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Case Study: F-15 AMAD Test Stand

Industry:

Aeronautics

Design Task:

The Hill Air Force Base contracted KDY to design, build, and program two test stands equipped with custom software to fulfill all operational testing requirements of the F-15 Eagle's Airframe Mounted Accessory Drive (AMAD) gearboxes. The stand was required to drive units under test (UUTs) of two different form factors at speeds ranging from 1000 to 9000 RPMs.

The system required a reservoir & heat exchanger to service the AMAD system with pressurized oil & cool the return oil via the chilled water supply on site.

Throughout testing several acceptance criterion would be monitored:

- UUT Case Pressure
- PTO Input Shaft Speed
- Oil Pressure; Oil Input & Output Temperature; Oil Flowrate;
- UUT Vibration

And multiple additional alerts regarding the UUTs electrical system & the test stand operational constraints.

Historically, vibration levels were measured manually & the many acceptance criterion were recorded by hand from analog sensors. This required operator attendance throughout the time-intensive testing.



The Solution:

Fully Automated Testing, Custom Alert Management

KDY designed & fabricated an operator-friendly test stand equipped with custom DAQ hardware enabling fully automated testing procedures, computer generated testing reports, and real-time alarms for parameters of interest.

The mechanical design featured:

- **Direct Drive Motor:** A High-Speed Parker MGV Series Motor to eliminate the need for a speed increasing gearbox, lowering maintenance & system costs.
- Calibration Friendly Design & Instrumentation:
 - Quick disconnect plumbing elements for easy introduction of flow or pressure standard
 - Thermowell mounted temperature probes for easy removal
- 3-Color Visual Alert System: State of acceptance parameters clearly indicated by mounted red/yellow/green light add-on; Eliminates need to continuously check sensors

Figure 1: F-15 AMAD Test Stand, as delivered

• **Noise- Reducing Enclosure:** Sound insulation & damping features to ensure noise reduction despite high vibration application

For the electrical system & software design, KDY utilized its experience as a <u>UL Listed Panel Shop</u> to build both a Motor Drive & Instrumentation panel with user-friendly features:

- Two Hoffman UL Type 4/12 enclosures with penetrations for a disconnect operator
- Drive panel isolation to electrically insulate motor drive from sensitive instrumentation
- Power/feed-through convenience port for easy calibration
- NI-based digital and analog I/O
- Test stand mounted enclosures for sensor proximity reducing EMI noise

KDY delivered custom software that dramatically increased ease of testing:

- Frequency Domain Vibration Analysis: NI 9234 Analog Input Module and LabVIEW's Sound & Vibration Module to automate vibration measurement and analysis
- Intuitive Calibration Software: Multipoint calibration for all sensors with remote laptop capabilities.
- Alert Management: Alarm logger & visual alert system reduced operator attendance throughout testing
- Windows Installer: And executable for easy installation and software management

Run Fill N	r Mode Maint Switch Serial Number Model Number uto EStop isabled	r	Test Sessior 00:00:00 MM/DD/YY
aration Data Alarms	Activity Log		
larm Channels			
Name	Condition	Response	Status
Case Pressure	<1 and speed . 3000 rpm	Alarm	ОК
Case Pressure	<4 or >6 and speed > 7900 rpm	Alert	OK
Case Pressure	>10 psig	Alarm	OK
Lube Oil Pressure	< 25 psig and speed >= 8000 rpm	Alarm	OK
Lube Oil Pressure	< 40 psig or > 70 psig and speed > 7900 rpm	Alert	OK
Lube Oil Outlet Temperature	>275 oF	Alert	OK
Lube Oil Inlet Temperature	>275 oF	Alarm	OK
Oil Flow	< .25 gpm and speed >= 3000 rpm	Alarm	OK
Oil Flow	< 5 gpm and speed >= 7900 rpm	Alarm	Tripped
Oil Flow	< 1 gpm or > 3 gpm and speed >= 7900 rpm	Alert	OK
Heat Rejection	>250 Btu/min and speed >=7900 rpm	Alarm	OK
Oil Pump Discharge Pressure	< 230 or > 260 and speed >=7900 rpm	Alert	OK
PTO Speed	>=16000	Alarm	OK
Vibration	>0.8 mils when rpm . 8,000	Alert	Tripped
Vibration	>2.0 mils for 1 second continuous	Alarm	OK
Shop Air	Low pressure (determined by Contractor if used)	Alarm	OK
Cutout switch	If cutout occurs < 8000 rpm or if cutout does not occur > 8600 rpm	Alert	ОК
Communication with motor con	If communication is lost between computer and motor controller for > 0.5 seconds	Alarm	OK
Oil reservoir switch	When reservoir level is low	Alert	OK
E-Stop	When emergency stop is pressed	Alarm	OK

Figure 2: Alert Management Software