TECHNICAL SPOTLIGHT

Subject: V2500 Ignition Lead Competitive Evaluation

Part Numbers: Champion: P/N CH53564
Unison Industries: P/N 9045405-1/-3/-5/-7
IAE P/N: 5U0006, 5U0052, 5U0068, 5U0072

Purpose: To provide design and experienced based competitive evaluation of Champion and Competitive Ignition Lead Designs for all International Aero Engines (IAE) V2500 engines.

Champion Claim: When used together the Champion **CH31964 igniter and CH53564** ignition lead designs provide lower overall cost of ownership and improved ignition system reliability from design approaches that optimize igniter life, mechanical robustness, temperature capability and ignition lead performance/survivability. From the lead perspective, the use of Champion's V2500 Ignition Lead will:

- Eliminate Dielectric Failures From Distress of Silicone Jacketed Conductor Wire
- Eliminate Risk of Corona Discharge
- Significantly Reduce Terminal Well Flashover
- Reduce Maintenance Burden, Delays and Cancellations; Improve Chapter 74 reliability

Champion V2500 Program Background: Champion's introduction of its CH31964 igniter design provided not only igniter improved performance, but ignition lead performance and survivability enhancement also. A combination of Champion's advanced igniter design and introduction of its own ignition lead design best practices established an immediate improvement in V2500 ignition system reliability. See Champion V2500 Igniter Competitive Evaluation for details on the terminal well temperature reduction improvements. Champion's lead design further addressed temperature capability shortcomings inherent in the Competitive design by focusing on improving air flow through the ignition lead such that a new part and an end of life ignition lead maintain the same air flow capacity. Reduction in cooling air flow through the lead directly contributes to increased temperature exposure to sensitive elastomeric parts which are critical to dielectric protection at the igniter connection.

Design Pedigree: The Champion V2500 ignition lead design implemented best practices for maintaining constant cooling air capacity and protection of temperature sensitive elastomeric components. Champion combined best practices for cooling air capacity from its General Electric (GE) CFM56/CF6 ignition lead designs and elastomeric part protection considerations from its Pratt & Whitney (PW) PW4000 ignition lead design. These ignition systems do not suffer from system reliability issues resulting from excessive temperature exposure.

Competitive Ignition Lead Design Issues: Champion conducted extensive research into the most prominent ignition lead failure modes with multiple Airline Operators. Three of the top four field issues were a result of excessive temperature exposure to elastomeric parts. The fourth field issue was a contributor to the excessive temperature exposure. The top four issues are:

- Terminal Well Flashover
- Dielectric failures in igniter end termination from thermal distress of silicone components
- Corona damage to the conductor wire insulation
- Reduction in cooling air flow rate due to innerbraid collapse

Figure 1 illustrates internal locations of the top four field issues. **Figures 2-4** show actual field photos of the significant survivability issues encountered with the Competitive ignition lead design and NGK Igniters.

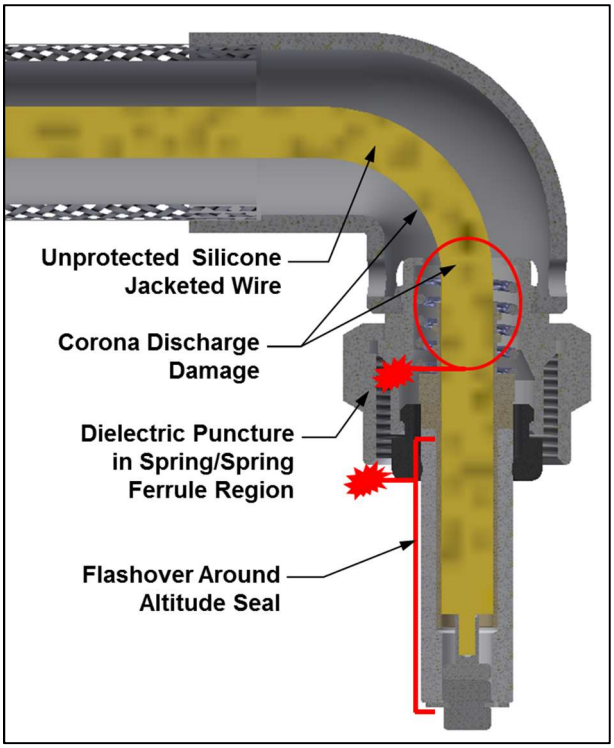

Figure 1. Illustration of Lead Termination and Associated Failure Locations of Competitive Lead

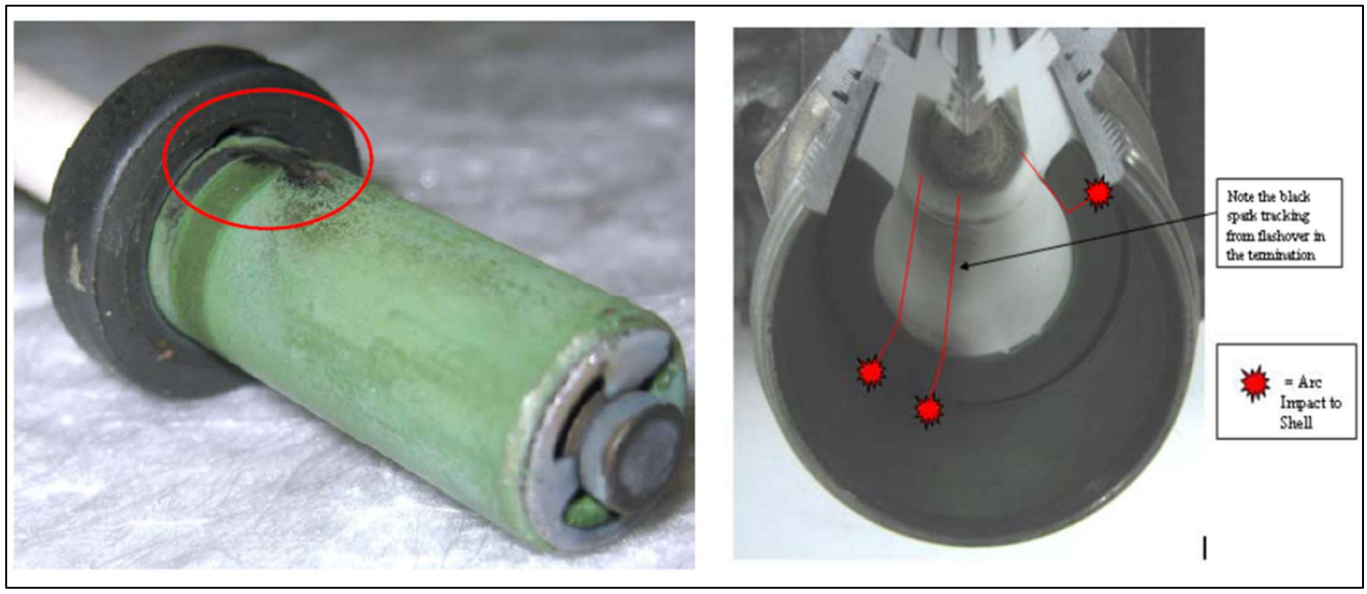

Figure 2. Photos of Competitive Igniter and Lead with Terminal Well Dielectric Flashover

Figure 3. Photos of Competitive Lead with Severe Dielectric Failures in the Igniter Termination

Figure 4. Photo of Competitive Lead with Corona Discharge Damage on Conductor Wire

Figure 5. Photo of a Competitive Lead Design with Collapsed Innerbraid Resulting in Restricted Airflow

Champion Design Improvements: Champion identified three (3) major design improvements to improve life, performance and reliability over the competitive design. These three areas are:

- **Cooling Airflow Capability/Capacity**
- **Improved Dielectric Protection of the Elastomeric Conductor wire**
- **Reduction In Corona Effect**

Cooling Air Flow Capability and Capacity: The ignition lead design accepts fan air through the exciter cooling duct, into the internal conduit of the lead and ultimately exhausts at the igniter to lead connection. Champion understood reduction in airflow capacity between new and "in-service" leads would account for increased temperature of the sensitive elastomeric insulating components in/around the igniter termination. A functional review of new and "in-service" Competitive leads gave evidence to a ~20% loss in flow capability. A quick teardown review revealed collapse of the innerbraid (due to vibration) occurred which partially blocks the airflow. An example of innerbraid collapse is shown in **Figure 5 and 6**. Champion developed a patented approach to solve reduced airflow during the installed life of air-cooled ignition leads. See **Figure 7** for an illustration of the approach. This design configuration ensures the airflow at the beginning and end of the ignition lead life remains unchanged. The Champion design also improves the new part flow capacity by **nearly 10 percent** over a new Competitive design. This equates to more effective cooling of the sensitive ignition lead elastomeric components and reduces igniter seal temperatures to eliminate concerns of igniter leakage.

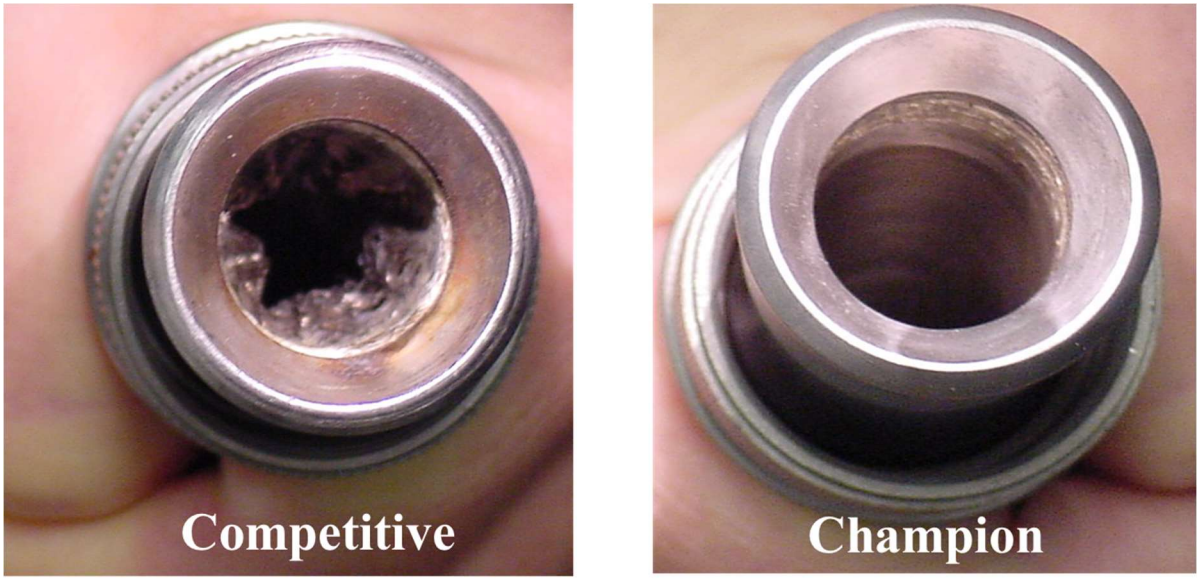

Figure 6. Comparison of Competitive (Collapsed) and Champion (Fully Open) Design Airflow Passage

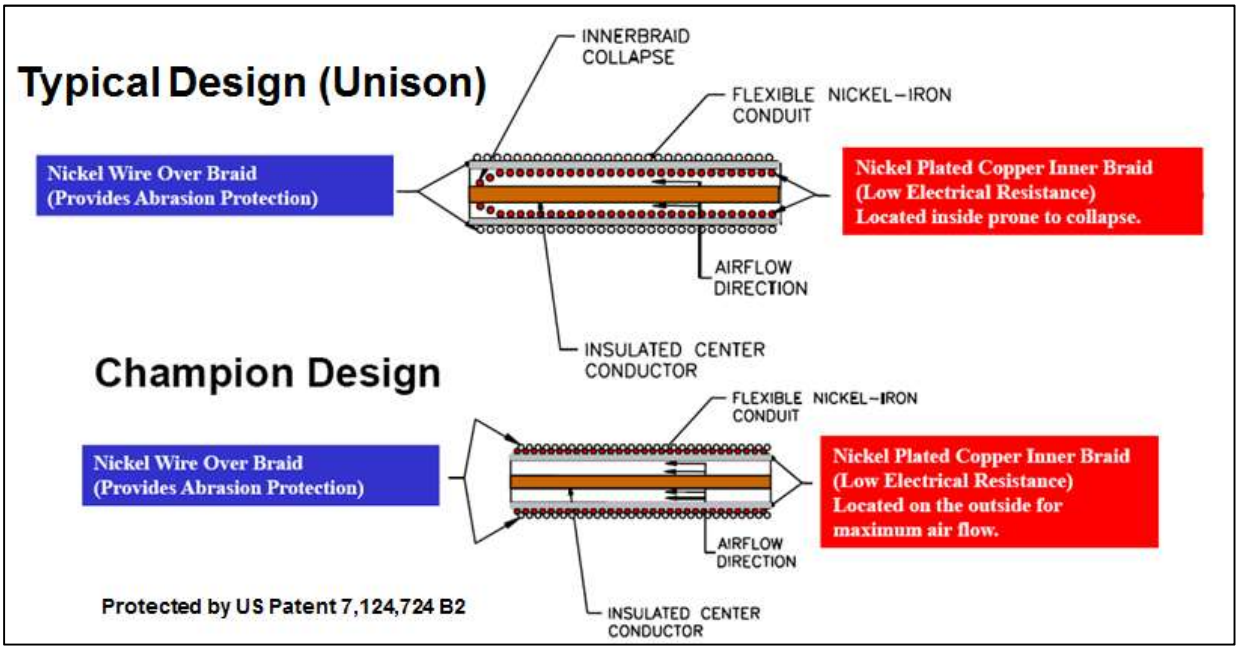

Figure 7. Comparison of Competitive (Collapsed) and Champion (Fully Open) Design Airflow Passage

Improved Dielectric Protection of Elastomeric Conductor Wire and Reduced Corona Effect: This improvement mechanically and dielectrically protects the silicone jacketed conductor wire from exciter termination contact to igniter termination contact and has proven pedigree in other large commercial turbofan engines. It provides tremendous abrasion protection and thermally/electrically insulates the conductor wire from the surrounding environment. The improved insulation of the conductor wire decreases the Electric Field Strength between the center conductor and return path, which reduces the Corona Effect threat. See **Figure 8** below.

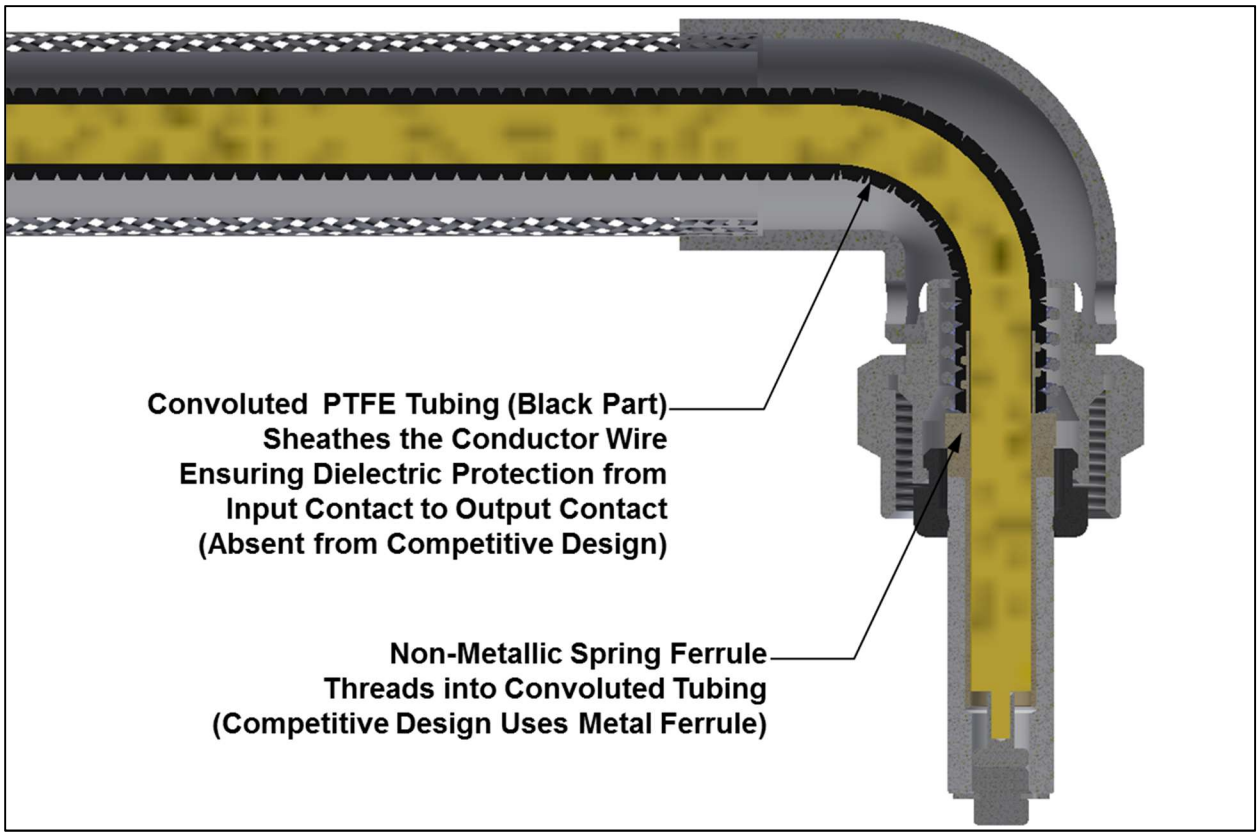

Figure 8. Champion Internal Construction Changes to Improve Dielectric Protection