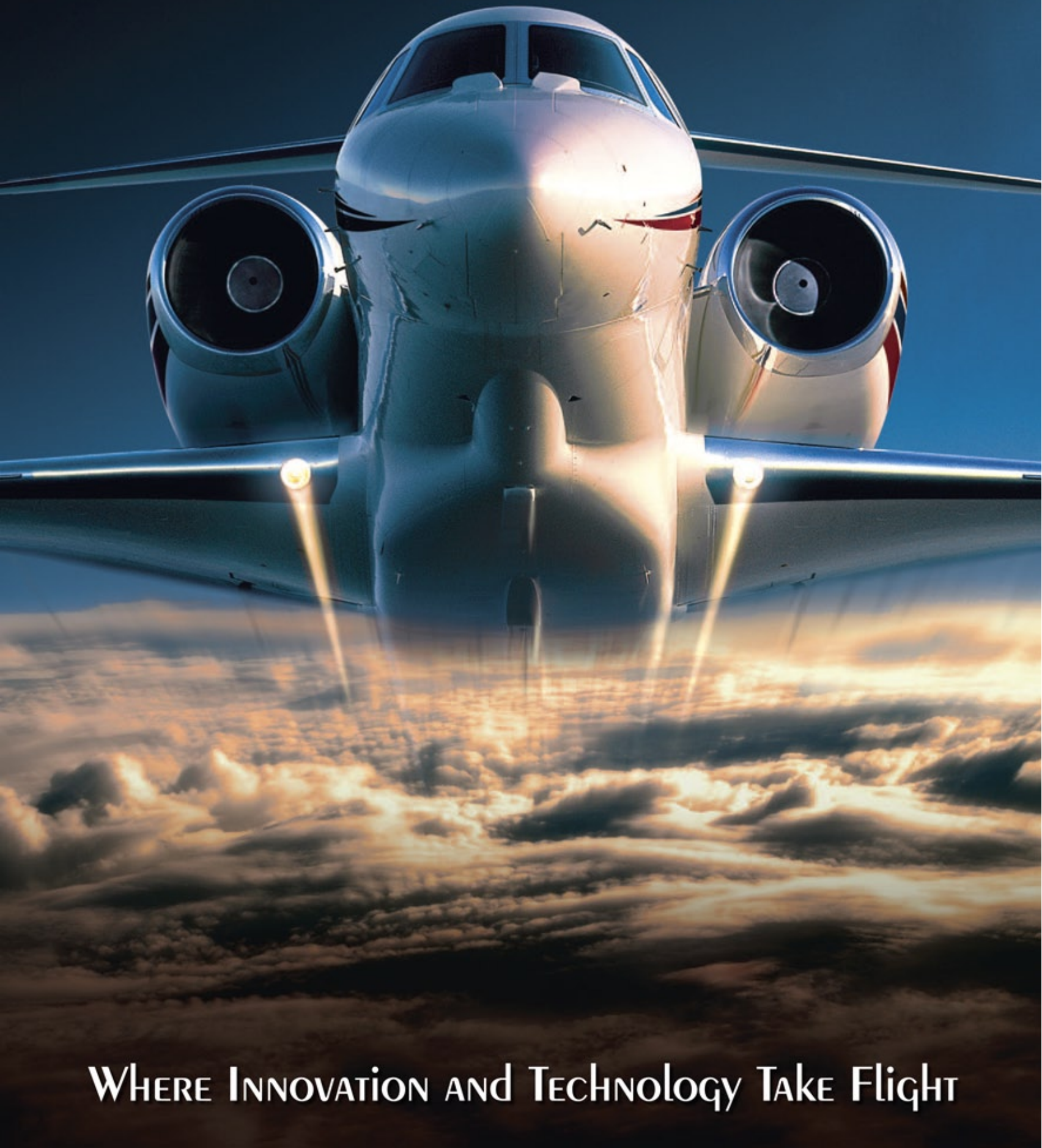
kulite®

Aircraft Pressure Transducers

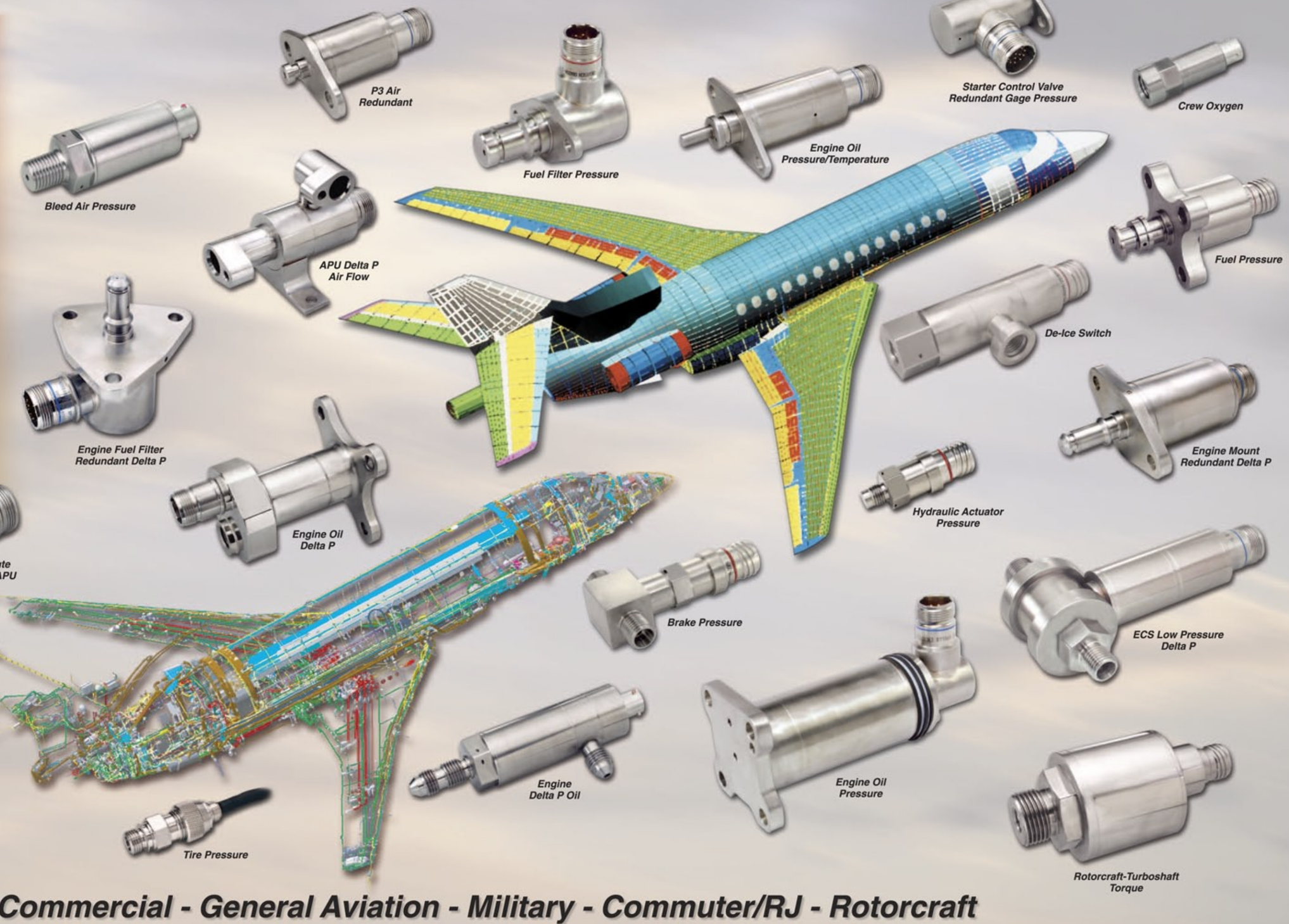


Where Innovation and Technology Take Flight

Advanced Technology For Advanced Performance

KULITE AIRCRAFT TRANSDUCERS FEATURES

- Solid State Silicon Technology-No Moving Parts
- Operational Modes; Gage, Sealed Gage, Absolute & Differential
- Isolated Sensor Eliminates Any Risk of Contamination
- Mature Technology Over 50 Years Experience
- Custom Designed For The Application With A Unique Part Number
- Pressure Ranges From 1 psi Up To 20,000 psi
- Low Level Output Model Series APT-1000 Has 10VDC Input and 100mV FS Output
- High Level Output Model Series APTE-1000 Has 28VDC Input and Voltage Output Or Current Draw Signal
- Live Zeros Available For All Aircraft Transducer Models
- EMI Protection and Secondary Containment
- Multiple Choice of Inlet Ports and Connectors
- TSO C47 & C45 FAA Certified Hardware



Commercial - General Aviation - Military - Commuter/RJ - Rotorcraft

Illustration Courtesy Dassault/Falcon

This drawing is for illustration purposes only and indicates areas where Kulite Transducers have been installed on an aircraft.

Kulite Transducer Applications

AUXILIARY POWER UNIT (APU)
Bleed Air Pressure
Air Inlet Pressure
Main Oil Pressure
P3 Air Pressure
P1 Total Air Pressure
Exhaust Air Pressure
Fuel Filter Delta P Pressure

HYDRAULIC PRESSURE TRANSDUCERS HIGH PRESSURE SEALED GAGE & ABSOLUTE
Actuator Pressure
Accumulator Pressure
Brake Pressure (FDR)
Brake Pressure Anti-Skid
Flap Pressure
Flight Controls Pressure Monitoring
Hydraulic Filters Delta P
Hydraulic Pressure Switch
Hydraulic Pump Pressure
Hydraulic Reservoir
Rudder Actuation
Spoiler Actuation
Landing Gear Pressure
Oleo Pressure & Temperature

PROPULSION / ENGINE
Differential Oil Pressure
Engine Oil, Absolute Pressure
Engine Oil, Gage Pressure
Engine Torque Pressure, Gage
Fuel Filter Pressure
Fuel Pump Pressure
Oil Filter Differential Pressure
Oil Temperature & Pressure
P1 Total Air Pressure, Absolute
P2 Compressor Inlet, Pressure
P2.5 Inlet Pressure, Absolute
P3 Bleed Air Pressure
P3 Compressor Discharge Pressure
Transmission Oil Pressure
Redundant Oil Pressure Delta P
Redundant Fuel Filter Delta P
Starter Air Valve Redundant Pressure

ENVIRONMENTAL CONTROL SYSTEM (ECS)
Air-Conditioning Compressor Discharge Pressure
Air-Conditioning Inlet Pressure Gage & Absolute
Air Duct Differential Pressure
Air Filter Differential Pressure
Cabin Air Pressure Gage & Absolute
De-Ice Hot Air Pressure Switch
De-Ice System Gage Pressure
Oxygen Quantity Pressure Measurement
Oxygen Regulator Pressure
Oxygen, Crew Cabin Pressure
Pneumatic Gage & Absolute Pressure
Potable Water Gage Pressure
Potable Water Level Measurement
Vapor Cooling System Pressure

COMBINATION / DUPLEX
Oil Pressure & Temperature (RTD)
Oil & Fuel Gage Pressure
Oil Pressure & Redundant Pressure
Oil Filter Delta P With Redundant Temperature
Redundant Absolute Oil Pressure
Redundant P3 Air Pressure
Combined Absolute With High Pressure Switch
Oxygen Pressure & Temperature

MISCELLANEOUS PRESSURE TRANSDUCER APPLICATIONS
Tension-Compression Load Cells For Flight Controls
3 Wire Electronic Pressure Switches
Quadruple Duplex Pressure Measurements
TPS Tire Pressure System Transducers
P3 Air Flow Differential Pressure
Oxygen Quantity Measurement
Nitrogen Quantity Measurement
Delta P Low Pressure Filter Pressure
Pitot-Static Air Pressure
Barometric For UAV

ELECTRONIC (3W) PRESSURE SWITCHES
Low Oil Pressure Delta P Switch
De-Ice Hot Air Pressure Switch
Fuel Pressure Switch
Hydraulic Pressure Switch
Bleed Air Pressure Switch
Thrust Reverser Pressure Switch

Kulite Aircraft Pressure Transducers
Product reliability in the most severe aircraft environment

*Kulite Semiconductor Products, Inc. is recognized worldwide as The Leader in **Pressure Transducers**, **Sensors and Transmitters** supporting almost every major aircraft program. The unique piezoresistive sensor coupled with the lightweight package concept is the ideal product of choice for the aircraft engineer looking to reduce weight, increase reliability and fulfill the need for higher accuracy while meeting cost objectives.*

Kulite silicon sensor advantages in aircraft applications:
- *High frequency response*
- *Excellent long term stability*
- *Media compatibility*
- *Negligible non-linearity and hysteresis*
- *Custom accuracy < 0.1%*
- *Ruggedized to application*
- *Excellent repeatability*
- *High temperature capability +800°F (427°C)*
- *Digital and/or analog output*

Kulite transducer technology has demonstrated for over 50 years that it is a superior product necessary to meet the stringent requirements for aircraft pressure measurement applications.

Aircraft Pressure Transducers
Military Applications

Main Fuel Throttle
Dual Pressure

Lift Fan
Pressure
Pressure/Temperature
Temperature

Turbo Machine
Triple Pressure
Single Pressure

Hydraulic System
Filter Pressure
Bootstrap Pressure

Fuel Filter
Delta Pressure

Bomb Release
Pressure/Temperature

Electrohydrostatic Actuators
Pressure
Pressure/Temperature

Engine Mount
Dual Pressure,
Dual Temperature
Quadruple Pressure
Fuel Dual Delta Pressure
Oil Dual Delta Pressure
Triple Differential Pressure,
Dual Absolute Pressure

Lift Fan Servo Control Module
Triple Pressure

Small - Lightweight - Reliable

Photography Courtesy Lockheed Martin

Flexible - Responsive - Reliable
Special Products

Kulite engineering is quick to respond to "Special Needs" of adapting silicon technology and custom electronics packaging to meet increasing needs for higher reliability and better performance. The following are only a few examples that illustrate the versatility of the Kulite Product for ***Pressure*** *-* ***Load*** *or* ***Mass*** *measurements in an aircraft environment. Our custom engineered product has led to Kulite's position as the Industry Leader.*

Please consult your nearest Kulite Sales Office for your particular application. Data sheets for all products shown are available at our web site: www.kulite.com

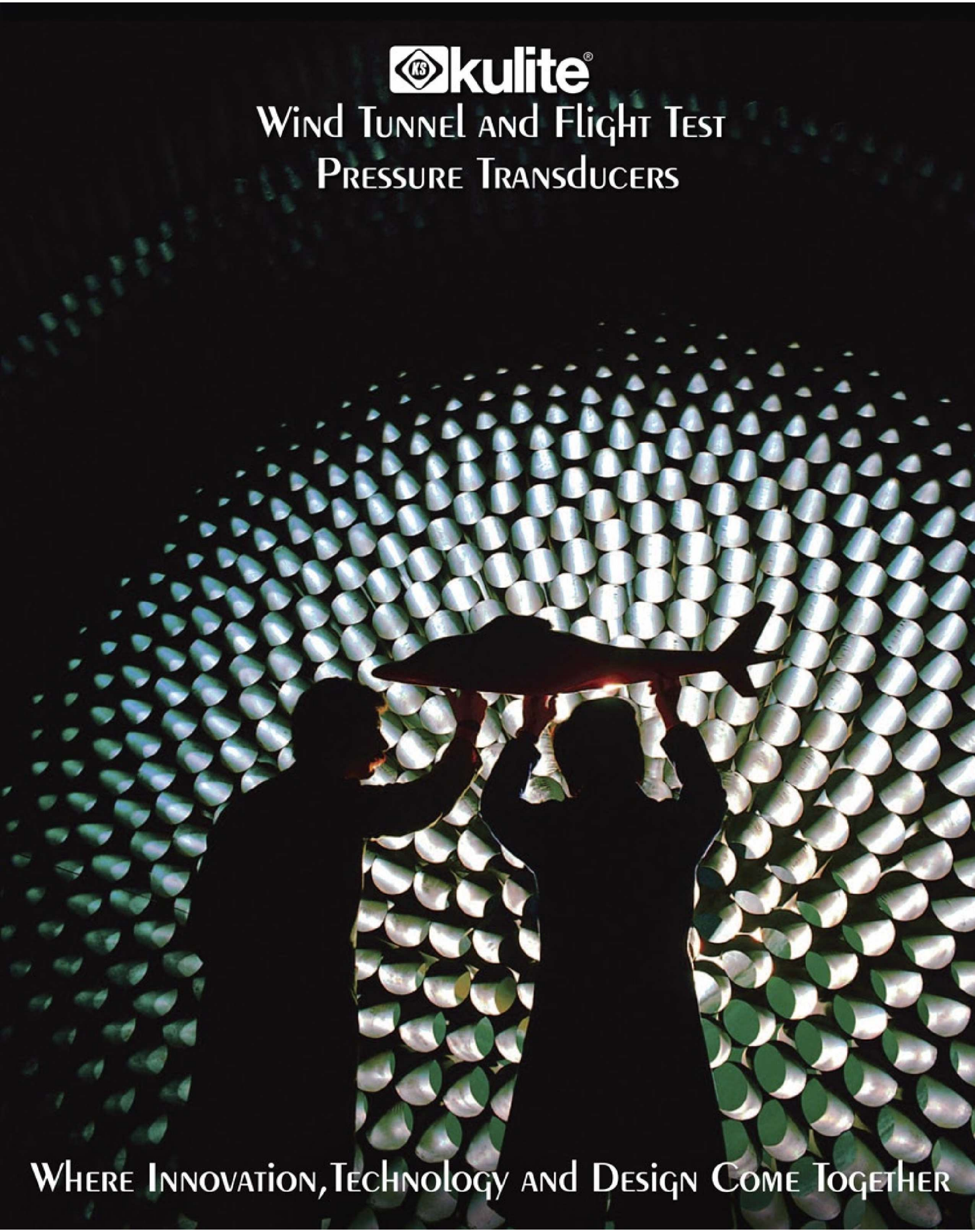
Kulite holds 3rd party approval for AS9100 and ISO9001 as well as SIRA and CSA certifications. Kulite is an approved FAA/EASA/CAAC repair station. Please visit our web site for details.

KULITE SEMICONDUCTOR PRODUCTS, INC.
One Willow Tree Road • Leonia, New Jersey 07605 USA • Tel: 201 461-0900 • Fax: 201 461-0990 • Email: info-kulite@kulite.com • http://www.kulite.com

Photography Courtesy Bell Helicopter, Front Cover Courtesy Cessna

kulite®

Wind Tunnel and Flight Test Pressure Transducers



Where Innovation, Technology and Design Come Together

World's Smallest Transducers For Wind Tunnel Testing and the Flight Test Engineer

LQ-062 / LL-072 / LQ-125 / LL-250
FLAT PACK SERIES
- World's Smallest
- Patented Leadless Technology
- Surface Mount for Blades/Vanes with High "G" Level
- For Dynamic and Static Measurements
- Pressure Survey on Blades, Structures and Acoustic Pressure Measurement

XCL/XCEL-072 SERIES
- Patented Leadless Technology
- Probe Type Pressure Transducer
- For Dynamic and Static Measurements
- Inlet Pressure Measurement
- Front and Back of Compressor Measurement
- Burner Pressure Measurement

Amplified and Microprocessor Corrected Flatpacks
- 5 VDC Output
- Nozzle and Fuselage Applications
- Moisture Protected

XCQ-062
- World's Smallest
- Ideal For Wind Tunnel Applications
- Excellent Static and Dynamic Performance
- Rugged
- .066" Diameter
- Available in All Standard Pressure Ranges

Inline Amplifiers
- 5, 10 VDC
- 4-20mA
- Microprocessor Corrected
- Digital Output

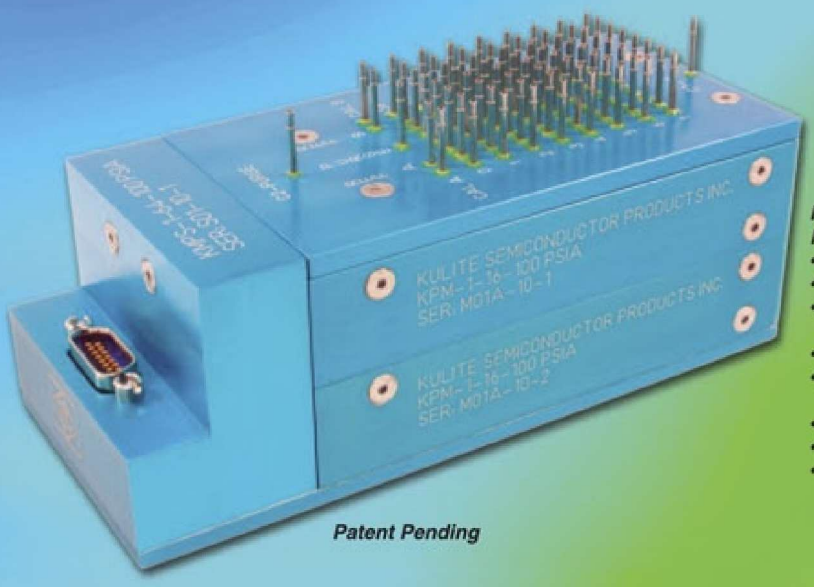
XTL/XTEL-140 SERIES
- World's Smallest
- Patented Leadless Technology
- Threaded Pressure Transducer
- For Dynamic and Static Measurements
- Wide Compensated Temperature Range -40°F to +450°F (-40°C to +232°C)
- Miniature Probes and Multi-Pressure Rakes

XTEH-7L-190 SERIES
- Patented Leadless Technology
- High Natural Frequency
- Suitable For Stall Avoidance Application
- -65°F to +750°F (-55°C to +400°C) Temperature Capability

Flow Angle Probe
FAP-250
FAP-HT-250

- High Frequency
- Patented Ultra Miniature Rugged Design
- Temperature to 525°F (273°C) HT Series
- Ideal For Aero Propulsion Measurements and Complex Flow Structures

Pressure and Temperature
Temperature Only Transducers
- World's Smallest Pressure and Temperature Sensor at 6mm
- Combined Pressure and Temperature Capability
- Patented Leadless Technology



Pressure Scanner
KMPS-1-64
- High Accuracy Digital Compensation
- Multiplexed Analog Output
- High Speed Digital Output (RS-485 or Ethernet)
- No Heating or Cooling Needed
- Wide Temperature Range -65°F to +250°F (-55°C to +120°C)
- Auto Zero
- Integral Purge
- Plug and Play Modules

Patent Pending

Kulite Miniature Pressure Transducers for Flight Test and Wind Tunnel Testing

Kulite is the first name in pressure transducers for the flight test and wind tunnel engineer. Kulite has been serving the wind tunnel and flight test community for over 50 years.

Kulite state of the art pressure transducers are ideal for the flight test environment. The core technology is a patented piezoresistive silicon-on-insulator miniature sensing element. These transducers have found wide acceptance in aerospace applications, for wind tunnel, flight test and acoustic measurements with decades of use on many important flight test programs. Kulite has established the industry standard of excellence for dynamic pressure measurement. The extremely small size of these devices have made them uniquely suited to a large variety of test and production applications in industry and research and development.

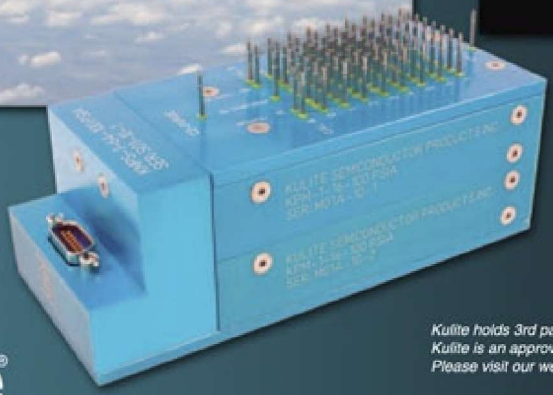
Kulite offers custom outputs such as 5 or 10 volts, 4-20ma. Digital outputs such as RS-485, Ethernet, wireless and Canbus. High accuracy microprocessor corrected transducers are also available.

Kulite recognizes that the needs of the test community are unique. Kulite has available a product support team of engineers experienced in this field ready to work with you to provide the proper instrument for a given application. Kulite stands ready to offer in depth technical assistance and rapid turnaround times when required.

Kulite Silicon Sensor Advantages:

- ***High frequency response***
- ***Excellent long term stability***
- ***Negligible non-linearity and hysteresis***
- ***Excellent repeatability***
- ***Custom accuracy <0.1%***
- ***Ruggedized to application***
- ***High temperature capability +1000°F (538°C)***
- ***Static/dynamic outputs***

Kulite Wind Tunnel and Flight Test Pressure Transducers For Extreme Environments



Kulite holds 3rd party approval for AS9100 and ISO9001 as well as SIRA and CSA certifications.
Kulite is an approved FAA/EASA/CAAC repair station.
Please visit our web site for details.

kulite®

KULITE SEMICONDUCTOR PRODUCTS, INC.
One Willow Tree Road • Leonia, New Jersey 07605 USA • Tel: 201 461-0900 • Fax: 201 461-0990 • Email: info-kulite@kulite.com • http://www.kulite.com

World Headquarters, Leonia, NJ

Building Two, Leonia, NJ

Building Three, Leonia, NJ

This bulletin describes the capabilities of Kulite and the wide range of Solid State Pressure Transducers used in numerous aircraft applications that require high performance and reliability.

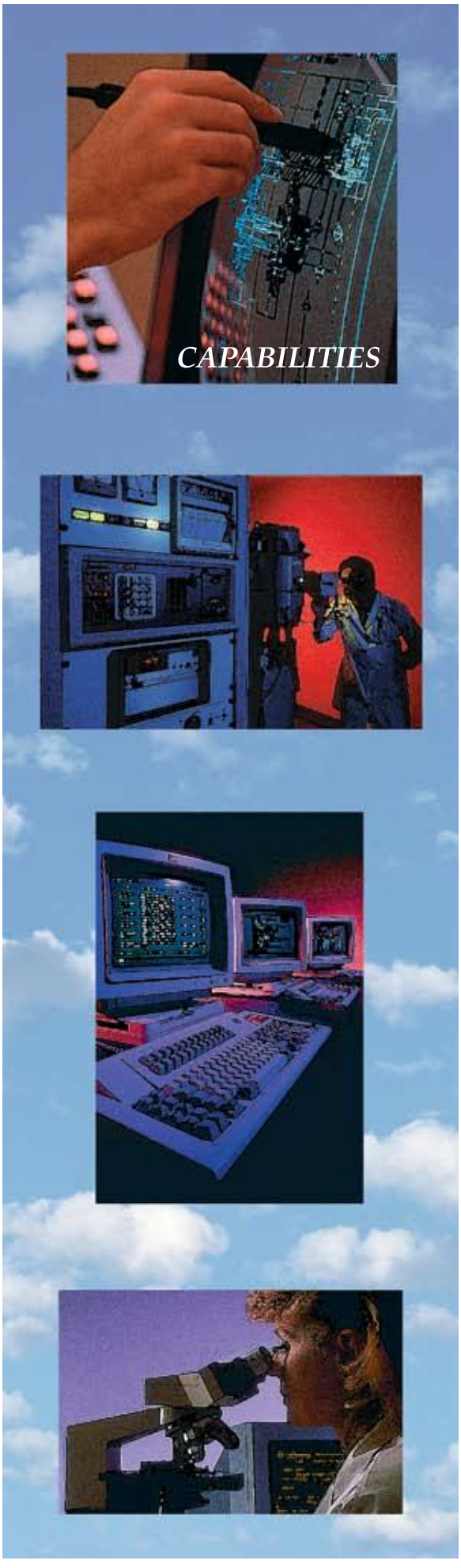
All Kulite Aircraft Transducers have evolved from over four decades of having pioneered the development of miniature static and dynamic pressure measurement devices. This technology has long been accepted in the aerospace community as the "State of the Art".

The pressure sensor portion of the device utilizes Piezoresistive Technology consisting of a silicon on silicon sensor diaphragm with a fully active four-arm Wheatstone Bridge. The high natural frequency, low hysteresis and superior thermal characteristics enable outstanding pressure measurement performance in any aircraft environment.

Kulite recognizes the severe demands of an aircraft environment which require ruggedized packaging. The Kulite design approach offers small size, light weight and all-welded construction which provides a hermetic product and a protective barrier for the sensor.

For many years Kulite has worked closely with airframe engineers to continually improve design and performance. This interface has resulted in many different applications some of which are identified in this bulletin. All Kulite Aircraft Transducers are designed for each application. Transducer documentation includes a Design Package, Qualification, FAA Approval, Acceptance Test Data and rigid Quality Control.

Since 1960 Kulite has focused on producing the industry's most accurate and reliable pressure measurement instrumentation. Kulite continues to expand this technology and welcomes the challenge to meet new requirements for the future.



Facilities
Kulite is located in Leonia, New Jersey, convenient to major suppliers and transportation. Design, development, test, manufacture and administration are located in three modern buildings comprising over 100,000 square feet.

Transducer Design Engineering
The Engineering Department uses AutoCAD™ with EDI capability for mechanical design while circuit design is done using schematic capture software, capable of electronic modeling, simulating and analyzing circuits. This shortens development cycle time.

Development Engineering
Kulite's environmental laboratory provides necessary testing to Customer and Military specifications. Thermal cycling from minus 100°F to plus 400°F, Random and Sinusoidal Vibration, computer controlled, can be achieved from 20 to 2000 Hz 60 G rms and 10 to 350 Hz 80 G peak respectively. The laboratory has equipment for Impulse, Shock, Humidity and Altitude testing.

Semiconductor Engineering
Design, development and production of silicon sensors, the heart of any pressure transducer, is done using modern Diffusion Furnaces, Evaporators and Sputtering equipment. Material characteristics are controlled by using Statistical Process Control. Kulite is vertically integrated, maintaining complete control of its semiconductor technology to ensure production schedules are met.

Transducer Manufacturing
Manufacturing uses computerized assembly and in-process inspection techniques to Aerospace recommended practices, Customer and Military Specifications. Travelers and build instruction sheets are created for each design in order to insure correct assembly and to control configuration. Acceptance testing and Environmental Stress Screening (ESS) of the final product is done using modern computerized methods with complete traceability. Laser, electron beam and TIG welding processes are employed. Kulite has manufacturing capability to produce in excess of 10,000 pressure transducers per month.

Quality Assurance
Kulite is accredited to ISO9000:2000 and SAE AS9100 as supplemented or superseded by Customer requirements. The Department has resident FAA DMIRs and customer designated DSQRs. The Company has an FAA/EASA certified Repair Station.

Product Support
Kulite supports the various repair, warranty and contract commitments required for its Aerospace products at the Leonia facility. The Department works to ATA and FAA standards for Service Bulletins, Component Maintenance Manuals and PMA. Kulite's sales engineers are available for customer on-site field support worldwide. AOG service is available.

The Kulite Integrated Sensor Pressure Transducer

Piezoresistive silicon pressure transducers use the minute flexure characteristics of single-crystal silicon wafers, suitably doped for semiconduction, to effect a voltage output proportional to pressure sensed on the face of the silicon sensor. The pressure sensitivity of the device is enhanced by micro-machining the chip to a thickness appropriate to the pressure range.

Using photolithography and integrated circuit manufacturing techniques Kulite designs and manufactures an extremely small pressure sensing device with high natural frequency, low hysteresis, superior thermal characteristics and high accuracy under the extreme conditions of temperature and vibration found in all aerospace applications.

Dielectrically Isolated Silicon on Silicon Sensor Technology

Kulite's latest silicon technology consists of a monolithic structure composed of an atomically fused, dielectrically isolated Wheatstone bridge integrated circuit, fused onto a silicon substrate which acts as a force-summing diaphragm.

It is known as dielectrically isolated "silicon-on-silicon" and exhibits excellent stability and thermal characteristics, allowing Kulite transducers to operate at temperatures up to 900°F.

This sensor is an evolution from the "first generation" diffused semiconductor technology. It uses two silicon wafers bonded to but separated by a silicon oxide barrier. One wafer is chemically etched to make the Wheatstone bridge integrated circuit, the other is micro-machined to provide the force collector, which translates the applied pressure into strain on the integrated circuit.

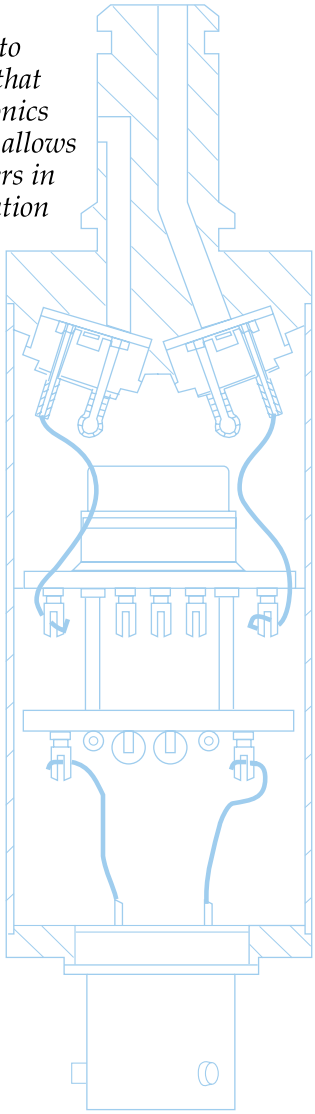
Benefits of Using Kulite's Silicon-on-Silicon Pressure Transducer Technology:

- *Piezoresistive sensors are monolithic devices which increases their reliability.*
- *A high sensitivity of silicon sensors means high sensor output, typically 100 mV.*
- *A single crystal silicon structure makes the sensor inherently free of hysteresis.*
- *The single crystal structure and packaging yields typically less than 0.1% drift per year of operation, affording long term stability.*
- *Sensed media temperature can be as high as 900°F.*
- *The sensing element is fabricated to provide a small force collector. Size and weight of the finished transducer can be minimized.*
- *Dielectric isolation of the sensing element means the sensor will have high dielectric strength.*
- *No P-N junctions means the sensor is not susceptible to electro magnetic interference, and has very low noise levels at elevated temperatures.*

Electronic Signal Conditioning and Mechanical Design

Kulite can adapt the output of the pressure sensor to interface with virtually any ECU, FADEC, EICAS or any other control or monitoring device. A voltage, current, frequency or digital output can be provided by Kulite's Electronic Design Group. The company maintains a capability to design and produce microcircuitry ASIC based designs, as well as discrete component designs, including surface mount devices, to temperature above 300°F.

Also, the Company's ability to design mechanical packages that provide the solid state electronics in a stress free environment, allows customers to place transducers in severe temperature and vibration environments.



Retrofit Capability

Kulite maintains a unique ability to provide transducer designs that will perform as a fit, form and function replacement for existing older transducer technologies, thus affording the customer better reliability, performance, stability and lighter weight.

Typical Aircraft Transducer Applications

Engine Oil Pressure
Hydraulic Pressure
Fuel Pressure
Air Pressure
- *Cabin Air*
- *Crew Air*
- *Altitude*
- *Tire Pressure*

Environmental Control System (ECS)
Rudder Boost
Engine Torque
Oxygen
Bleed Air
Turbo Discharge
Heat Exchanger (Cooler)
Reaction Control System (RCS)
Compressor Inlet & Discharge (P2) (P0) (P3)
Gear Box Oil Pressure
Brake Pressure
Vapor Control System
De-Ice System
Actuators

Aircraft Instrumentation

Flight Test
Structural Verification
Fatigue Testing
Test Rigs
Test Cells
Iron Bird
Wind Tunnel

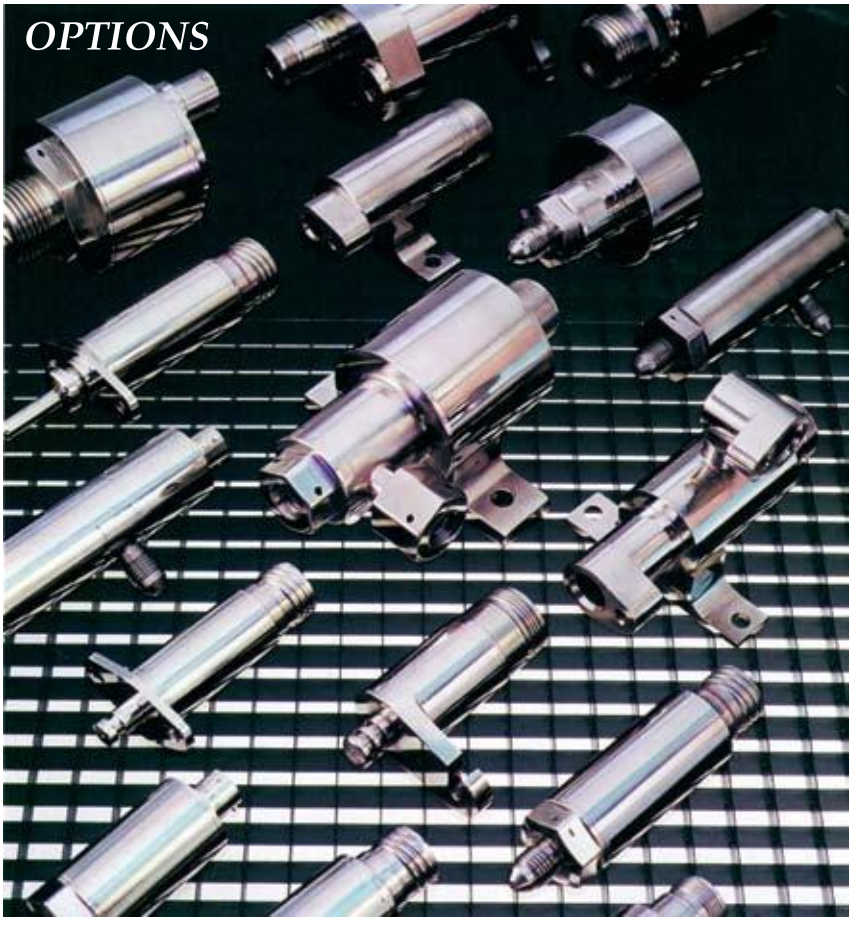
DESIGN FEATURES

Design Features of Kulite Aircraft Transducers

Mature Sensor Technology	*40 Years of Experience*
Environmentally Isolated Diaphragm	*Eliminates Risk of Sensor Contamination*
Micromachined Overpressure Stops	*Protects Unit From High Overpressure*
Ultra Low Non Linearity and Hysteresis	*Increased Accuracy*
Media Compatible Materials	*To Best Fit the Application - Such as 316 & 17.4 SS, Inconel, Titanium*
Secondary Containment	*Mechanical Safety Feature*
ASIC Electronics (APTE Series)	*Small, Lightweight, Reliable*
EMI Protection (Moderate or Heavy)	*Increased Reliability*
Live Zero	*Indicates System Readiness*
Environmentally Protected Dual Diaphragms	*Patented Feature for Hermetically Sealed Vented PSIG/Gage Transducer*
Light Weight	*Most Designs Less Than .5 LB*
Hermetically Sealed	*Environmental Protection*

Options

Multiple Choice Connectors	*Redundancy (Dual or Triple)*
Unique Configurations	*Multiple Choice Pressure Ports*
Flange Mount	*Combined Pressure and Temperature*
Drainage Design	*Voltage and Current Outputs*
Electronic Pressure Switch	*Ruggedized/Foamed (For High g Environments)*



OPERATIONAL MODES

Operational Modes

All Kulite Pressure Transducers are designed and produced for a variety of aircraft applications. The operational mode of the transducer can be any one of the following:

Absolute Pressures (PSIA)

Sealed sensor unit which measures pressure relative to an internally sealed vacuum. Typical applications are P_0, P_3 in aircraft engine applications. Also sometimes used for high pressure such as hydraulic, brake and oxygen pressures.

Gage Pressures (PSIG)

The pressure is measured relative to ambient pressure such as oil pressure. Kulite uses a patented dual diaphragm (dual sensor) approach consisting of a first sensor to measure the primary pressure and a secondary sensor to measure the ambient pressure. The outputs are subtracted to give a true gage pressure reading. This approach yields a hermetically sealed vented gage pressure transducer. Typical applications are engine oil, gear box oil and fuel pressures.

Sealed Gage Pressures (PSISG)

The pressure sensor is sealed at zero at atmosphere pressure. Mostly used in higher pressure applications such as hydraulic pressures.

Differential Pressures (PSID)

The transducer measures the difference between two pressure sources connected to two inlet ports. Differential transducers are used in certain pressure applications such as across filters, etc.

TYPICAL SPECIFICATIONS

TYPES OF ELECTRICAL OUTPUT	LEVEL AND EXCITATION
Unamplified	0-100 mV with 10 Volt excitation, variations possible per customer specifications
Amplified (current loop)	4-20 mA
Amplified (voltage output)	0-5 VDC or with off-set voltage (.5 to 5.5 VDC) with 15 to 33 VDC excitation or 26-28 VAC, variations possible per customer specifications
28 VDC	Synchronous and Variable Reluctance AC
Impedances (unamplified)	>1000 ohm input, <2000 ohm output, nominal on unamplified units, common mode available

TRANSDUCER ACCURACY	PERCENT OF FULL SCALE
Total Error Band	< .5% to 2% nominal over compensated temperature ranges standard. Variations possible per customer specifications
Long Term Stability	< 0.1% per year

OPERATING ENVIRONMENTS	PARAMETERS
Temperatures (sensed and ambient)	-65°F to +450°F (-55°C to +232°C) Higher and lower ambient and sensed media temperatures available per customer specification.
Pressure Ranges	Up to 20,000 PSI standard, higher per customer specification
Compatibility with Sensed Media	All types of Aerospace Fluids and Gases
EMI/C, Salt Spray, Humidity, Sand and Dust, CBN, Vibration	Designed to comply with all Mil-Std and Aerospace relevant harsh environments

Continuous development and refinement of our products may result in specification changes without notice.

Customer • Program

Over the years, Kulite has collaborated with numerous Aircraft Manufacturers to develop and perfect pressure transducers for new airborne applications. Many of these applications were required to provide interface with modern avionics, glass cockpits, FADEC and Systems Management. The following is a partial listing of Kulite major aircraft activity . . .

Abex/NWL • Global Express, Dash 8-400 *Aerospatiale • Dolphin, A330, A340*

Agusta • 109, 209 *Airbus Industries • A-300, A-340* *Aircraft Braking Systems • Dash 8-400*

Alenia • ATR-42 *Allied Signal Canada • MD 11, F-22, V-22, C-17* *Allied Signal AES • X33*

Allied Signal Engines • 737, 757, 777 *Allison Engines • 2100, 3007, T-406, T-56, 250*

Basler Turbo Conversions • DC-3 *Bell/Boeing • V-22* *Bell Helicopter • 206, 222, 407, 412, 427, 430*

Benz Airborne Systems • UH-1N *Boeing Commercial • 737, 747, 757, 767, 777* *Boeing Military • E3A*

Boeing Aircraft & Missile Systems Division • F-18, ATF, EV8B, C-17, AH-64, MDX Explorer

Boeing Douglas Aircraft • MD-11, MD-80 *Bombardier/Canadair • Challenger, RJ, GX, CL215*

Bombardier/deHavilland • Dash 8, Dash 8-400 *Bombardier Learjet • Model 45, Model 60*

Bombardier/Shorts Bros • Model 45, Model 60 *British Aerospace • Jetstream 31 & 41, 146-300*

CASA • C101, CN235 *Cessna • Citation X, 525, 545, 555, 565* *Crane Hydro-Aire • Global Express, EMB-145*

Commander Aircraft • Commander 114 *Dornier • DO-228, DO-328, 128G* *Dowty Yakima • Premier 1*

Embraer • EMB-120, EMB-145 *Enstrom Helicopter • TH-28, 480* *Eurocopter • TIGER, BK-117*

Fairchild Aircraft • Metro *Fairchild Controls • APACHE Longbow* *Fokker Aircraft • F-50, F-70, F-100*

GE Aircraft Engines • GE90, 404, CF34-8C *Gulfstream Aerospace • G IV, G V* *Gull Airborne Division • S-76*

Hamilton Standard Division • B-777, B747, F18, Dash 8-4 *Israel Aircraft Industries • Galaxy, Westwind 1125*

IPTN Industries • CN 235, CN 250 *Kawasaki Heavy Industries • BK-117, MDX, OHX* *LET • L610* *Lockheed Martin • F-22, CF-34* *Lycoming • P3C* *Mitsubishi • MH-2000, FSX* *Mooney Aircraft • TLS BRAVO* *Northrop-Grumman • AWACS, F-18E/F* *Panavia • Tornado*

Parker-Hannifin • V-22, F-22 *Piaggio • P-166, P-180* *Pilatus • PC7, PC9, BN28*

Piper Aircraft • Malibu, Cheyenne II *Pratt & Whitney Canada • P150, P360, P901* *Pratt & Whitney • F-119*

Raytheon Aircraft • King Air, 1900, 400A, T1-A, JPATS *Raytheon E-Systems • Premier 1*

Rolls Royce • Pegasus, Adour *Saab Aircraft • S-340, S-2000* *Samsung/Daewoo • KTX-1*

Scott Aviation • Model 45, Model 60 *Shorts Brothers • 300, 360, RJ, Model 45* *Siai-Marchetti • S-211*

Sikorsky • S76, S-92 *Sino Swearingen • SJ-30* *Sundstrand • A-320, 737, B-2, F-22*

Turbomeca • 737, A320, KC-135, Arriel 2 *Valment • L-80 TP* *Westland • WG-30, Lynx 3*

Williams International • Commanche

Kulite thanks the following companies for use of their photographs in the production of this brochure: Bell/Boeing, Bell Helicopter and Cessna.