

JUNE 2016



**Sensata**  
Technologies

# SENSATA AEROSPACE GROUP

STAY IN THE AIR WITH SENSATA SENSORS AND CONTROLS

## SENSATA OVERVIEW



**AIRPAX**

**BEIKIMCO**

**BEI SENSORS**

**crydom**

**DeltaTech**  
CONTROLS

**KAVIAR**

**KLIXON**

**MAGNUM**  
DIMENSIONS

**NEWALL**

**Liney**

**SCHRADER**

**SENSOR**  
NITE

## Where are Sensata devices?

**1,500** in commercial jets    CIRCUIT BREAKERS, SWITCHES

**60** in RVs and large boats    CIRCUIT BREAKERS, SWITCHES

**50** in automobiles    SENSORS, CONTROLS

**50** in agriculture / construction vehicles    SENSORS, SWITCHES, CIRCUIT BREAKERS

**dozens** in large HVAC systems    SENSORS, SWITCHES

**30** in U.S. homes    SENSORS, SWITCHES, SAFETY DEVICES



# Where are Sensata devices?

In mission–critical aircraft systems

## Navigation

- ✓ Communication / Navigation / ID
- ✓ Airborne Flight Info
- ✓ Voice / Flight Data Recorders
- ✓ Traffic Alert / Collision Avoidance
- ✓ Enhanced Ground Proximity Warning
- ✓ Communication Address, Reporting
- ✓ Flight Management
- ✓ Displays (Flat, HUD)
- ✓ Weather Detection Radar
- ✓ Air Data Sensors
- ✓ SATCOM Antennae

## Engine

- ✓ Alternators, Generators
- ✓ Engine Control / Starters
- ✓ Nacelle Subsystem
- ✓ Oil / Air / Fuel Coolers
- ✓ Thrust Reversers
- ✓ Hydraulic Motors
- ✓ Power Transfer Unit
- ✓ Anti–drive Unit
- ✓ Auxiliary Power Unit (APU), Controls / Start

## Cabin

- ✓ Cabin Pressure / Temp. Control
- ✓ Air Cycle Machine
- ✓ Environmental Control
- ✓ Smoke Detection
- ✓ Window Heat Control

## Other

- ✓ HF Radio
- ✓ Microwave Landing
- ✓ Ice Detection / Control
- ✓ External Lighting
- ✓ Hydraulic Pumps / Power / Etc.
- ✓ Wheels, Brakes, Anti–skid, Landing Gear
- ✓ Emergency Power Turbine
- ✓ Integrated Pneumatic System (Valves, Heat, Water, Lighting)



UP TO  
**1,500**

CIRCUIT BREAKERS &  
SWITCHES PER JET



**Sensata**  
Technologies

# SENSATA AEROSPACE



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**KLIXON**

**KAYLEO**

**BEIKIMCO**

**BEISENSORS**

## Applications

### Sensata Space Heritage



**Advanced Extremely High Frequency (AEHF)**  
Military Com Satellite  
Northrop Grumman  
M1 Thermostat



**James Webb Space Telescope (JWST)**  
Space Exploration  
Northrop Grumman  
M1 Thermostat



**Hubble Space Telescope**  
Space Exploration  
Lockheed Martin  
M2 Thermostat



**Defense Meteorological Space Program (DMSP)**  
Military Weather Satellite  
Lockheed Martin  
M2 Thermostat



**GPS III**  
Global Positioning  
Lockheed Martin  
M2 Thermostat



**JCSAT-9 / JCSAT-10**  
Japan / Asia Telecom  
Lockheed Martin  
M2 Thermostat



**Atlas V Rocket**  
Payload Launcher  
United Launch Alliance  
M1 Thermostat



**GOES-R**  
NOAA Weather  
Lockheed Martin  
M2 Thermostat

## Sensata Thermostat Space-flight Heritage – below is a partial list of the programs which have used our thermostats

Sensata Thermostat Series	Program	Application	Launch Date
11041 / M1	RESTORE-L	Survival Heaters	2020
11041 / M1	James Webb Space Telescope	Survival Heaters	2019
11041 / M1	Advanced Extremely High Frequency	Survival Heaters	2013
11041 / M1	Multiple Classified Satellites	Survival Heaters	n/a
11041 / M1	Atlas V Launch Vehicle	Self-Destruct Battery Heater	2008
11041 / M1	LCROSS Satellite	Survival Heaters	2008
11041 / M1	DAWN satellite	Survival Heaters	2006
11041 / M1	Delta II Launch Vehicle	Self-Destruct Battery Heater	1989
11041 / M1	Space Shuttle	Equipment Bay Temp Control	1981
11041 / M1	GPS Block I	Survival Heaters (261 thermostats per satellite)	1978 thru 1985
11041 / M1	Apollo Service Module	Survival Heaters	Entire program
M2	Defense Meteorological Space Program (DMSP)	Survival Heaters	1997-2003
M2	GPS III	Survival Heaters	2018
M2	Hubble Space Telescope	Survival heaters on replacement batteries	2008
M2	JCSAT-9 & JCSAT-10	Antenna Hinge Dampener Heaters	2006
M2	Clementine Lunar Orbiter	Survival Heaters	1994
M2	Multiple Classified Satellites	Survival Heaters	n/a
3BT	EXOMars Mission (ESA)	FREND (Fine Resolution Epithermal Neutron Detector), located on Trace Gas Orbiter (TGO)	2016
3BT	RESTORE-L	Survival Heaters	2020
4BT	Joint Polar Satellite System	(Ozone Mapping Profiler Suite)	2017
4BT	Solar Dynamics Observatory	Survival Heaters	
4BT	Gamma Ray Large Area Space Telescope (GLAST)	Survival Heaters	2008



# Sensata Sensing and Controls Portfolio

- Circuit Protection  
Aircraft Circuit Breakers



- Thermostats  
(Hermetic)



- Switches  
(Hermetic)



- Linear Variable Differential Transformers (LVDT), Rotary Variable Differential Transformers (RVDT), Force Sensors & Cockpit Controls



- Pressure Sensing



- Pots & Encoders / Motors & Actuators



# Pressure Sensing Technologies

Technology	Pressure Range	Pressure Reference	Analog Output	Seal	Thermal Capability
Ceramic Capacitive	5-1,000 psi	Gauge, Absolute, or Differential	Amplified	Elastomeric	-50°C to 150°C
MEMS Capacitive	2 to 20 inH2O	Gauge or Differential	Amplified	Adhesive	-20°C to 85°C
Thin-film Strain Gauge	100-40,000 psi	Gauge	Amplified	Welded CRES	-50°C to 200°C
Board Mount PRT	2 to 20 inH2O	Gauge, Absolute, or Differential	Unamplified or Amplified	Adhesive	-20°C to 85°C
Oil-filled PRT	5-5,000 psi	Gauge, Absolute, or Differential	Unamplified or Amplified	Welded CRES	-50°C to 150°C
Micro-fused Strain Gauge (MSG)	3500 psi - 70,000 psi	Gauge (full scale)	Ratio metric - Amplified only	CRES	-40C to 140C



# Temperature Sensor Overview

Product Name

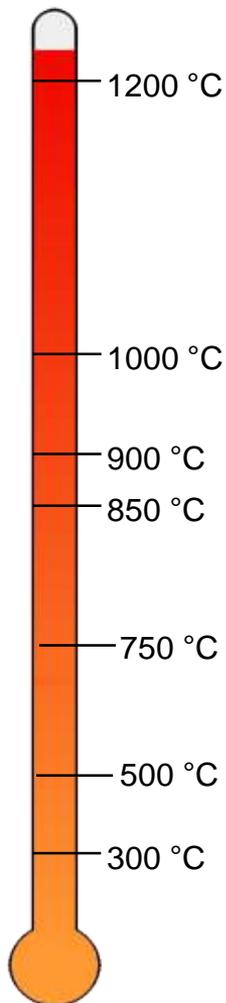
**DTC Thermocouple**

**PTC RTD's**

TS200A  
 TS200 C, D, G  
 DARTS200-Low Cost  
 DARTS200 D

DARTS 200 A

DARTS 500 E  
 M14 M12  
 DARTS 500-B  
 M14 M12



**Working range : -40°C up to 1200°C**

## Digital Thermo Couple

- In House Made TC's
- ASIC with SENT/PWM Output
- High Volume Manufacturing
- SOP CY14
- High Performance Diesel/ Gasoline e.g. Turbo

## Open Pt HTS

- Low Cost Package
- Low Cost PTC Sense Element
- Diesel Turbo Chargers

## Closed Pt HTS

- Improved Capability to 850 C
- Low Cost Package
- Low Cost PTC Sensing Element
- CY14-15
- T4,T5, T6, T7, T8, T9

## Mid Temperature Sensor

- Integrated Connector
- CY12
- EGR Coolers > 250 C



# Position Sensors Product Overview

## KAVLICO™ Linear Variable Differential Transformers (LVDTs)



## KAVLICO™ Rotary Variable Differential Transformers (RVDTs)



## BEI Sensors Rotary Potentiometers



## BEI Sensors Linear Potentiometers



# KAVLICO™ Linear Variable Displacement Transducer (LVDT)

Kavlico LVDTs are the standard for flight and fuel control position measurements. They operate using a non-contacting mutual induction principle, providing friction-free motion and nearly infinite resolution. These LVDTs have been refined and improved for over 50 years, and that is why over 1 million Kavlico LVDTs are installed in aircraft worldwide.

Product Specification	Typical Capability
Range	0.010 in to 20.0 in / (0.254 mm to 508 mm)
Excitation	2 Vrms to 28 Vrms 400 Hz to 10,000 Hz
DC-DC Electronics	Included or Separate (Option)
Linearity	±0.25% F.S.
Accuracy	±0.5% F.S.
Temp. Coefficient	±0.0025% per °F (±0.0045% per °C)
MTBF	1,000,000 hours Min.
Temperature	-80 °F to 500 °F (-62 °C to 260°C)
Redundancy	1, 2, 3 or 4 channels
Environmental	MIL-STD-810 or RTCA-DO-160

## Typical Applications

- Flight control actuators
- Valves
- Landing gear & steering systems
- Cockpit controls
- Engine bleed air systems
- Fuel controls
- Fly-by-wire systems
- Brake-by-wire systems
- Environmental control systems
- Power Turbine Applications



# KAVLICO™ Rotary Variable Displacement Transducer (RVDT)

Kavlico RVDTs are the industry standard for angular and rotary measurements in aviation applications. These lightweight, robust sensors are specially designed for harsh environments, are capable of  $\pm 80^\circ$  angular range in single and multiple channel designs, and with integral gear heads, they are available for applications with higher angular displacements or multiple revolutions.



Product Specification	Typical Capability
Linear Range	$\pm 40^\circ$ (Single Cycle) $\pm 80^\circ$ (Dual Cycle)
Excitation	2 Vrms to 28 Vrms 400 Hz to 10,000 Hz
DC-DC Electronics	Included or Separate (Option)
Accuracy	$\pm 0.25\%$ FS
Temp. Coefficient	0.004% per $^\circ\text{F}$ (0.007% per $^\circ\text{C}$ )
MTBF	1,000,000 hours per channel
Temperature	$-80^\circ\text{F}$ to $350^\circ\text{F}$ ( $-62^\circ\text{C}$ to $177^\circ\text{C}$ )
Redundancy	1, 2, 3 or 4 Channels
Gear Box (option)	Up to 4,000:1 Gear Reduction
Environmental	MIL-STD-810 or RTCA-DO-160



# BEI Sensors - Potentiometers

## Wirewound

- DC In/DC Out, low power consumption & infinite resolution
- MIL-PRF-12934 QPL
- Product Offering: Rotary (1200 – 1800 Series)



## Conductive Plastic/Non Wirewound - Rotary

- DC In/DC Out, low power consumption & infinite resolution
- MIL-PRF-29023 QPL
- Product Offering: Rotary (9850-9860 Series)



## Conductive Plastic/Non Wirewound - Linear

- DC In/DC Out, Low power consumption, Infinite resolution & Long stroke length
- Product Offering: Linear (600, 700, 6300, 6400 & 9600 Series)



## Hybrids

- Pro: DC In/DC Out, Low power consumption, Infinite resolution & MIL-PRF-12934 QPL'd.
- Product Offering: Multi Turn Rotary (3200-4700 Series)



# KAVLICO™ Force Transducers & Force Rods

Product Specification	Typical Capability
Range	±20 lbf to ±1000 lbf (±89 N to ± 4448 N)
Limit Load	±3000 lbf (± 13335 N)
Ultimate Load	±4500 lbs (± 20017 N)
Excitation	2 Vrms to 28 Vrms 400 Hz to 10,000 Hz
DC-DC Electronics	Included or Separate (Option)
Accuracy	±1.0%FS
Spring Deformation	±0.020 in to ± 0.080 in (±0.50 mm to ± 2.00 mm)
Temperature	-67 °F to 275 °F (-55 °C to 135 °C)
MTBF	500,000 hrs
Environmental Spec.	MIL-STD-810 or RTCA-DO-160

## Typical Applications

- Aircraft linkage for limiting flight loads
- Flight Data Recorder
- Aileron, Elevator & Rudder control
- Active Collective & Cyclic Controls
- Active Side Stick Control



# Kavlico™ Cock-pit controls

Kavlico designs and manufactures a line of custom cockpit/pilot control devices that meet the small envelope, minimum weight, and high reliability requirements of today's highly competitive aerospace industry. All Kavlico cockpit control devices utilize Kavlico RVDTs as sensing elements.

**Devices include:**

- Speed Brake Control Handle
- Landing Gear Control Handle
- Steering Control (Tiller)
- Thrust Control Lever Flight
- Flap Selector Lever



# KLIXON® PRECISION THERMOSTATS

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**KLIXON**



**KAVZIRO**



**BEI KIMCO**



**BEI SENSORS**

# Half-Inch Series (4344, M1, 11041)

## Features

- UL and military certifications
- Versatile thermostat
- Cost effective hermetic solution

## Specifications:

- Max Current: 7 A
- Switch Action: SPST
- Temperatures (°F): -65 to 550
- Differential (°F): 20 to 70
- Shock: 100G (11041)
- Vibration: 20G (11041)
- Weight: 4.8 grams

## UL Certification (4344):

- E34618 (120/240 VAC)

## Military Certification:

- MIL-PRF-24236/1 (11041)

## Other Certification:

- NASA S-311-641/05

## Applications

- Aircraft heaters
- Aircraft bleed air
- Aircraft de-icing
- Satellite heaters
- Medical X-Ray
- Fire suppression systems
- Semiconductor equipment



# “TINY” Thermostat Series (3BT, 4BT)

## Features

- Military QPL listed
- Fast response times
- Smallest size/mass of any thermostat available

## Specifications:

- Max Current: 1 A
- Switch Action: SPST
- Temperatures: 0° F to 350° F
- Differential: 30° F
- Shock: 100G 6 mS
- Vibration: 30G 5-2000 Hz
- Weight: 0.2 – 0.9 grams

## Military Certification:

- MIL-PRF-24236/13 (4BT)
- MIL-PRF-24236/19 (3BT)

## Other Certification:

- NASA S-311-641/06 (4BT)
- NASA S-311-641/07 (3BT)

## Applications

- Motor Protection
- Transformers
- Batteries
- Heaters
- Circuit Boards
- Various Aero/Satellite



# Narrow Differential Series (M2)

## Features

- NASA S-311-641 certified
- Narrow differential
- Hermetic construction

## Specifications:

- Max Current: 2 A
- Switch Action: SPST
- Temperatures (°F): 0 to 300
- Differential (°F): 2 to 5
- Shock: 100G 6 ms
- Vibration: 10G 10-2000 Hz
- Weight: 5.4 grams

## NASA Certification:

- S-311-641/02

## Military Certification:

- MIL-PRF-24236/20

## Applications

- Aircraft heaters
- Aircraft bleed air
- Aircraft de-icing
- Satellite heaters
- Guided missiles
- Train/Rail applications



# High Current Series (4391)

## Features

- High current thermostat
- SPST or SPDT
- Manual reset option
- Over-molded device

## Specifications:

- Max Current: 12 A
- Switch Action: SPST/SPDT
- Temperatures (°F): 0 to 450
- Differential (°F): 15 to 60
- Vibration: 5G 5-500 Hz
- Weight: 21 grams \*

\* Without over-mold

## Applications

- Aircraft galley equipment
- Aircraft water heaters
- Gun turret hydraulics
- Rail/transport
- Mining equipment
- Refrigerated transport



# Half-Inch Series (4344, M1, 11041)

## Features

- Brass or stainless steel hermetic design
- Custom lengths, lead wires, connectors
- Standard or narrow differential
- Military certification

## Specifications (3BT):

- Max Current: 1 A
- Switch Action: SPST
- Temperatures (°F): 0 to 350
- Differential (°F): 30
- Shock: See 3BT
- Vibration: See 3BT

## Military Certification:

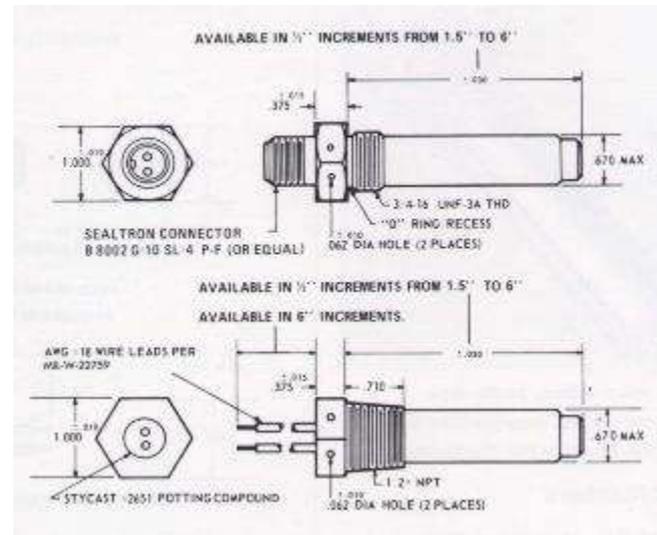
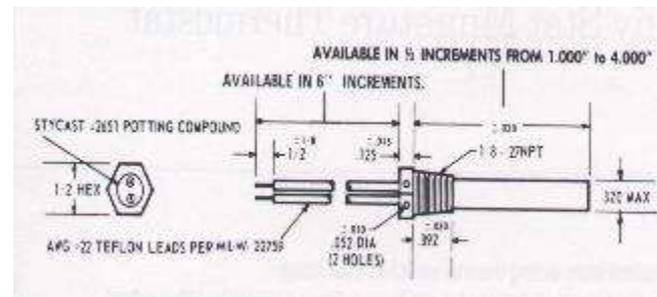
- MIL-PRF-24236/2/11/25

## Applications

- Aircraft hydraulic systems
- Aircraft air cooling systems
- Helicopter gearboxes
- Compressor discharge gas
- Locomotive coolant valves
- Slurry pumps

## Specifications (11041):

- Max Current: 7 A
- Switch Action: SPST
- Temperatures (°F): -65 to 550
- Differential (°F): 20 to 70
- Shock: See 11041
- Vibration: See 11041

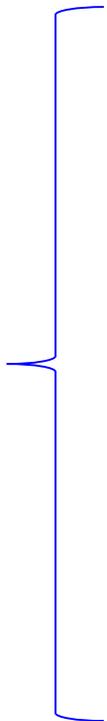


# KLIXON® Hermetic Switches, TYPES & SPECIFICATIONS

Performance Ratings and Characteristics		AT Basic (Silver Contacts)	AT Basic (Gold Contacts)	3AT (High Temp)	4AT (Low Temp)	10AT (High Current)	
Current Rating (Amperes)	28 VDC	Resistive	3	1	1	3	4
		Inductive	1	0.5	0.5	1	1
		Lamp	1	0.5	0.5	2	2
Life at Rated Load (Min. Cycles)		25,000	50,000	25,000	10,000	25,000	
Mechanical Life (no electrical load)		100,000		100,000	50,000	50,000	
Operating Temperature Range (°F)		-65 to +275		-65 to +450	-275 to +275	-85 to +275	
Dielectric Strength (Terminal to Case)		1000 VRMS		500 VRMS	1000 VRMS	1000 VRMS	
Dielectric Strength (Terminal to Terminal)		800 VRMS		500 VRMS	800 VRMS	800 VRMS	
Insulation Resistance at 500 VDC		100 megohms		100 megohms	100 megohms	100 megohms	
Voltage Drop at 1 Amp		.040		.120	.040	.040	
Seal / Maximum Allowable Leakage		MIL-PRF-8805, Design Enclosure 5, Dry Nitrogen with 10% Helium Backfill					
Shock Resistance		200 G, 6 millisecond sawtooth					
Vibration Resistance		65 G, 10-2000Hz, .5DA or 65 G RMS					
Actuation Characteristics							
Actuating Force maximum @ STP (ounces)		22		20	28	22	
Release Force maximum @ STP (ounces)		4		4	1	4	
Pretravel maximum (inch)		.009		.009	.009	.009	
Movement Differential maximum (inch)		.003		.003	.003	.005	
Overtravel minimum (inch)		.003		.003	.003	.003	
Maximum force on actuator		5 lbs					



# Hermetic Switch Packages (Typical)



Side Plate



Roller



Plunger



Pushbutton



Leaf Actuated

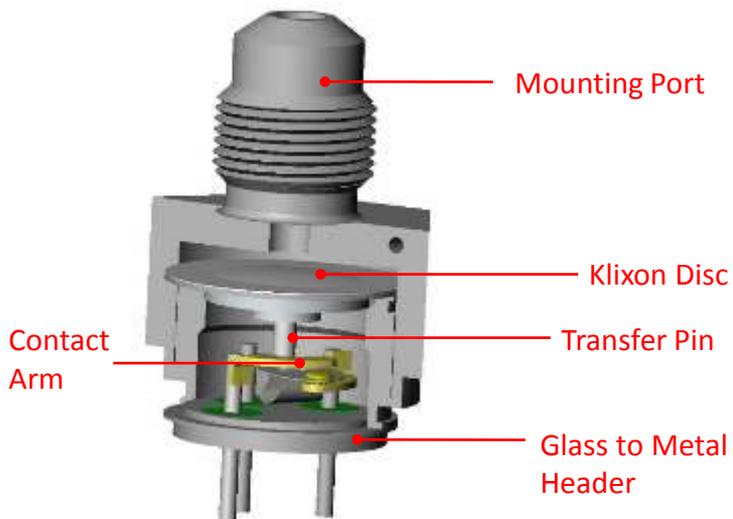


Foot Switch

*Virtually an unlimited number of configurations using basic AT switch (cell)*



# Pressure Switch (6PS)



## Typical Applications

- Fire suppression systems
- Generator gearbox oil pressure

SPECIFICATIONS	
Temperature Rating	-65°F to 275°F (-53.8°C to +135°C)
Vibration Resistance	25 G, 20–2000 cps (no contact chatter in excess of 10 microseconds)
Burst Pressure	8,000 PSI minimum
Proof Pressure	8 times actuating pressure
Life @ Rated Current	50,000 cycles
Current Capacity	Resistive : 5amp @ 28 VDC Inductive : 2amp @ 28 VDC Lamp : 1amp @ 28 VDC
Dielectric Strength	Terminal to terminal : 1000 vrms Terminal to case : 1000 vrms
Weight	Without Leads : 30 grams maximum With Connector : 60 grams maximum
Metal Parts Exposed to Pressure & Environment	300 series stainless steel CA-360-2 (1/2 hard leaded brass)
Potting Material	Epoxy resin

PRESSURE SPECIFICATIONS	
Range of Actuation Pressure Settings	at STP from 45 PSIA to 700 PSIA
Range of Deactuation Pressure Settings	Standard : 60% to 85% of actuation pressure Special : 85% to 90% of actuation pressure
Range of Tolerances on Actuation & Deactuation Pressure	Standard : up to ±6% of actuation pressure (±10 PSI minimum) Special : up to ±4% of actuation pressure (±5 PSI minimum) <i>Choice of deactuation pressure setting and tolerances affects price</i>

Pressure	Actuation Pressure (PSIA)		Deactuation Pressure (PSIA)			
	Standard Tolerance	Special Tolerance	Standard 60% to 85%	Special 85% to 90%	Standard Tolerance	Special Tolerance
45 to 134	± 10	± 5	28 to 112	40 to 117	± 10	± 5
135 to 164	± 10	± 7	83 to 137	117 to 144	± 10	± 7
165 to 249	± 15	± 10	101 to 208	142 to 216	± 15	± 10
250 to 369	± 20	± 15	153 to 310	217 to 324	± 20	± 15
370 to 429	± 25	± 20	225 to 361	319 to 378	± 25	± 20
430 to 489	± 30	± 20	261 to 412	370 to 432	± 30	± 20
490 to 549	± 35	± 25	297 to 463	421 to 486	± 35	± 25
550 to 599	± 40	± 25	333 to 510	472 to 540	± 40	± 25
600 to 700	Consult Factory					



## KLIXON® Aircraft Circuit Breaker Features & Options

- Single pole or three pole versions
- Ratings from 1/2 to 100 amps
- Trip free design
- Temperature or non-temperature compensated
- Qualified to global commercial and military standards
- Optional auxiliary switch
- Thermal and magnetic sensing
- Push button, toggle or rocker switch
- Long push button
- Various terminal configurations
- MS and commercial configuration
- Manual reset (Push Pull)

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