



# Technology developments

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# Agenda

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- Overview of fuel and motion control products and key technology areas
- Hydraulic and actuation systems
  - More electric hydraulics – Zonal power packs
  - Automatic bleed valve

# Fuel & Motion Control Systems products



 Hydraulic power     Motion control     Fuel systems

## Pumps



## Motor pumps



## Power transfer units



## Power packs



## Generators



## Reservoirs



## Filter modules



## Heat exchangers



## Landing gear actuators



## Flight control actuators



## Utility actuators



## Nosewheel steering



## Hydraulic motors



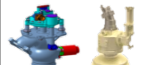
## Fuel distribution



## Engine fuel pumps



## Aerial refueling



## Fuel tank inerting



## Fuel measurement



## Controllers



## Valves



# Fuel & Motion Control Systems

## New product development – Key technologies

### Automatic bleed valve

- Decreases aircraft maintenance time
- TRL 6 Achieved in 2015

### Utility actuation

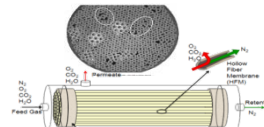
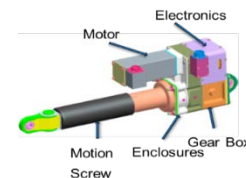
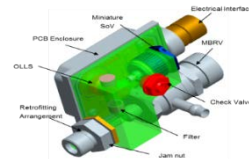
- Decreased development time and component commonality for Electro-Mechanical Actuators through scalable architectures

### Fuel inerting / flammability reduction systems

- Quantify drivers for system maintenance and repair
- Develop and Demonstrate improved life-cycle cost systems

### Zonal hydraulics & high speed motor-pumps

- Improved power density electric motor driven systems
- Reduced hydraulic system complexity & leak points



# Fuel & Motion Control Systems

Zonal hydraulics

# What is a Zonal system?

- A Zonal system is a small hydraulic power system that serves a specific set of local flight control or utility actuators
  - Includes Integrated Power Pack, short hydraulic lines and actuators
- Zonal systems are totally isolated from each other and from the main systems
- Zonal systems can be used as:
  - Back up for multi-channel flight control actuators (Can replace EHA's and EBHA's)
  - Dedicated power source for utility systems (e.g. Cargo Door, Nose gear actuation and steering)

# How a Zonal system works

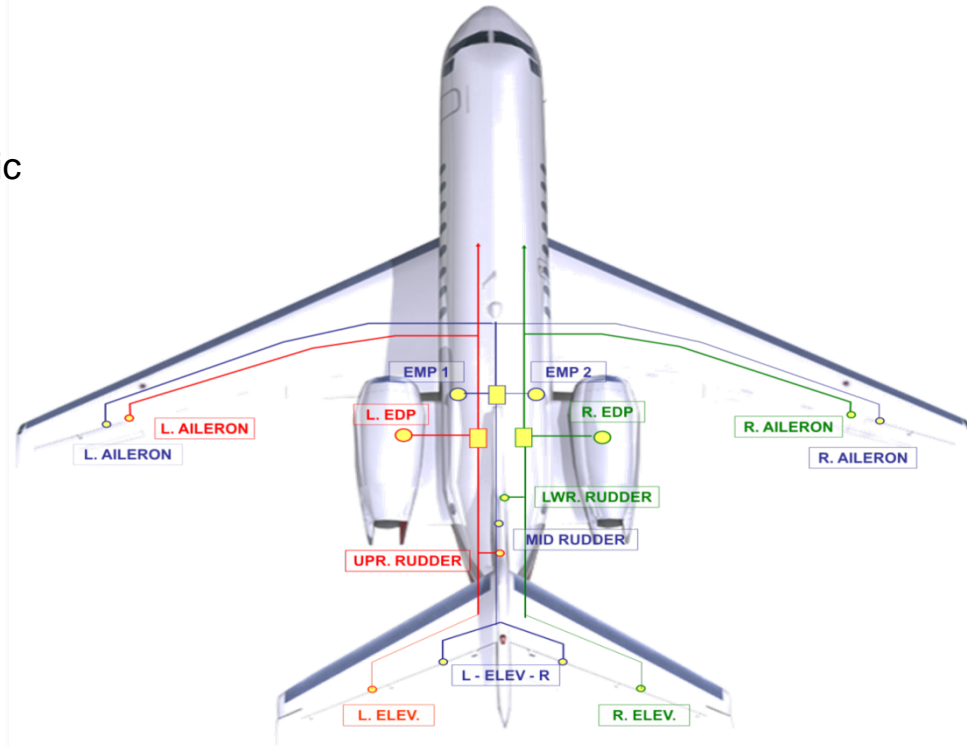
## Conventional 3-System

Left

Center

Right

- 2 Main systems (L+R) plus back-up electric
- Main → EDPs, EMPs, PTU
- Backup → EMPs, RAT



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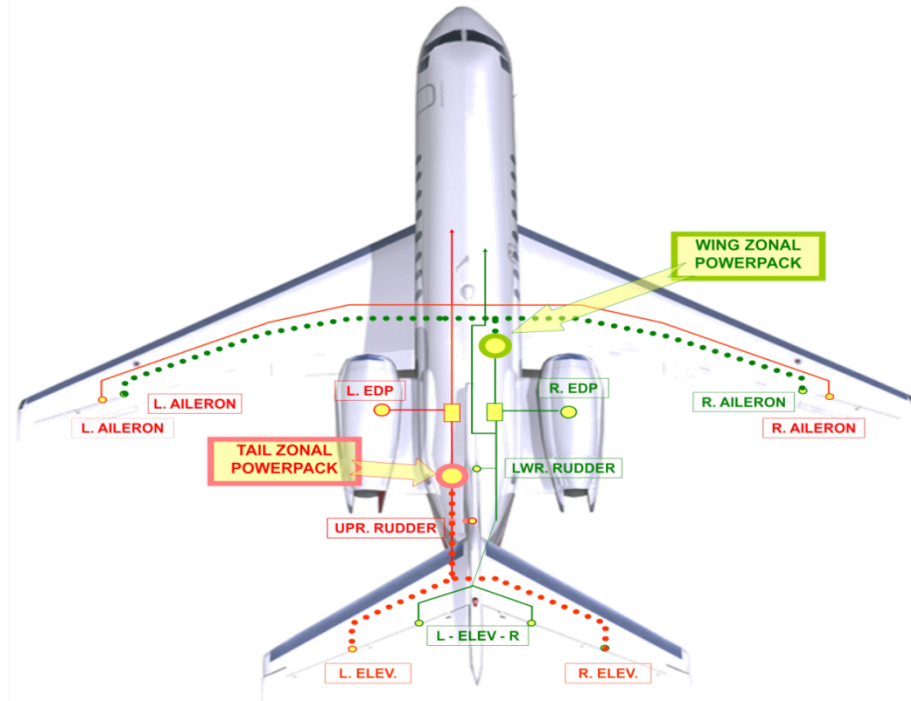
## Zonal wing + Tail

Left

Center

Right

- 2 Main systems (L+R) plus 2 Zones
- Main → EDPs, EMPs, PTU
- Zones → Zonal Powerpacks

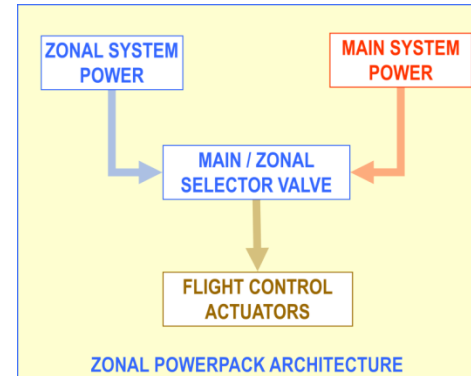
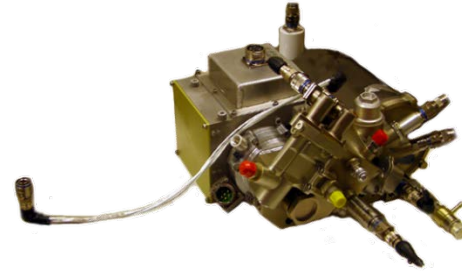




# How a Zonal PowerPack works

The Hydraulic PowerPack (HPP) is a key element of a Zonal system

- PowerPack switches control of actuator from Main to Internal power using selector valve
- Same actuator can be powered by either source



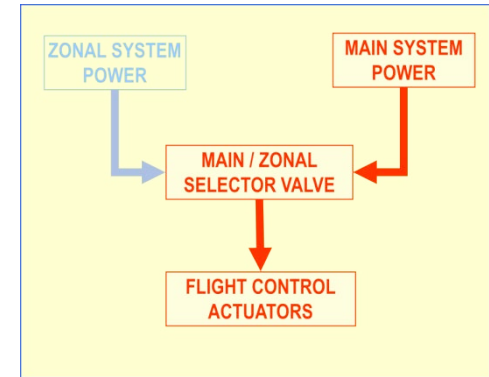
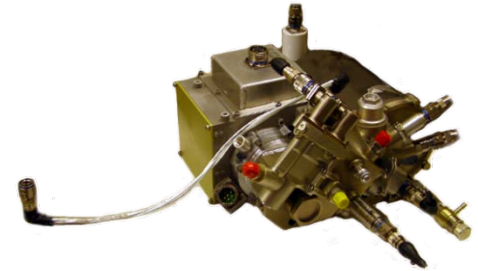
# How a Zonal PowerPack works

## PowerPack key element of Zonal system

- PowerPack switches control of actuator from Main to Internal power using selector valve
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## Normal operating mode

- Mode: MAIN PowerPack – OFF
- Main system powers actuator
- Main / PowerPack totally isolated
- PowerPack / actuators totally isolated



# How a Zonal PowerPack works

## PowerPack key element of Zonal system

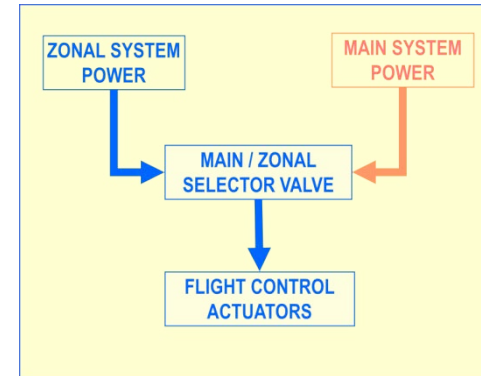
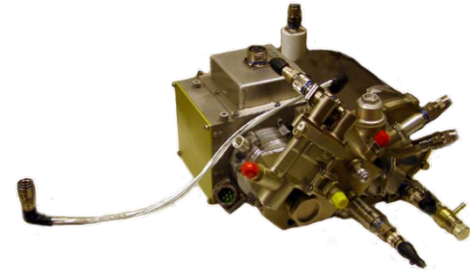
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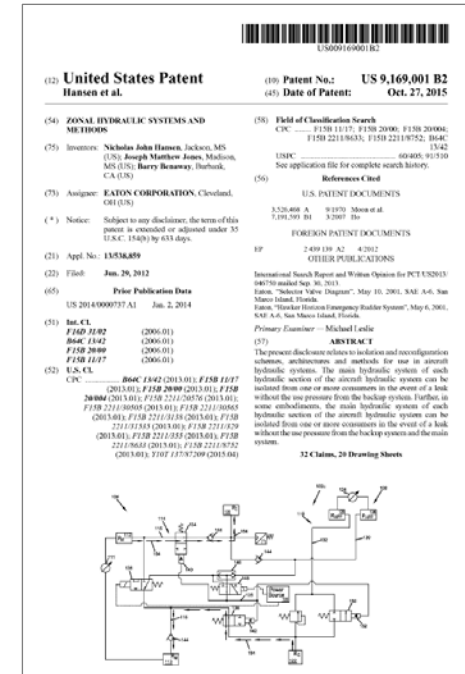
## Emergency operating mode

- Mode – ZONAL PowerPack – ON
- PowerPack powers actuator
- Main / PowerPack totally isolated
- Main / actuators totally isolated



## Main & Back-up system isolation is required:

- Isolate main system from HPP system to segregate failure modes
- Isolate main system from consumers in the event of a consumer leak
- Isolate critical consumers from main system in the event of a main system leak – power provided by HPP



# Zonal PowerPack design features

Installs in tight space

Integrated thermal management

Flexible electrical power control

Robust isolation between main system / Powerpack / Actuator

Direct connection to avionics data bus

# Benefits of Zonal systems

## for Back-up of Fly-by-wire flight controls

### Improved survivability

- Avoids hydraulic lines through rotor burst zone

### Adaptable to all types of aircraft electric power supplies

- Wild frequency AC, DC

### Simplified hydraulic installation

- Eliminates a third system, reduces tubing installation

### Reduced power consumption

- Power packs are powered off when not needed

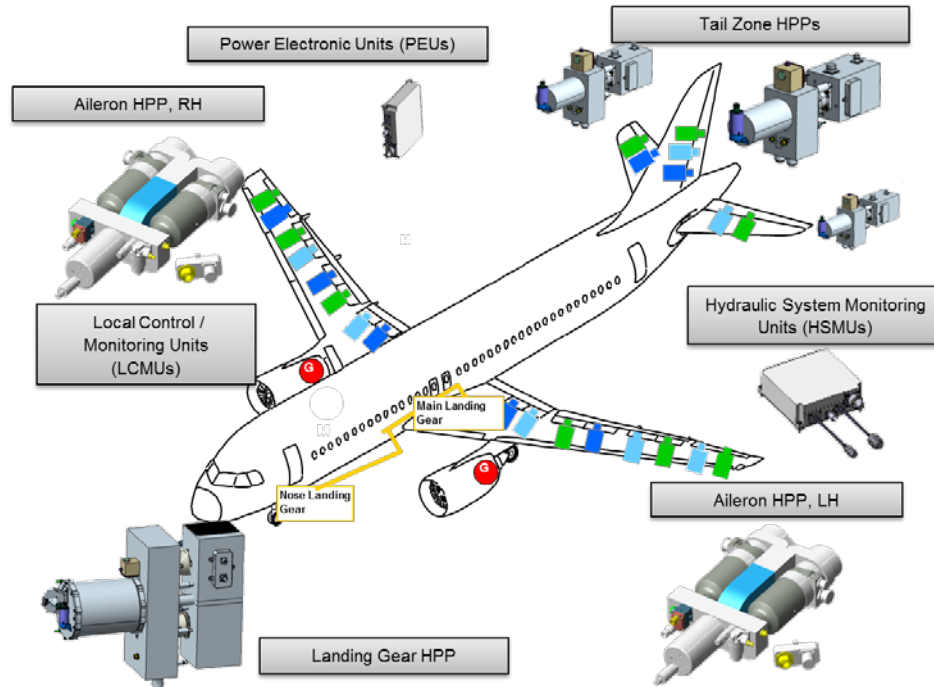
### Increased system availability

- Power Pack reliability greater than main (central) systems

### Reduced weight

- Less tubing, hydraulic fluid

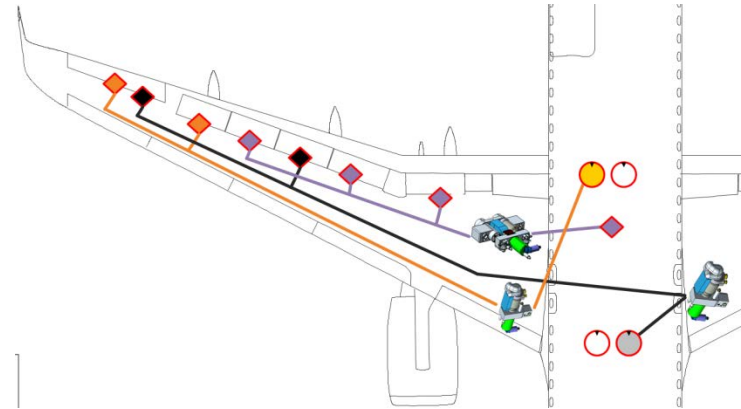
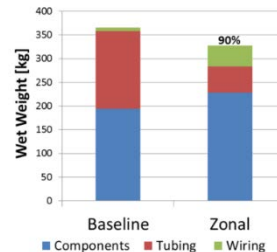
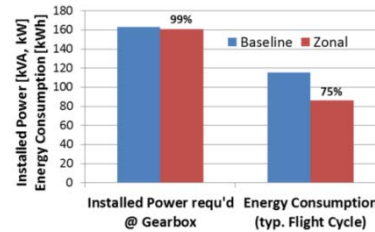
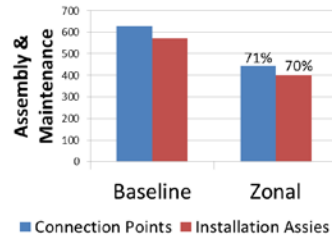
# Future more electric aircraft “Zonal” architecture



# Future more electric aircraft Trade-study\*

Reduced installation and maintenance cost, installed power, and weight are achievable

\* Study conducted on a theoretical 150 passenger single aisle aircraft



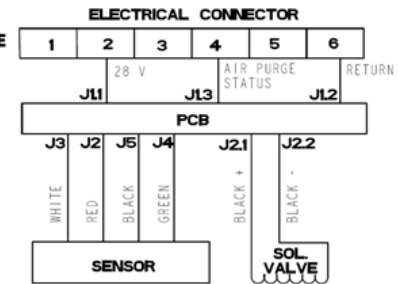
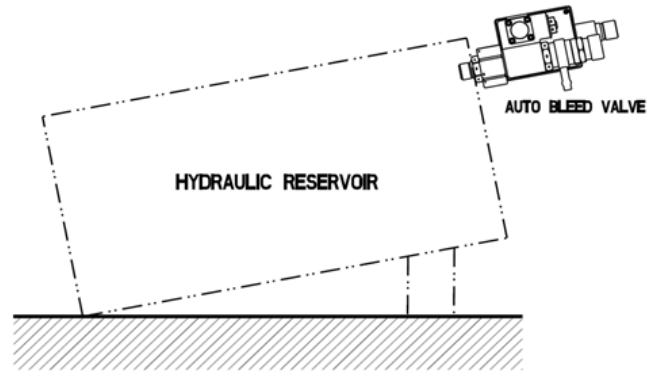


# Fuel & Motion Control Systems

Automatic bleed valve

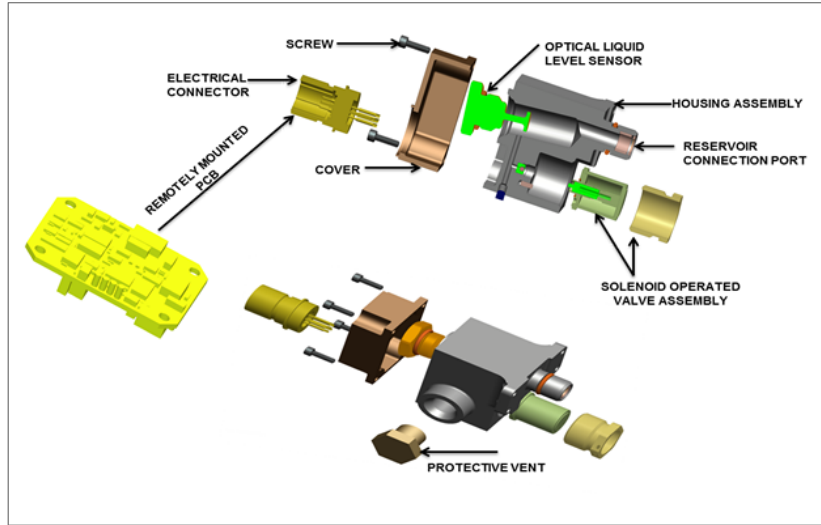
# Automatic bleed valve

Functionality	Basic ABV	Integrated ABV
Auto-Bleed	✓	✓
Relief	✗	✓
Manual Bleed	✗	✓
LRU	✗	✓
Weight	0.4 lbs	1 lbs
Envelope	2.2 x 1.8 x 2.1	4.3 x 3.1 x 2.33
Retrofit Mounting	✗	✓

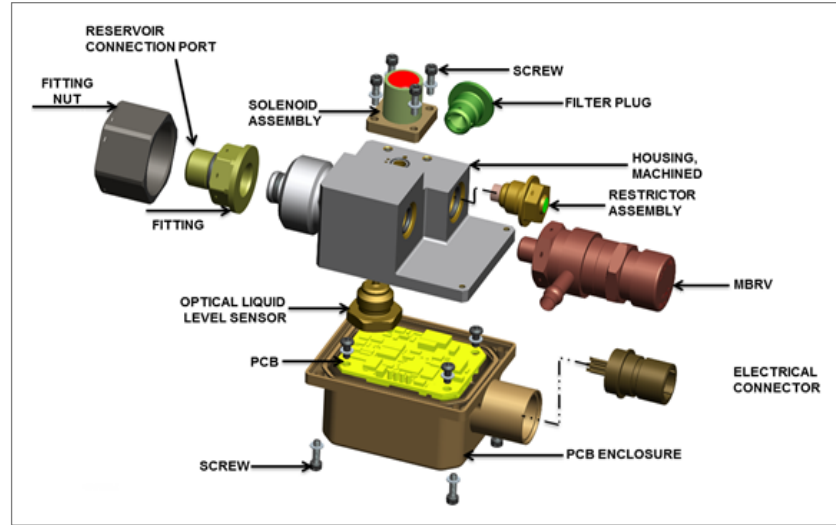


# Auto bleed valve construction

## Basic ABV

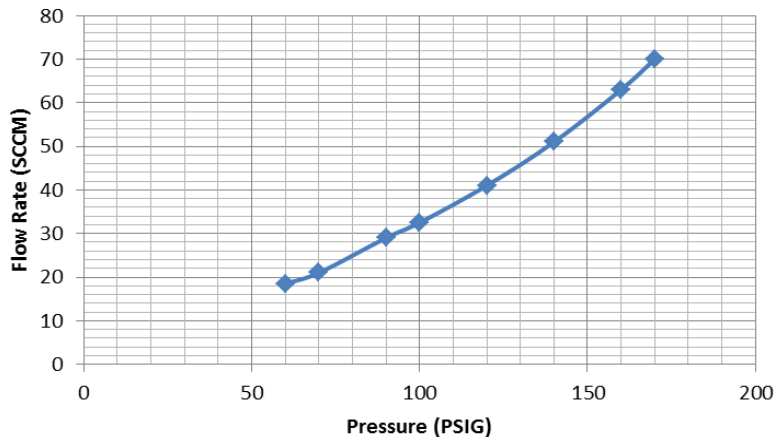


## Integrated ABV

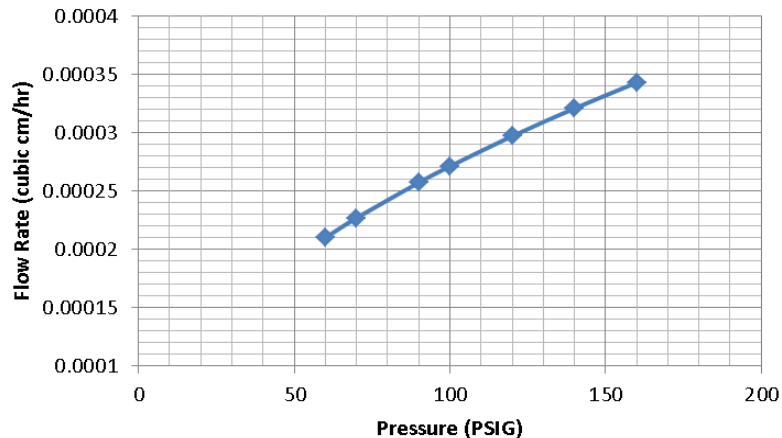


# Auto-bleed valve flow characteristics

## Air Flow Rate when Open



## Fluid Flow Rate when Open



Valve design provides suitable Air-Flow Rate to purge air, yet restricts hydraulic fluid flow

Valve includes logic to limit "Open" time, Fault code reported if hydraulic fluid is not detected after repeated bleed attempts.

# Auto-bleed valve verification tests

SR NO	Description	Requirement	Basic	Integrated
1	Functional Test		C	C
2	Temperature & Temperature Variation	DO160G Section 4 Cat F2, Section 5 Cat B	C	C
3	Endurance Test	30,000 Cycles	C	C
4	Pressure Impulse Test	0-150 PSIG At Room Temperature	C	C
5	Burst Pressure	250 PSIG	C	C
6	Long Term Hydraulic leakage	150 hrs at 150 PSIG at room temperature (Fluid viscosity - 2 cSt)	C	X*
7	Vibration Test	DO160G Section 8 Category R Curve E and E1	C (*Curve C & C1)	C (*Curve E & E1)
8	Voltage Spike	RTCA-DO-160G, Section 17, Category A.	X*	C
	Audio Frequency Conducted Susceptibility	RTCA-DO-160G, Section 18, Category Z.	X*	C
	Induced Signal Susceptibility	RTCA-DO-160G, Section 19, Category C & W.	X*	C
	Radio Frequency Conducted Susceptibility	RTCA-DO-160G, Section 20, Category Conducted - R.	X*	C
	Radio Frequency Radiated Susceptibility	RTCA-DO-160G, Section 20, Category B	X*	C
	Emission of Radio Frequency Energy	RTCA-DO-160G, Section 21, Category L.	X*	C
	Lightning Induced Transient Susceptibility -	RTCA-DO-160G, Section 220, Category A3G3.	X*	C
	Power Input	RTCA-DO-160G, Section 16.0, Category Z.	X*	C

C – Successfully completed

X\* - Not repeated on both Basic and Integrated variant, Basic & Integrated variants have Same Sensor, Solenoid Valve, & PCB.



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