

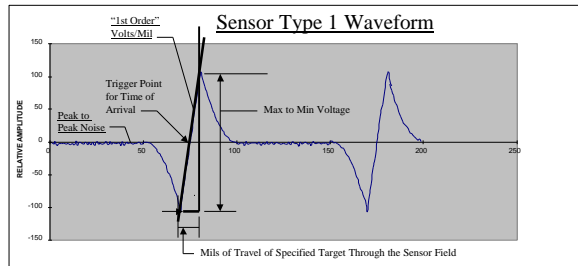
Table 4. NSMS ALTERNATE SENSOR REQUIREMENTS

MEASUREMENT APPLICATION	Bandwidth For Bipolar Signals (10% - 90% Min Rise Time For Unipolar Sig.)	Sensor Field Geometry (i.e. Active Area Of Signal Integration)	Maximum Spatial Jitter (Over Entire Blade Tip Velocity Range) *See note below regarding sensor testing Note: 1 mil = 0.001 in	Maximum Available Sensor Dimensional Envelope	Minimum Operating Range (Typical Gap Closure During Run)	Blade Tip Velocity Range	Sensor Environment (Pressure, Temperature, And G's)	Typical Blade And Gas Path Characteristics	Comments
Basic LPC/Fan Health: Detection Of Flutter & Low Order Resonance Modes (1st Bending & 1st Torsional Modes) For Rotor Dia. 12 in. To 25 in. (S) 25 in. To 40 in. (L)	88 kHz (4 microsec)	Spot w/ Spot Dia. 0.250 in. Max. (S) w/ Spot Dia. 0.800 in. Max. (L)  Or  Line w/Line Length 0.200 in. Min. (S) w/Line Length 0.625 in. Min. (L)	± 2.5 mils Jitter (S)  ± 5 mils Jitter (L)	Application Dependent  Typically: (0.40 in. Dia. X 4.5 in. High) (S) (1.5 in. Dia. X 2.0 in. High) (L)	0.000 in. To 0.075 in. (S) 0.150 in. (L) (Minimum)  Closure 0.050 in. (S) 0.110 in. (L)	120 ft./sec To 1900 ft./sec	Gas Path Temps : 300 To 600 F; 30 To 150 psig; 50 G's pk-pk (500 Hz To 8.0 kHz); Subject To Oil, Rub Debris; Case Temps 250 To 550 F	Blades Are Elect Conductive, Non-Magnetic, 0.030 in. Min Thickness (S) 1.5 in. Min. Cord (S) 1.0 in. Min. Span (S)  0.030 in. Min Thickness (L) 2.5 in. Min Chord (L) 2.0 in. Min Span (L)	Non-conductive blades are being developed for some applications.
Gen 3: LPT/HPT: Structural Diagnostics: Stress Amplitude For Non-Integral Order And Major Integral Order Resonance Modes For Rotor Dia. 12 in. To 25 in. (S) 25 in. To 40 in. (L)	350 kHz (1 microsec)	Spot w/ Spot Dia. 0.030 in. Max. (S) w/ Spot Dia. 0.100 in. Max. (L)  Or  Line w/Line Length 0.250 in. Min. (S) w/Line Length 0.625 in. Min. (L)	± 1 mil Jitter (S&L)	Application Dependent  Typically: (0.40 in. Dia. X 2.0 in. High) (S) (0.375 in. Dia. X 4.0 in. High) (L)	0.000 in. To 0.075 in. (S) 0.150 in. (L) (Minimum)  Closure 0.050 in. (S) 0.110 in. (L)	120 ft./sec To 1900 ft./sec	Gas Path Temps : 1700 To > 2700 F; 100 To 300 psig; 50 G's pk-pk (1.0 kHz To 8.0 kHz); Case Temps To 2000 F	Blades Are Elect Conductive, Non-Magnetic, Solid Blade Tips, With & Without Tip Shrouds, Blade Temp's > 2000 F. 0.020 in. Min Thickness (S) 1.0 in. Min. Cord (S) 1.5 in. Min. Span (S)  0.030 in. Min Thickness (L) 1.0 in. Min Chord (L) 2.0 in. Min Span (L) Flame & Carbon Particles	Many applications (i.e. shrouded turbine blades) require a standoff mounting with the probe in the gas path. Typical probe range is 1000 mils to 1600 mils. Gas path probes have additional criteria (500 g capability, resonant frequency at least 1.3 x max rpm/60, etc.) that are application specific.
Gen. 4 Structural Diagnostics: Stress Amplitude For Non-Integral & Integral Orders  HPC & LPC With Rotor Diameters Of 9 in. To 18 in. (S) 18 in. To 36 in. (L)	12 MHz (30 nanosec)	Structural diagnostics appl. require that the location of measurement on the blade be known precisely. To accommodate this constraint requires either: 0.010 in. (max.) spot probe (S) 0.020 in. (max.) spot probe (L) w/ stand-off capability into the gas path to project a line across the blade, or line probe with an illumination length of: 0.250 in. to 0.450 in. (S) 0.500 in. to 0.900 in. (L)	± 0.05 mil Jitter (S&L)	Application Dependent (Typically) 0.375 in. Dia X 0.75 in. High) (S) 1.5 in. High) (L)  Capable Of Low Profile Configuration 0.75 in. High Ref. I.D. Of Gas Path (w/ Electronics Circumferential)	0.000 in. To 0.075 in. (S) 0.150 in. (L) (Minimum)  Closure 0.050 in. (S) 0.110 in. (L)	120 ft./sec To (2200 ft./sec Typical Max)	Gas Path Temps : 300 To >1200 F; 30 To 700 psig; 50 G's pk-pk (1.0 kHz To 8.0 kHz); Subject To Oil, Rub Debris; Case Temps To 1200 F	Blades Are Elect Conductive / Non-Magnetic, Coated & Uncoated Blade Tips; Blade Temp's Up To >1200 F;  0.020 in. Min Thickness (S) 0.75 in. Min. Cord (S) 1.0 in. Min. Span (S)  0.030 in. Min Thickness (L) 0.75 in. Min. Cord (L) 1.0 in. Min. Span (L)	
Gen. 4 Structural Diagnostics: Stress Amplitude For Non-Integral & Integral Orders:  HPT & LPT With Rotor Diameters Of 12 in. To 25 in. (S) 25 in. To 40 in. (L)	12 MHz (30 nanosec)	Structural diagnostics appl. require that the location of measurement on the blade be known precisely. To accommodate this constraint requires either: 0.010 in. (max.) spot probe (S) 0.020 in. (max.) spot probe (L) w/ stand-off capability into the gas path to project a line across the blade, or line probe with an illumination length of: 0.188 in. to 0.375 in. (S) 0.375 in. to 0.500 in. (L)	± 0.05 mil Jitter (S&L)	Application Dependent (Typically) 0.375 in. Dia. X 0.75 in. High) (S) 2.0 in. High) (L)  Capable Of Low Profile Configuration 0.75 in. High Ref. I.D. Of Gas Path (w/ Electronics Circumferential)	0.000 in. To 0.075 in. (S) 0.150 in. (L) (Minimum)  Closure 0.050 in. (S) 0.110 in. (L)	120 ft./sec To 2600 ft./sec (2200 ft./sec Typical Max)	Gas Path Temps : 1700 To > 2700 F; 200 psig; 50 G's pk-pk (1.0 kHz To 8.0 kHz); Case Temps To 2000 F	Blades Are Elect Conductive, Non-Magnetic, Solid Blade Tips, With & Without Tip Shrouds, Blade Temp's > 2000 F. 0.020 in. Min Thickness (S) 1.0 in. Min. Cord (L) 1.5 in. Min. Span (S)  0.030 in. Min Thickness (L) 1.0 in. Min Chord (L) 2.0 in. Min Span (L) Squealer Tip * (L) * Squealer Tip Blades Have A Pocket At The Tip  Flame & Carbon Particles	Many applications (i.e. shrouded turbine blades) require a standoff mounting with the probe in the gas path. Typical probe range is 1000 mils to 1600 mils. Gas path probes have additional criteria (500 g capability, resonant frequency at least 1.3 x max rpm/60, etc.) that are application specific.

\* When testing of a sensor with a "target" is required in order to measure the "jitter" the thickness of the target shall be as specified under "Typical Blade And Gas Path Characteristics" column.

**Procedure for Determining Spatial Jitter of Sensor/Signal Conditioning:**

- 1) Establish the "1st Order" sensitivity of the sensor/signal conditioner in volts/mil in the vicinity of the trigger region for the characteristic waveform of the sensor (at specified bandwidth). Note: Establish sensitivity with a rectangular target equivalent to the Min. blade thickness specified (steel feeler gage stock acceptable).
- 2) Divide the Max peak to peak noise by the volts/mil to determine the "1st order" approximation of the spatial jitter



Ex: For type 1 waveform: Max to Min volts = 2 over a travel of 120 mils.  
"1st Order" sensitivity = 2 volts / 120 mils = 0.0166 v/mil  
Noise = .02 v-p-p. Spatial Jitter = .02/0.0166 = 1.2 mils p-p ( ± 0.6 mils)

