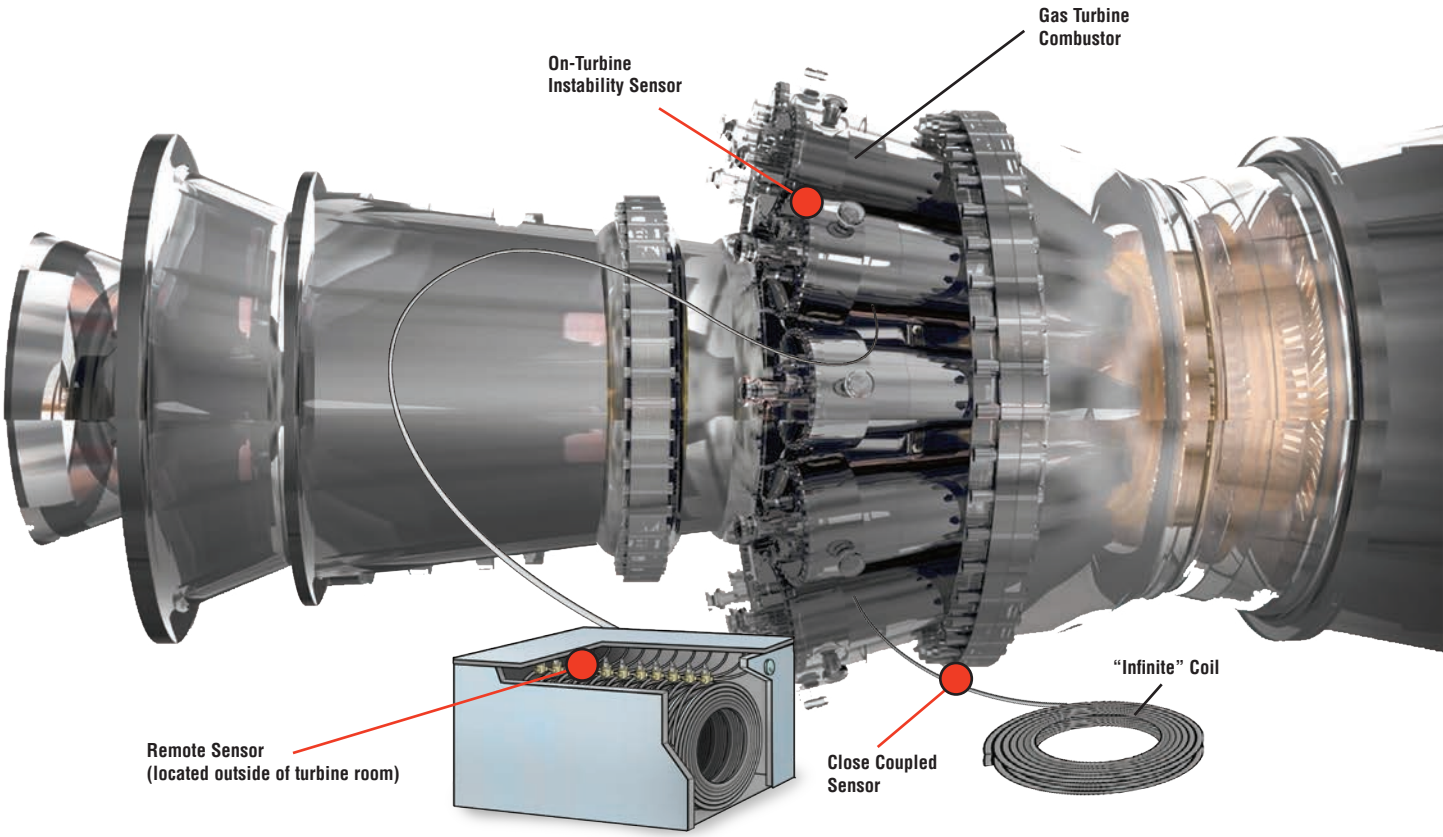


SUGGESTED SENSOR PLACEMENT

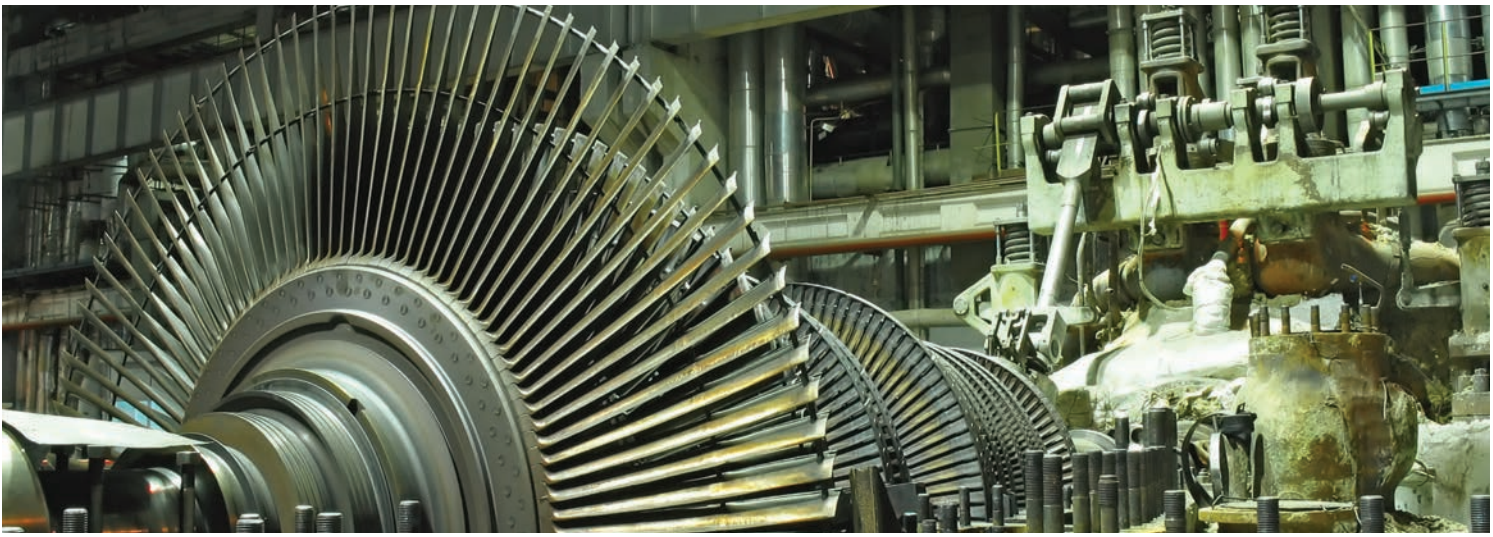
The diagram above shows a typical setting for a gas turbine in a power generation plant. Shown within the illustration are the three standard methods of measuring pressure; Remote, Close Coupled and On-Turbine Instability Sensor (OTIS). The red bullets indicate the location of the actual sensor for each different method.

COMBUSTION DYNAMICS INSTRUMENTATION

For more than 40 years, PCB® has specialized in the design and manufacture of innovative sensors and measurement systems for the gas turbine market. In those four decades, our expertise in combustion dynamics instrumentation has met the industry's most demanding requirements for dynamic combustion measurement and turbine engine monitoring.

With the move toward increased fuel efficiency and lower exhaust emissions, today's gas turbine engines are based on technological innovation yet also bring potential problems. Burning a leaner flame keeps NOx emissions low but at the same time increases instability (combustion dynamics) in the gas turbine engine. This instability can damage components in the combustion chamber such as nozzles, baskets and transition pieces, as well as downstream components such as blades, resulting in downtime and loss of revenue.

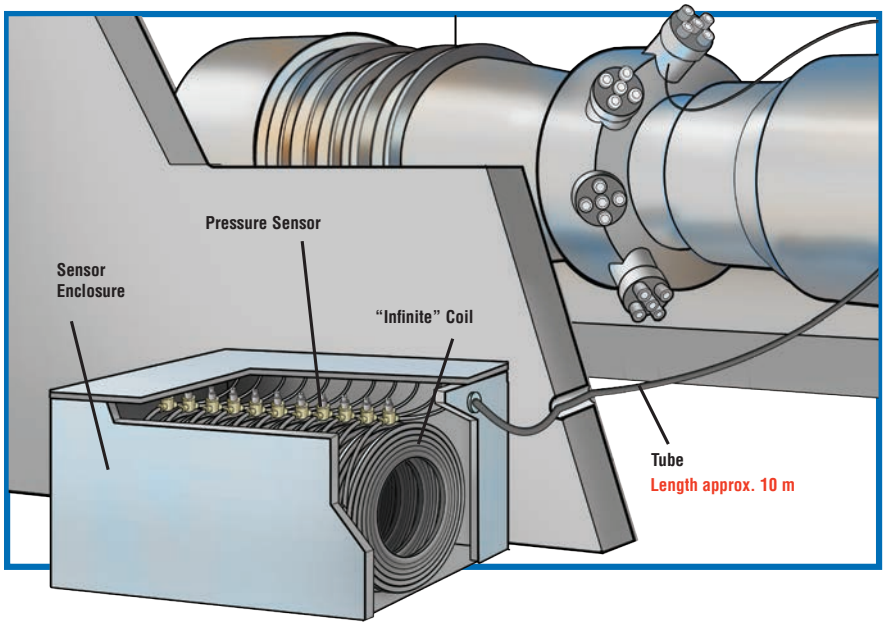
IMI's instrumentation is designed to detect and measure dynamic pressure spikes, pulsations and surges in gas turbine engines. Our pressure sensors have three basic applications for detecting and measuring dynamic pressure phenomena and combustion instability in gas turbine engines: remote sensors, close coupled sensors and On-turbine Instability Sensors (OTIS).



REMOTE SENSORS

These pressure sensors have either a portable or permanent configuration. Portable systems consist of pressure sensors that are connected to sensing lines running to some or all of the combustors. Similar to the portable systems, permanent systems provide sensors mounted outside the turbine enclosure.

The sensors are then connected through sensing lines (tubing) to each combustor. Because of the long sensing lines involved, the ability to “purge” condensation is required. There are advantages to this simple, low cost approach. Because the sensors are mounted outside the turbine enclosure, the conditions the sensors must endure are relatively mild, thus allowing for the use of less expensive sensors with longer life expectancy. In addition, these sensors can be serviced while the turbine is online.



ICP® PRESSURE SENSOR

MODEL 121A44

- Sensitivity: 100 mV/psi
- Measurement Range:
- 50 psi pk
- 316 stainless steel diaphragm
- 1/4” NPT fitting

ICP® PRESSURE SENSOR

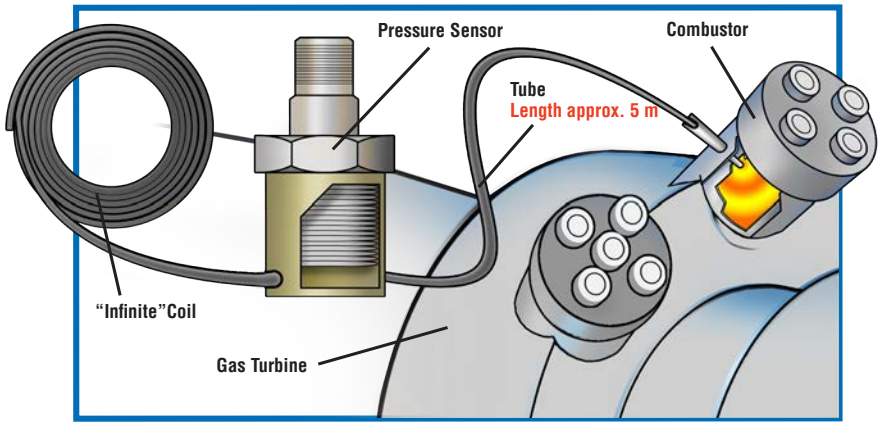
MODEL 102M205

- Sensitivity: 50 mV/psi
- Measurement Range: 100 psi pk
- 316 stainless steel diaphragm
- 3/8-24 UNF fitting

CLOSE COUPLED SENSORS

Close coupled sensors permanently mounted to a gas turbine are ideal for monitoring combustion dynamics (instability). Operating at a wider frequency range than remote sensors, the high sensitivity and higher-temperature capability of these sensors allow for precision measurement in turbine locations where the application of other instrumentation is not possible.

Close coupling of the sensors to the combustor enables the measurement and detection of dynamic pressure phenomena such as high frequency events that can cause damage to downstream components such as blades. Like the portable and permanent remote sensors, close coupled sensors also require a purging system to eliminate condensation.



HIGH TEMPERATURE PRESSURE SENSOR

MODEL EX171A01

- Sensitivity: 1200 pC/psi
- Measurement Range: 10 psi
- Frequency Range: Up to 5 kHz

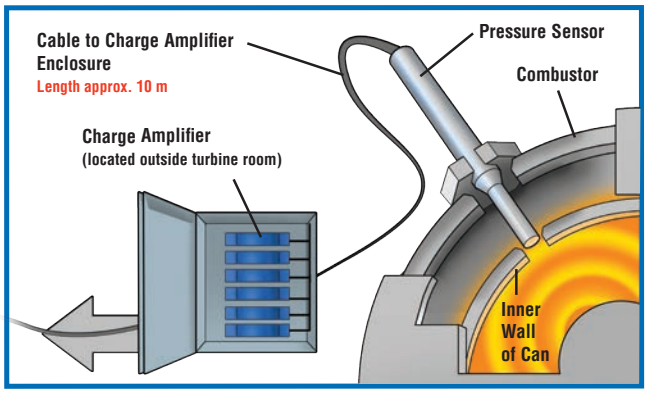
IN-LINE CHARGE CONVERTER

MODEL 422E55/D

- Sensitivity: 0.5 mV/pC
- Voltage Output: ±2.5 V pk
- Temperature Range (Operating): -65 to +250 °F
- Housing Material: Stainless steel

ON-TURBINE INSTABILITY SENSORS (OTIS)

High temperature sensors directly mounted to the combustor basket provide 24/7, consistent, reliable combustion dynamics data monitoring so that tuning changes can be made at anytime. On-Turbine Instability Sensors allow for diagnostics, part fatigue analysis and the ability to continuously monitor and control emissions. The higher frequency capability of the OTIS sensors enable the use of auto-tuning and online diagnostic monitoring systems. In addition, these sensors provide an output that can easily connect to legacy combustion dynamics monitoring systems. By having sensors directly mounted to the combustor, operators save time during combustion analysis.



1200°F (649 °C)

EXTREME TEMPERATURE PRESSURE SENSOR

MODEL 176A02

- Sensitivity: 6pC/psi
- Measurement Range: 725 psi pk
- Frequency Range: Up to 20 kHz

1200°F (649 °C)

EXTREME TEMPERATURE PRESSURE SENSOR

MODEL 176A03

- Sensitivity: 16 pC/psi
- Measurement Range: 290 psi pk
- Frequency Range: Up to 10 kHz

662°F (350 °C)

HIGH TEMPERATURE PRESSURE SENSOR

MODEL 176A04

- Sensitivity: 15.5 pC/psi
- Measurement Range: 300 psi pk
- Frequency Range: Up to 10 kHz

968°F (520 °C)

VERY HIGH TEMPERATURE PRESSURE SENSOR

MODEL 176A05

- Sensitivity: 52 pC/psi
- Measurement Range: 725 psi pk
- Frequency Range: Up to 8 kHz

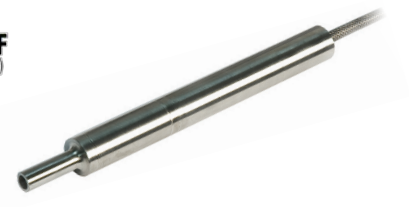
968°F (520 °C)

VERY HIGH TEMPERATURE PRESSURE SENSOR

MODELS 176M03 and 176M09

- Sensitivity: 17 pC/psi
- Measurement Range: 20 psi pk
- Frequency Range: Up to 10 kHz

662°F (350 °C)



VERY HIGH TEMPERATURE PRESSURE SENSOR

MODELS 176M07 and 176M12

- Sensitivity: 17 pC/psi
- Measurement Range: 20 psi pk
- Frequency Range: Up to 6 kHz

HIGH TEMPERATURE ACCELEROMETERS

Vibration monitoring of gas turbines can provide crucial information to diagnose potential problems, leading to an increase in uptime and a decrease in unplanned maintenance, catastrophic failures and accidents. Innovations in high temperature accelerometer technology for gas turbine monitoring now enable vibration measurement in extreme heat environments up to +1200 °F (+649 °C). IMI's high temperature accelerometers come in a variety of frequencies, temperature ranges and configurations. Integral charge amplifiers allow for use with standard data acquisition equipment.

EXTREME TEMPERATURE CHARGE ACCELEROMETER

MODELS 357A64 and 357M168

- Sensitivity: 1.15 pC/g
- Measurement Range: ±1000 g pk
- Frequency Range: Up to 10 kHz
- UHT-12™ element

VERY HIGH TEMPERATURE TRIAXIAL CHARGE ACCELEROMETER

MODEL EX356A73

- Sensitivity: 3.2 pC/g
- Measurement Range: ±500 g pk
- Frequency Range: Up to 4 kHz
- UHT-12™ element

EXTREME TEMPERATURE CHARGE ACCELEROMETER

SERIES EX357E9X AND EX357A9X

- Sensitivity: 2.3 pC/g (EX357E92/93), 3.3 pC/g (EX357A94/95) or 5.0 pC/g (EX357E90/91)
- Measurement Range: ±1000 g pk
- Frequency Range: Up to 3.0 kHz

DIFFERENTIAL CHARGE AMPLIFIERS

DIFFERENTIAL CHARGE AMPLIFIER

MODEL 422M182

- Sensitivity: 4 mV/pC
- Voltage Output: ±5 V pk
- Temperature Range (Operating): -60 to +185 °F

DIFFERENTIAL CHARGE AMPLIFIER

MODEL EX682A40

- Sensitivity: 10 mV/pC
- Voltage Output: ±2.5 V pk
- Temperature Range (Operating): -40 to +176 °F

DIFFERENTIAL CHARGE AMPLIFIER

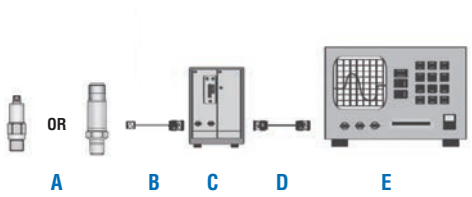
MODEL 421B3X

- Sensitivity: Configurable
- Voltage Output: ±5 V pk
- Temperature Range (Operating): -22 to +185 °F

FOR REMOTE PRESSURE SENSORS

MODEL 121A44:

A Model 121A44 – ICP® Pressure Sensor
B Model 052BPXXXAC – Cable with 2-socket MIL connector to BNC plug
C ICP® sensor signal conditioner (Optional)
D Model 012A03 – Cable with BNC plug to BNC plug (Optional)
E Readout, recording or data acquisition device



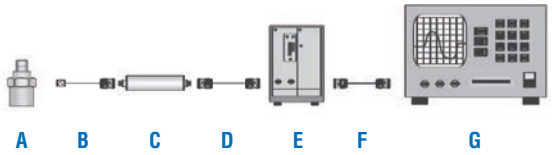
MODEL 102M205:

A Model 102M205 – ICP® Pressure Sensor
B Model 003CXX – Cable with 10-32 plug to BNC plug
C ICP® sensor signal conditioner (Optional)
D Model 012A03 – Cable with BNC plug to BNC plug (Optional)
E Readout, recording or data acquisition device

FOR CLOSE COUPLED PRESSURE SENSORS

MODEL EX171A01:

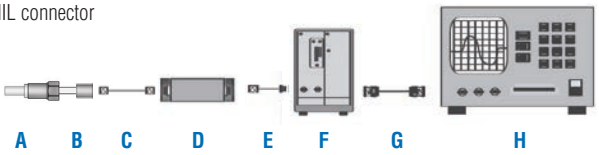
A Model EX171A01 – High Temperature Pressure Sensor
B Model 045ERXXXAC – Cable with 2-socket MIL connector to BNC plug
C Model 422E55/D – In-Line Charge Converter (Optional)
D Model 012A03 – Cable with BNC plug to BNC plug (Optional)
E ICP® sensor signal conditioner (Optional)
F Model 012A03 – Cable with BNC plug to BNC plug (Optional)
G Readout, recoding or data acquisition device



FOR ON-TURBINE INSTABILITY PRESSURE SENSORS

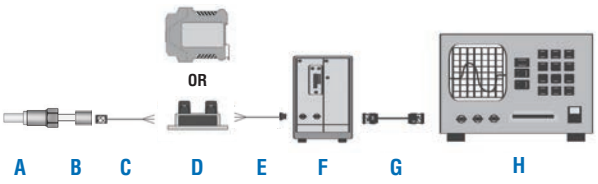
MODELS 176AXX AND 176MXX

A Model 176AXX or 176MXX – Differential Charge Pressure Sensor
B Model 013GNXXXGP- Hardline cable with 2-socket 7/16-27 connector to 2-pin 7/16-27 connector (Model 176A04 only)
C Model 045M19B – Softline cable with 2-socket 7/16-27 connector to 2-socket MIL connector
D Model 422M182 – Differential Charge Amplifier
E Model 012A03 – Softline cable with BNC plug to BNC plug
F ICP® signal conditioner (Optional)
G Model 012A03 – Softline cable with BNC plug to BNC plug (Optional)
H Readout, recording or data acquisition device



OR

A Model 176AXX or 176MXX – Differential Charge Pressure Sensor
B Model 013GNXXXGP- Hardline cable with 2-socket 7/16-27 connector to 2-pin 7/16-27 connector (Model 176A04 only)
C Model 045M21B – Softline cable with 2-socket 7/16-27 connector to pigtails
D Model 421B3X or EX682A40 – Differential Charge Amplifier
E Model 052ADXXXAC – Softline cable with pigtails to BNC plug
F ICP® signal conditioner (Optional)
G Model 012A03 – Softline cable with BNC plug to BNC plug (Optional)
H Readout, recording or data acquisition device



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