CHAMPION AEROSPACE™

TECHNICAL SPOTLIGHT

Subject: V2500 Igniter Competitive Evaluation

Part Numbers: Champion P/N CH31964 (REF S.B.CH31964-74-21-001); NGK JS-100A

Purpose: To provide design and experienced based competitive evaluation of Champion and NGK Igniters for all International Aero Engines (IAE) V2500 engine variants.

Champion Claim: The Champion **CH31964** is an advanced design that provides lower overall cost of ownership and improved ignition system reliability from design approaches that optimize igniter life, mechanical robustness, temperature capability and ignition lead survivability.

Champion V2500 Program Background: Champion developed the AA72SA type igniter configuration in the 1960's for the Pratt & Whitney JT8 commercial transport engine. The AA72SA design configuration is a well proven igniter for the application and has served airlines well for 40+ years. During the 1980's Champion was asked to propose the successful AA72SA for the new IAE V2500 engine and detail component and subassembly drawings were required as part of the proposal. Champion did not win the initial contract for the V2500 engine igniter and NGK developed an igniter practically identical to the 1960s vintage AA72SA. Champion elected to develop an improved igniter for the V2500 engine in the early 2000's utilizing advanced and proven technologies found in major commercial applications like the GE CF6, CFM56 and Pratt & Whitney PW4000 engines. **Figure 1** provides a cross sectional view of the Champion AA72SA igniter, the current NGK V2500 igniter, and the **Champion IPC listed CH31964** V2500 igniter. For comparison three primary areas of focus are noted in **Figure 1** and are subsequently reviewed in the Features and Benefits section below.

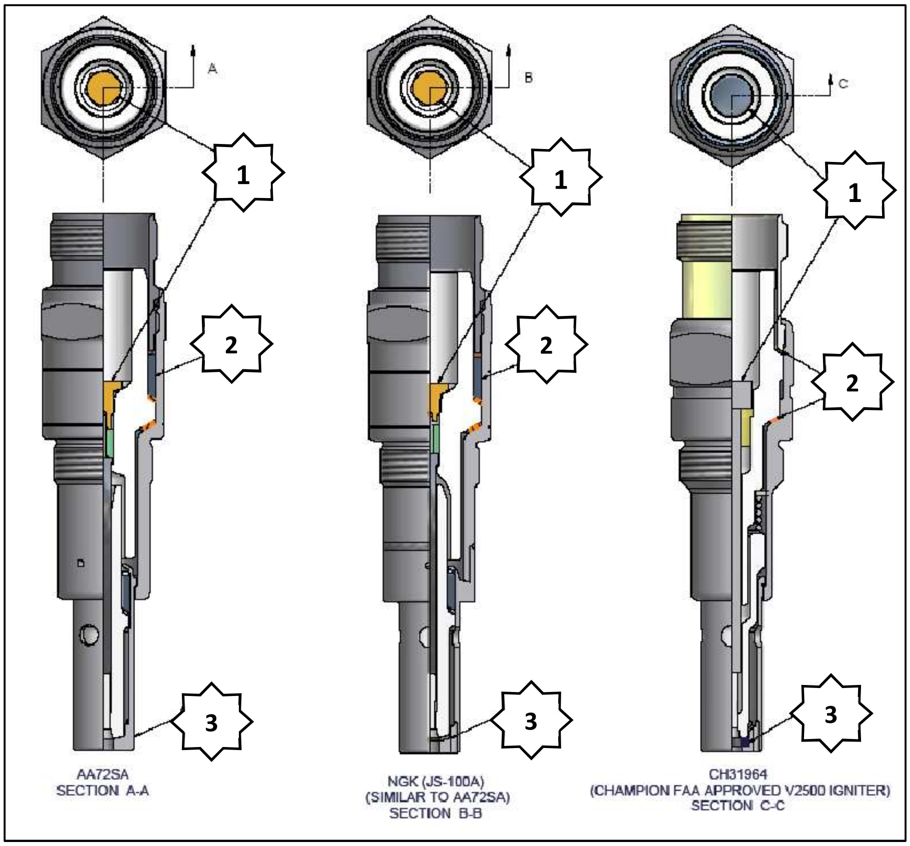

Figure 2: Champion Style Sectioned Tip

Design Pedigree: The NGK Igniter has no pedigree other than replication of Champion's 40 year old igniter technology. Champion replaced the antiquated 40 year old design by advanced igniter design configurations proven on CF34, CFM56, CF6 and PW4000 engines.

Features and Benefits: Champion identified three (3) specific areas of focus where the CH31964 igniter outrivals the NGK JS-100A competitive igniter to improve life, function and reliability.

Focus Area 1: Both the Champion AA72SA and NGK JS-100A igniters utilize a copper alloy (brass) for the terminal contact button (**Figure 1**). This material has good electrical properties, but has been shown to have poor arc erosion resistance (especially at high temperature), which makes it susceptible to arcing damage if the igniter to ignition lead is not properly maintained. Any arcing damage is cause for igniter replacement and results in similar terminal contact damage to the mating ignition lead. Without similar replacement of the mating ignition lead contact, arcing in the termination often continues until both contacts are replaced simultaneously. Champion has developed a tungsten contact for other modern commercial transport igniters (CFM56 and CF6) that greatly reduces contact arcing between the mating igniter and ignition lead. This feature is depicted in **Figure 1** and eliminates premature removal of igniters from the engine due to lead contact arcing. This enables igniters to remain installed to the spark erosion limit.

Focus Area 2: Both the Champion AA72SA and NGK JS-100A igniters utilize a talc-like material for the outer shell to insulator seal (**Figure 1**). This configuration provides a "leaking" seal that can result in low rate leakage of combustion gases through the igniter. This can result in elevated temperatures within the igniter to ignition lead termination and leads to ignition lead elastomeric component degradation. For other modern commercial transport igniters (CFM56, CF6, CF34, Trent Family and PW4000), Champion has developed a hermetic mechanical "hot-lock" seal for the outer shell and insulator seal. This feature is depicted in **Figure 1** and utilizes a proprietary process to generate a retained load on two metal gaskets. This seal has proven to be a superior sealing technology that remains hermetic (non-leaking) throughout the installed life to meet the demanding temperature and pressure cycling common in today's commercial engine applications.

Focus Area 3: The Champion AA72SA igniter uses a nickel alloy for spark erosion resistance of the ground electrode (**Figure 1**). NGK improved upon this by incorporating a thin braze retained iridium alloy disk (**Figure 1**). This NGK feature provides better spark erosion than the old style Champion JT8 igniter design; however, the material has high potential for cost volatility and decreased mechanical robustness. Champion utilized thermocouple equipped igniters to determine the actual igniter tip temperature and recognized that a pedigreed alloy would provide the optimum spark erosion resistance without cost volatility potential that could create price escalation. This feature is shown in **Figure 1** and results in superior spark erosion performance of the Champion **CH31964** design. Champion's internal benchmark testing results (See **Table 1**) under simulated engine temperature conditions confirms the new Champion CH31964 has lower spark erosion than the competitive NGK igniter. This better spark erosion performance directly leads to improved electrical performance capability over the life of the igniter in the form of significantly reduced dry and wet onset voltage. At the end of testing, Champion's igniter required about 4,000V less input to generate an ignition pulse at the igniter tip. This is significant margin over the NGK design which can equate to extended life in the engine.

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Champion GE Diameter	Champion CE Recession	Total Champion CE Wear	NGK GE Diameter	NGK CE Recession	Total NGK CE Wear	Champion Spark Test Dry/ Wet	NGK Spark Test Dry/ Wet	Total Sparks
0.194	0.227	0	0.187	0.242	0	6.8/13kV	7.4/17kV	0
0.194	0.229	0.002	0.187	0.247	0.005	3.5/3.5kV	4.0/6.5kV	250K
0.194	0.237	0.010	0.188	0.255	0.013	3.5/4.5kV	5.5/11kV	500K
0.194	0.241	0.014	0.188	0.263	0.021	2.5/5kV	4.0/7.5kV	750K
0.194	0.243	0.016	0.188	0.271	0.029	2.5/6kV	5.9/11kV	1000K
0.194	0.248	0.021	0.188	0.275	0.033	2.7/7kV	6/11.2kV	1250K
0.194	0.251	0.024	0.188	0.282	0.040	3.5/5.5kV	7.5/11kV	1500K
0.194	0.252	0.025	0.188	0.282	0.040	2.5/5.5kV	8/12.3kV	1750K
0.192	0.259	0.032	0.188	0.295	0.053	2.5/8.2kV	7/12.3kV	2000K
0.192	0.264	0.037	0.188	0.298	0.056	3.5/5.5kV	11/14kV	2250K
0.190	0.264	0.037	0.188	0.299	0.057	3.5/9.1kV	10/13kV	2500K
0.190	0.274	0.047	0.188	0.305	0.063	5.5/10kV	9/13kV	2750K
0.190	0.274	0.047	0.188	0.307	0.065	7.5/11.5kV	11/11.5kV	3000K
0.190	0.281	0.054	0.188	0.314	0.072	9/10kV	11/12.4kV	3250K
0.190	0.286	0.059	0.188	0.324	0.082	6.5/10kV	10/12.4kV	3500K
0.195	0.287	0.060	0.188	0.326	0.084	8.2/11kV	10/12.4kV	3750K
0.195	0.289	0.062	0.188	0.330	0.088	7.5/11kV	11/15kV	4000K

GE = Ground Electrode CE= Center Electrode kV= Kilovolts

Table 1: Sparking Life Comparison Testing

Igniter Design Temperature Capability and Effect on Ignition Leads: Champion's design approach to igniter development includes focus on thermal management to optimize life and survivability not only for the igniter, but the ignition lead also. Champion implemented design changes on its most demanding fielded igniter design application with the intent to reduce igniter to lead connection temperatures to enhance and improve ignition lead survivability. Lead connection temperatures were above the 450°F thermal limit for the silicone components (seals and conductor wire insulation). Champion introduced a reverse telescope hot-lock design that yielded terminal well temperatures **50-75°F** less (measured on engine) than the previous standard telescoping configurations. This significant temperature reduction can be the difference between premature lead failures and achievement of desired life.

Champion has reviewed field returns of NGK igniters and found the igniter design to show more heat discoloration on the silver plated region (terminal well area) than the Champion design. Champion recognizes this is due to the capability of the Champion design to reject/resist heat flow better than the NGK design. Champion's more favorable heat flow through the igniter also permits the sparking electrodes to remain cooler during operation and accounts for the lower erosion rate than the NGK igniter. See **Figure 2** for definition of these improved thermal management characteristics. Terminal well temperatures above the 450°F point will lead to critical silicone component thermal degradation and further result in dielectric punctures through thermally degraded wire insulation and lead seals. This all leads to ignition system reliability issues.