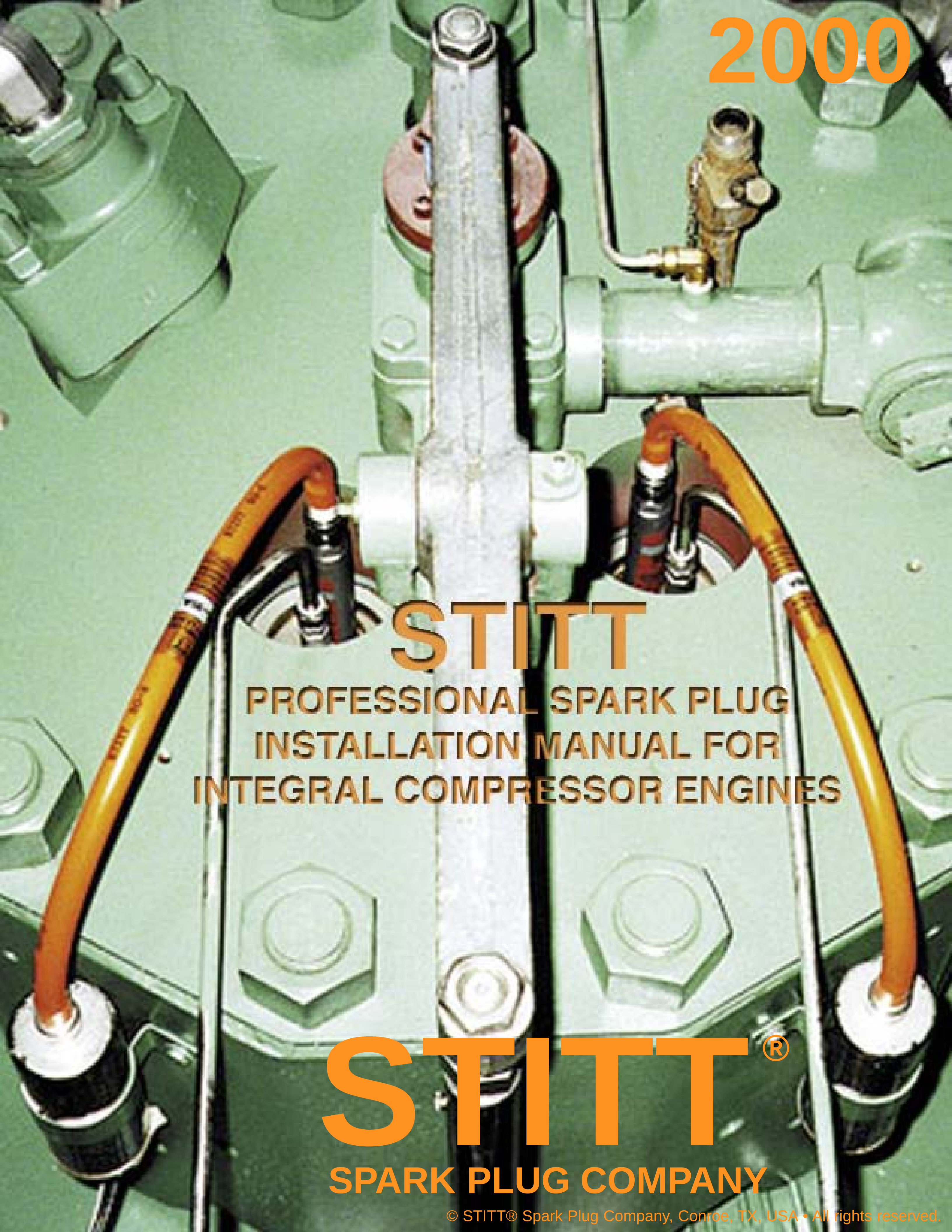


2000

STITT

PROFESSIONAL SPARK PLUG INSTALLATION MANUAL FOR INTEGRAL COMPRESSOR ENGINES

STITT®

SPARK PLUG COMPANY

A representative example of the Stitt one-piece, extended-length spark plugs incorporating the "AG" [Annular Gap] firing-end configuration. This configuration is intended for usage in pre-combustion chamber applications, principally. For more information, we recommend that our Annular Gap Catalog be consulted.

INSTALLING

A SET OF STITT "S-AG10-2" SPARK PLUGS
&
STITT "USL2A-18A" SAFETY-SHIELDED SECONDARY LEADS

Though it sounds as if installing a set of spark plugs is a pretty simple procedure, we have found that it is not always as simple as it is thought to be.

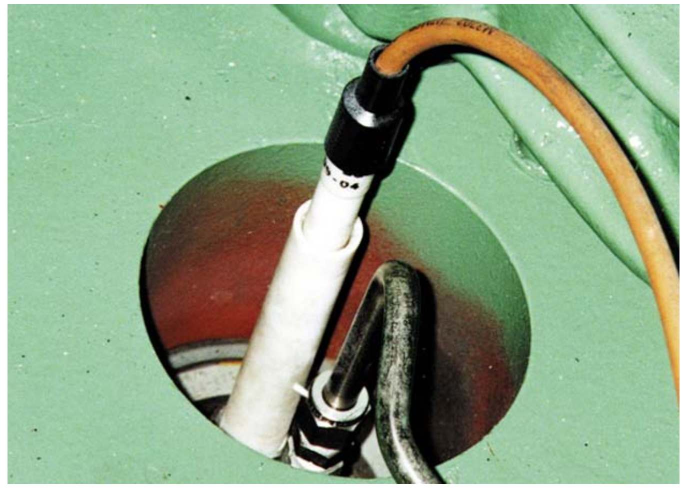
The method by which spark plugs are installed governs the future operating behavior of the engine. To assist the engine operator in eliminating spark plugs as a future operating problem site, we have developed this instruction manual to guide a professional spark plug installation.

The engine that we have selected to illustrate the proper procedures is a Clark Bros. (Dresser-Clark, Dresser-Rand)® TCVD12. This engine is a 2-stroke cycle, 450mm (17.72") X 483mm(19"), turbocharged, stationary, methane-fueled engine producing 6,000hp and driving integral compressors at 330rpm. The engine has been outfitted with precombustion chambers (PCC's) so as to produce cleaner exhaust emissions.

Because of the catastrophic failures of the insulators in the Cooper-Champion® RW80N spark plugs (exclusively recommended by Dresser-Rand for this application); because of the rapid deterioration of the plastic (Teflon®) spark plug boot extension assemblies, the engine operating company decided to replace the factory-sanctioned components with the Stitt recommended

Cooper-Champion RW80N after experiencing Insulator break-up during operation.

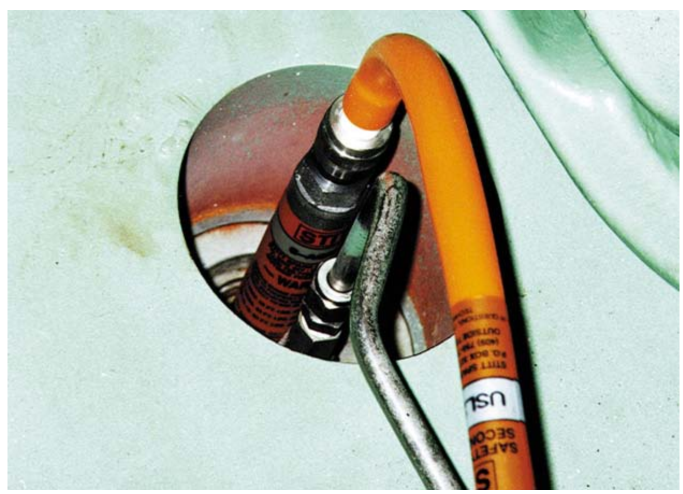
Within hours of the initial "on-site" engine start-up, the engine operating company noted that the Cooper-Champion spark plug failures resulted in a predictable electrical arc-fault in a Class 1, Group D, Division 2 location. In addition to the extra operating expense of unscheduled downtime required to replace the broken spark plugs.



Dresser-Rand factory configuration.

Also,the engine operating company noted that the engine manufacturer's component specification would result in a predictable dielectric puncturing of the plastic (Teflon) in a Class 1, Group D, Division 2 location, with an external arc-site forming from the spark plug to the fuel gas check valve (gas admission valve).

Based on those accurate assessments of risk and expense, this operating company replaced the factory-specified, high voltage ignition components with the Stitt Spark Plug Company product offerings to achieve performance and durability with "real" safety.



Stitt S-AG10-2 spark plug and Stitt USLA-18A Safety-Shielded secondary lead fitted to Dresser-Rand TCVD precombustion chambers.

Because spark plug performance and durability can be affected by other aspects of an engine's ignition system operation, the first part of this manual will attempt to guide the professional engine operator through the proper procedures for verifying the functionality and performance of those ignition system components (magneto, ignition control module, primary wiring, ignition coils) upstream of the spark plug, those components that drive the spark plug.

And never forget, from the objective level of engineering, the spark plug may be the most passive of secondary ignition components. It is principally a high voltage electricity feed-through providing a spark gap at a controlled rate of thermal transfer. When misfiring is detected, as a rule, it is not a combustion condition caused by the spark plug. If an ignition system component is responsible, it is typically a problem caused by the output inadequacies of the magneto or other ignition component shortcomings.

So for an optimized spark plug run, especially in an emissions critical gas engine, to eliminate other potential ignition problems, the first set of procedures for installing a set of spark plugs will not involve a spark plug...

PROCEDURE 1

VERIFYING FUNCTIONALITY OF "UPSTREAM" IGNITION SYSTEM COMPONENTS

For an engine of this elevated a BMEP at a continuous-duty level of performance, no deficiencies in critical components can be tolerated.

Though it is true that the Stitt "S-___-2" spark plug designs combined with the Stitt "USL2" Safety-Shielded secondary leads will solve the obvious problems of spark plug breakage and rapid Teflon deterioration, the Stitt components may not function as well as desired if there are any deficient upstream components in the ignition system.

Time constraints allowed this installation only the most elementary examination. But even at that level, it was determined that the ignition system components upstream of the spark plug were not "balanced". Some of them were not capable of furnishing the necessary ignition energy under any operating condition.

This very simple and fast examination of primary ignition circuit resistance values (Ohms,) revealed that the resistance levels for one cylinder were out of specification (too high). For this cylinder in the firing-order, the spark plugs were going to have a more difficult time being supplied with output energy from the ignition module. And though that is indicative of a primary wiring problem that should be corrected, that would have to take place at a later date when extra engine downtime could be scheduled.

What this examination did confirm is that all the primary wiring had continuity based on this ignition component manufacturer's specification. The ignition coils were all receiving input energy from the capacitors in the ignition module.

Two of the ignition coils were found to be non-functional. For this engine, that meant that one precombustion chamber was "dead" in two different cylinders. The spark plug could not fire because the coil was unable to supply it with energy.

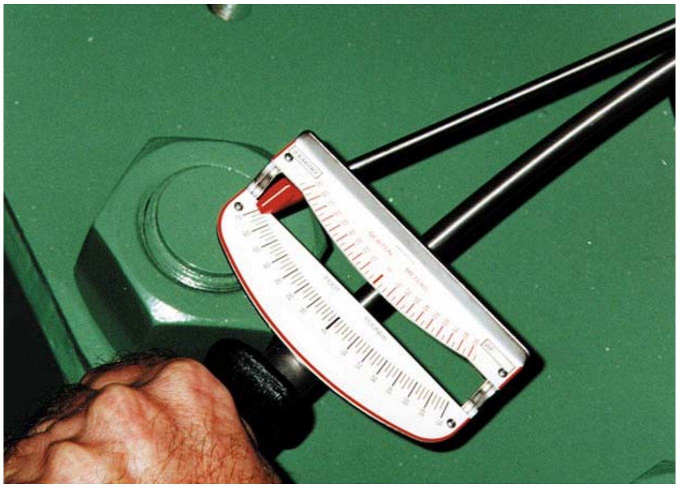
The "dead" coils were replaced at cylinder 2L, "Left-side precombustion chamber" and 2R, "Left-side precombustion chamber". Having identified and corrected the major deficiency with the upstream ignition components, the spark plug installation went forward.

SPECIAL NOTE:_In addition to the elementary Simpson Ohmmeter, there are other recommended instruments to verify ignition component condition. For example, a MegOhmmeter (Megger) for insulation evaluation, a heavy duty coil tester (Graham tester, for example) for ignition coil evaluation, and an oscilloscope (Engine Analyzer) for overall ignition system evaluation should be used to supplement the conventional Ohmmeter if a more complete picture of ignition system performance is to be assured. We recommend that you consult the ignition system component manufacturer for the recommended evaluation procedures of the ignition system component that is to be examined._

PROCEDURE 2

REMOVAL OF SPARK PLUGS

For this reference installation, we wanted to measure the “breakaway” torque required to remove each spark plug. Using a balance-beam style of torque wrench, here are the indicated results. The limit on this Stitt Torque Wrench is 75 ft. lbs.



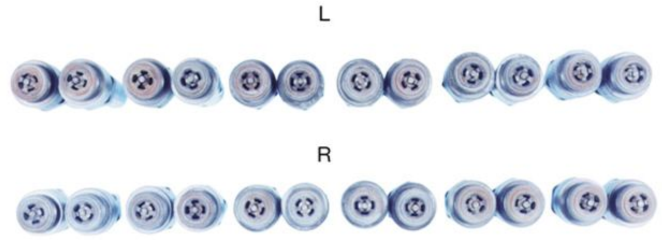
SPARK PLUG
BREAKAWAY TORQUE

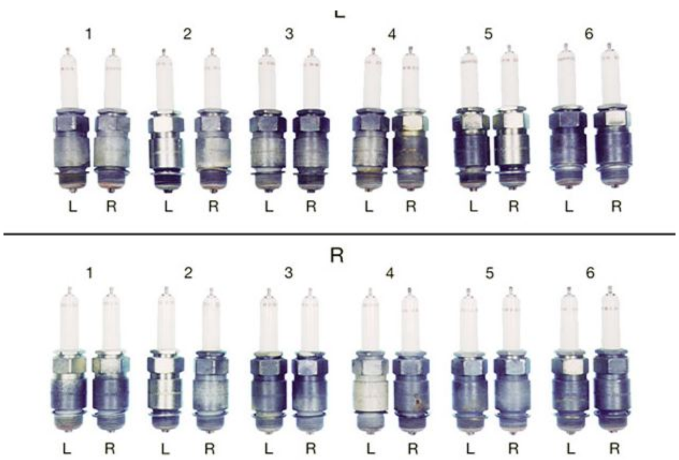
LEFT BANK				RIGHT BANK			
Cyl.#	Position	Ft. Lbs.	Newton Meters	Cyl.#	Position	Ft. Lbs.	Newton Meters
1	L	75+	100+	1	L	75+	100+
1	R	52	70	1	R	52	70
2	L	10	15	2	L	10	15
2	R	75+	100+	2	R	75+	100+
3	L	0	0	3	L	0	0
3	R	10	15	3	R	10	15
4	L	0	0	4	L	0	0
4	R	72	98	4	R	72	98
5	L	42	60	5	L	42	60
5	R	38	55	5	R	38	55
6	L	55	75	6	L	55	75
6	R	35	50	6	R	35	50

It should be noted that certain spark plugs could not be loosened at the maximum level (75 ft.lbs.) that can be indicated by our recommended style of torque wrench. Other spark plugs required either no breakaway torque or an excessively low level of breakaway torque: these were only hand-tight in the precombustion chambers. These extremes of abnormal spark plug tightness can be revealing of conditions that can cause serious spark plug operating problems.

The spark plug removal process should provide for the spark plugs being marked for the engine cylinder location in which they operated. For this engine, standing on the catwalk, looking at the cylinder head, the spark plug positions would be clearly identified as 1LL (cylinder #1 Left bank, Left side spark plug), 1LR (cylinder #1 Left bank, Right side spark plug); 2LL, 2LR; and so on.

The spark plugs should be visually examined so as to identify any anomalies.



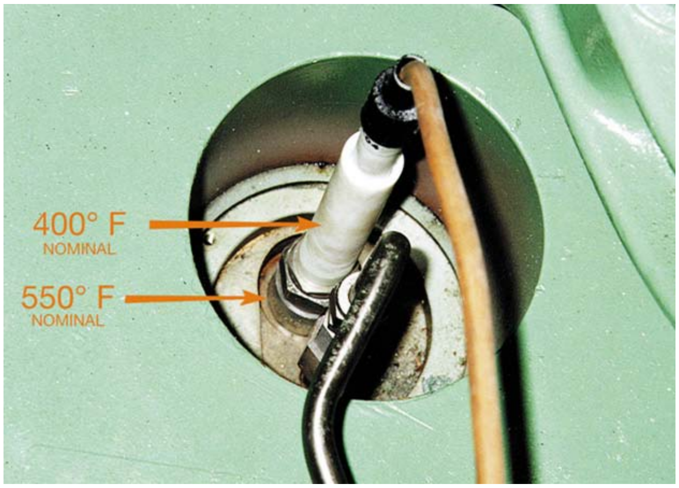


Visual analysis of spark plugs removed from service. Major interest is to quickly determine where there are differences on the engine that the spark plug might reveal.

If plastic (Teflon) extension-spark plug boot assemblies are going to be operated, then at each spark plug change, these assemblies should be inspected and validated as being suitable for a return to service.

Plastic (Teflon) extension assemblies removed after approximately 1,500 hours of operation. In even this short a period of time, the thermal distress exhibited in the bottom two inches (50.8mm) would indicate to us that these components are running up on the requirement that should call for their replacement if emissions critical operation is to be assured.

The reason for this level of inspection is because Teflon, like all polymeric materials, deteriorates over time when exposed to certain temperature levels. In this application, where the Teflon is attached to an operating spark plug in a stationary engine application, the continuous exposure to elevated operating temperatures will accelerate Teflon's loss of electrical insulation capabilities.



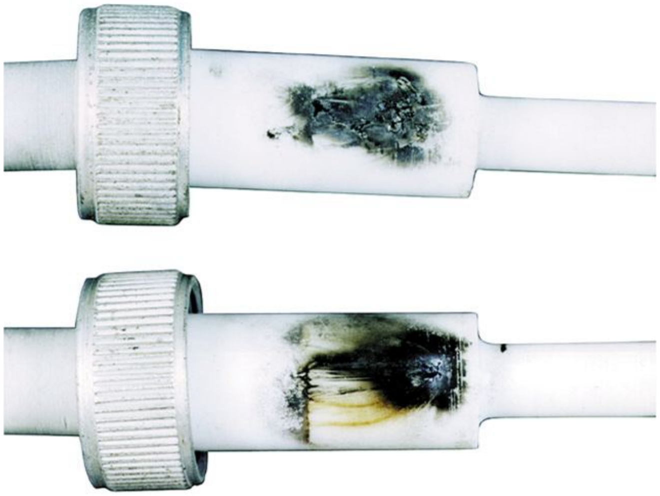
Temperatures in the areas of a spark plug and extension assembly in an operating, stationary engine.

In fact, virtually from the time this plastic material was first put into service on this engine, it was subjected to an operating temperature level that exceeded the Underwriters Laboratories Temperature Index for Teflon (PTFE), 356°F (180°C). Essentially, this Index identifies a polymeric material's maximum continuous-use temperature under very low continuous or low intermittent stresses in applications requiring maximum retention of the desired properties. In this case, the desired property is electrical insulation. But in this ignition application, the stresses are high continuous and the requirement is maximum retention of the desired property. Recognizing this, the short performance life of Teflon under these conditions must be considered.

Technically, the only way that we know that this material can be validated as regards its dielectric capabilities is to pass it through a high voltage dielectric testing loop. If that kind of testing cannot be performed, you might want to question the usage of such predictably failure-prone ignition components, especially if they are intended to be reusable.

At the very least, we recommend that the engine operator examine them visually for evidence of thermal deterioration and dielectric puncturing.

Without some high level of inspection, validation of performance, Teflon (and all other polymeric materials) are not suitable for performing as an electric insulator for any long-term exposure to the temperatures that those materials will be subjected to in normal operation in an engine (see our manual #PTFE-5/96).



Some industrial ignition component manufacturers offer only plastic terminations at a favorite price. This photograph is of a major ignition system component manufacturers plastic (Teflon) insulators exhibiting dielectric puncturing. This common style of insulation failure in this location should be of major concern to the engine operator. It causes misfiring, of course. Not a desirable situation for an emissions critical gas engine. It should be noted that these insulation failures are occurring at a location that operates at temperatures hundreds of degrees cooler than the same material that is electrically insulating the high voltage connection to the spark plug.

For the emissions critical gas engine, the durability problem of a supposedly reusable ignition component fabricated from plastic materials should be seriously investigated.

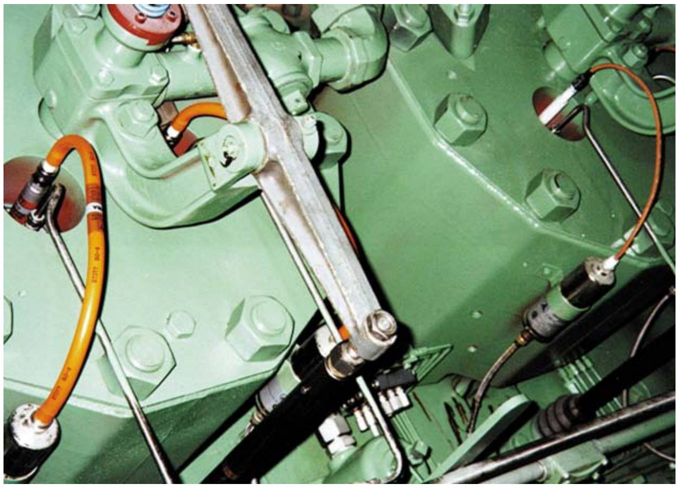
For this engine, eliminating this plastic component will eliminate a certain failure site. Not to have to reuse them, not to have to replace them, will save thousands of operating cost dollars.

From an installed cost analysis, the Stitt components will be less costly than those recommended by the engine manufacturer.

The Stitt S-AG10-2 spark plugs cost no more than the short Cooper-Champion RW80N spark plugs. No expensive and failure-prone plastic extension has to be used, and re-used, when using the one-piece, extended-length Stitt "S-___-2" series of spark plugs (e.g., S-AG10-2).

The one-piece, extended-length "S-___-2" series spark plugs, combined with the all 96% alumina oxide ceramic termination "USL2" Safety-Shielded secondary leads, results in a significant advance over the components favored by Dresser-Rand. Using the Stitt components, operating deficiencies are eliminated by design. The operating thermal environment is countered by Stitt's elimination of plastic, termination components.

The best news for the engine operator is that the Stitt solutions are no more expensive than the engine manufacturer's plastic ideas.



STITT Replacement Components

1. STITT S-AG10-2
2. STITT USL2A-18A Safety-Shielded Secondary Lead

Dresser-Rand Factory Components

1. Cooper-Champion RW80N
2. Teflon Extension Assembly
3. Secondary Lead

THE MOST COST-EFFECTIVE HIGH VOLTAGE IGNITION COMPONENTS FOR OPERATING THIS ENGINE ARE THOSE RECOMMENDED BY STITT.

PROCEDURE 3

VERIFYING THE CONDITION OF THE SPARK PLUG PORTS

The threads of all Stitt spark plugs are rolled threads. And they are formed to comply with dimensions that are standardized by the Society of Automotive Engineers (SAE). These dimensions are published annually in the SAE HANDBOOK as Standards for Spark Plugs - SAE J548d.

SPARK PLUG THREADS

Spark Plug Thread Size	Major Dia. Max mm	Major Dia. Min mm	Pitch Dia. Max mm	Pitch Dia. Min mm	Minor Dia. Max mm	Minor Dia. Min mm
14mm x 1.25mm	13.868 (0.5460")	13.868 (0.5460")	13.104 (0.5159")	12.997 (0.5177")	12.339 (0.4858")	
18mm x 1.5mm	17.955 (0.7069")	17.955 (0.7069")	16.980 (0.6685")	16.853 (0.6635")	16.053 (0.6320")	
7/8" - 18	22.225 (0.8750")	22.225 (0.8750")	21.295 (0.8384")	21.191 (0.8343")	20.493 (0.8068")	

It must be noted that the SAE also establishes standard dimensions for the threads in the cylinder head into which the spark plug will be fitted. The reason for this should be clear: The cylinder head, the precombustion chamber, the spark plug adapter must be in the proper condition to accept a SAE J548d-dimensioned spark plug.

SPARK PLUG PORT THREADS

Spark Plug Thread Size	Major Dia. Max mm	Major Dia. Min mm	Major Dia. Max mm	Major Dia. Min mm	Major Dia. Max mm	Major Dia. Min mm
14mm x 1.25mm		14.034 (0.5525")	13.297 (0.5235")	13.188 (0.5192")	12.692 (0.4997")	12.499 (0.4921")
18mm x 1.5mm		18.039 (0.7102")	17.153 (0.6753")	17.026 (0.6703")	16.426 (0.6467")	16.266 (0.6404")
7/8" - 18		22.225 (0.8750")	21.412 (0.8430")	21.308 (0.8389")	20.851 (0.8209")	20.698 (0.8149")

If the spark plug port threads in the cylinder head are below the SAE minimum dimensions, then the spark plug may not be easily removable after it has finished its operating interval. It has been our observation over the years that most reports of spark plug seizing have not been the fault of the spark plug, nor an instance of "galling". What we have found to be the case in virtually all instances of spark plug "sticking" is spark plug port threads either in the cylinder head, or in the precombustion chamber, or in the spark plug adapter (diesel conversions) that are undersize.

Typically, the undersized spark plug port is found in engines (cylinder heads) that are relatively new. That an undersized spark plug port is allowed to reach the engine operator is the result of the engine manufacturer (cylinder head manufacturer, cylinder head repairer) failing to gauge the spark plug port threads for compliance with SAE J548d as a routine Quality Control procedure. Irrespective of ISO 9000 certifications, we do not think that any engine manufacturer gauges 100% of these critical threads. Statistically, this can only mean that defective spark plug port threads will be reaching the engine operator.

Engines that have been in service for some years can also have undersized ports. Generally this is caused by the residue of combustion carbon, and or thread compound building up in the roots of the spark plug port threads.

More typically, we find that the older engine (particularly integral compressor engines using 7/8"-18 threads) has spark plug port threads that exceed the SAE standard dimensions. And that is because spark plug port threads are a wear area. Each time a spark plug is screwed in and out of a spark plug port, some material will be removed from the port threads, gradually enlarging them over time.

When a spark plug port is enlarged beyond the SAE maximum dimensions, then the spark plug may not be able to transfer combustion heat out of its firing-end into the engine cooling medium at the rate that is required to keep the spark plug thermally compatible with the engine's thermal loading. This can result in accelerated rates of wear (erosion) of the spark plug electrodes. This is often noticed as shorter than expected spark plug life.

In some instances, it will be the oversized spark plug port that will be the real culprit that causes spark plug galling. Because of the oversize spark plug port preventing normal rates of thermal transfer out of the spark plug threads, the spark plug steel will have been forced to operate at temperature levels that promote true thermal galling.

So, recognizing now how the spark plug port threads can affect a spark plug's operation, we advise the operator that a professional spark plug installation must include a set of procedures intended to benchmark spark plug port conditions. We recommend that this gauging process be conducted in the following manner

SPARK PLUG PORT GAUGING PROCEDURE

Using the TCVD12 for illustration, here are the steps that should be taken in the proper sequence.

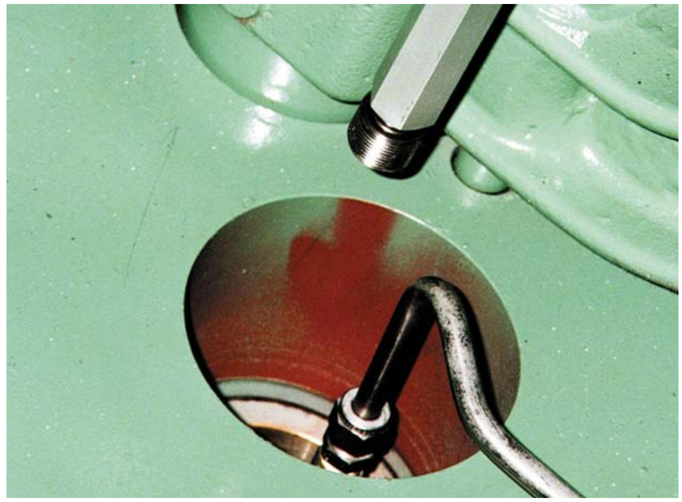
1. Because oversize spark plug port threads cannot be remedied with the cylinder head on the engine, the first thing that should be done is to identify which spark plug ports (cylinder heads) are out of tolerance because they are oversize. This requires the usage of the NO GO side of our "GO-NO GO" gauges.

GNG14 for 14mm x 1.25 SAE spark plug ports

GNG18 for 18mm x 1.5 SAE spark plug ports

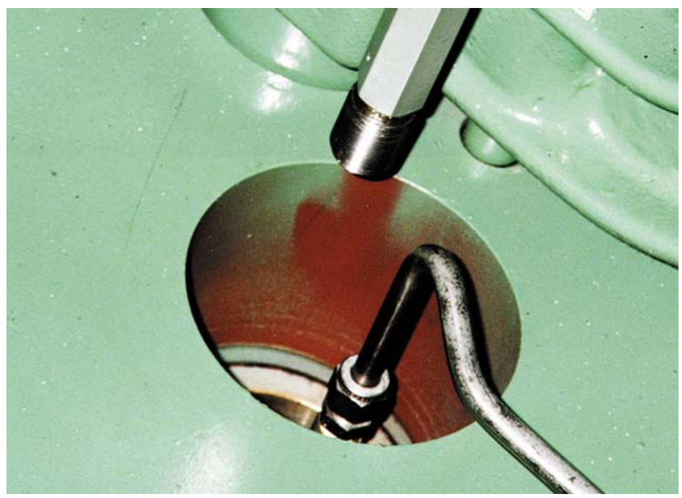
GNG78 for 7/8" - 18 SAE spark plug ports

For spark plug ports that are at the bottom of deep spark plug wells, these gauges must be fitted into an extended length holder if they are to be used successfully. For this TCVD12 that has its 7/8"-18 spark plug ports at the bottom of a spark plug well, we recommend that our GNG78X8 be used. For other engine models, "GO-NO GO" gauges with compatible extended length holders are listed in the chart on page 12 of this manual.



For the subject TCVD12, the NO GO gauge could not be threaded into any spark plug port. Based on this result, it can be safely recorded that no precombustion chamber has an oversize port.

2. Having verified that there are no spark plug ports unsuitable for service because of enlarged spark plug port threads, the GO side of the gauge was used to determine whether the engine has any undersize spark plug ports.



For the subject TCVD12, the GO gauge could not be threaded into sixteen (16) of the twenty-four (24) spark plug ports. According to the gauge, only two (2) cylinders (1R & 4R) had a pair of properly dimensioned spark plug ports. And that probably explains why the engine operator routinely used thread lubricant. The operator, never having gauged these threads before this installation, had always thought that spark plug "sticking" was a spark plug problem. Little did the operator realize that the heart of the "sticking" problem probably resided in the spark plug port threads as were furnished by the engine manufacturer. In fact, in the light of our findings concerning spark plug port dimensioning, it might be said that many engine operators are using thread lubricants to facilitate spark plug installation.

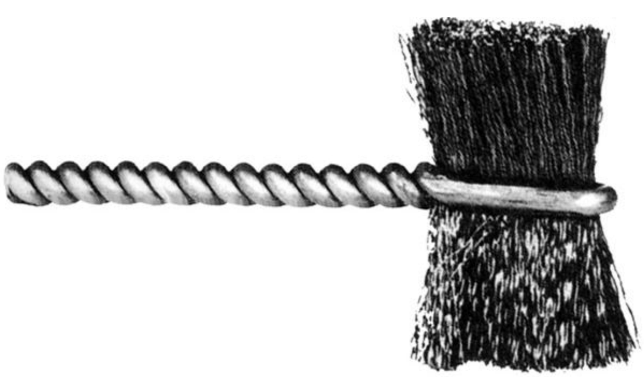
3. Because an accumulation of carbonized thread lubricant in a spark plug port can prevent a GO gauge from threading into the port, it is important that such debris be removed so that a determination can be made as to why the GO gauge is unable to be threaded into the spark plug port. In other words, is the spark plug port really defective? Or, has it just been rendered undersize because the thread lubricant and other debris have never been removed from the roots of the port threads?

Though the operator believed that he had been cleaning out the spark plug threads by routinely screwing a thread chasing tool into the ports, it must be emphasized here that such tools may not be dimensioned so as to remove the material that has lodged in the roots of the port threads. Using such a tool might make an engine operator feel as if he has been doing a conscientious maintenance job, but that is all the operator has been getting out of using such a tool. Just a feeling.

A proper thread cleaning is not accomplished by the use of many popular thread chasers.

FBT78 Full Bottoming Tap for 7/8” 18 SAE spark plug ports.

Though the Full Bottoming Tap is a splendid tool for cleaning out very hard to clean spark plug ports, it is an unforgiving tool. Carefully used, it can benefit an engine. Carelessly used, it can damage an engine. We do not favor its usage unless the component it is to be used on can be removed from the engine and taken to a good workshop.



BR78 Clean-Out Brush.

To completely and safely clean a spark plug port without dismantling the engine, the only tool that we can recommend is one of our spark plug port Clean-Out Brushes. These are fabricated from fine wire steel and are dimensioned for each principal industrial spark plug thread size (14mm, 18mm, 7/8”-18).

1. BR14 for 14mm X 1.25mm SAE spark plug ports
2. BR18 for 18mm X 1.5mm SAE spark plug ports
3. BR78 for 7/8”-18 SAE spark plug ports

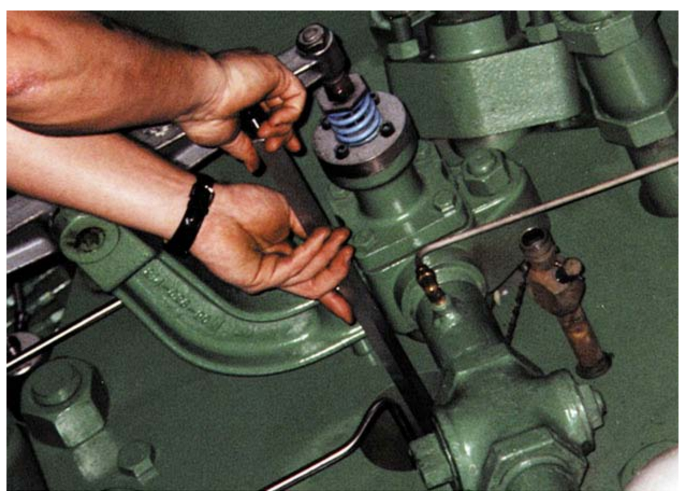
These brushes are meant to be used with a reversible drill motor. And for the deep spark plug well cylinder head, extensions are offered so that the brush can be used. For a complete listing of Clean-Out Brushes, Clean-Out Brush Holders, and Extensions for various engine models, see the chart on page 11 of this manual.

For the TCVD12, the BR78 would be used with the BH2 brush holder and two (2) BX6 brush holder extensions.

4. After cleaning, the spark plug ports should be gauged again with the GO side of the GNG78X8 gauge.

But since cleaning might now reveal that the spark plug ports could be oversize, the NO GO side of the GNG78X8 should be re-used to verify that none of these ports is oversize. The NO GO side of the gauge still could not be threaded into the spark plug ports of these cylinders.

5. After cleaning, the GO side of the GNG78X8 still could not be threaded into the spark plug ports of any additional precombustion chambers. So, six teen (16) precombustion chambers could only be noted then as being intrinsically undersize.



6. The operator of this TCVD12 now had to make the determination as to whether to remove these precombustion chambers with defective spark plug ports and replace them. Or whether to leave them on the engine and enlarge the ports (bring them into compliance with the minimum SAE specifications)

by using the Stitt 7/8”-18 Full-Bottoming Tap (FBT78) and extended length holder (FBTX12).

ENGINE SPARK PLUG PORT MAP

LEFT BANK				RIGHT BANK			
Cyl. #	Position	Under-Size	Counter-Bore	Cyl. #	Position	Under-Size	Counter-Bore
1	L	Y	No	1	L	N	No
1	R	Y	No	1	R	N	No
2	L	Y	No	2	L	N	No
2	R	Y	No	2	R	Y	No
3	L	Y	No	3	L	Y	No
3	R	Y	No	3	R	Y	No
4	L	N	No	4	L	N	No
4	R	Y	No	4	R	N	No
5	L	Y	No	5	L	Y	No
5	R	N	No	5	R	Y	No
6	L	Y	No	6	L	Y	No
6	R	N	No	6	R	Y	No

Because the operator needed to have this engine back in service as soon as possible, it was decided to do nothing at this time beyond noting the gauging results. For future rectification.

SPECIAL NOTE:

IT IS IMPORTANT TO NOTE THAT OUR SPARK PLUG PORT CLEANING PROCEDURES WERE DEVELOPED FOR NON-PRECOMBUSTION CHAMBER ENGINES. FOR ALL CIRCUMSTANCES, ESPECIALLY SOME PRECOMBUSTION CHAMBER DESIGNS, WE DO NOT KNOW IF THE CLEANING SHOULD EVER BE PERFORMED WITH THE PRECOMBUSTION CHAMBER FITTED INTO THE ENGINE. WE THINK THAT IS A DECISION BEST LEFT TO THE OPERATING COMPANY MAINTENANCE PROCEDURES FOR RESOLUTION.

BUT, FOR A MAIN GALLERY COMBUSTION ENGINE, BECAUSE THREAD TAPPING COMPOUND MAY BE USED, BECAUSE THE CLEAN-OUT BRUSHING WAS PERFORMED, THERE IS ALWAYS THE POSSIBILITY THAT DEBRIS FROM THESE PROCEDURES WILL FALL INTO THE POWER CYLINDERS AND WILL BE LEFT ON PISTON CROWNS.

SO, TO CONCLUDE THESE PROCEDURES PROFESSIONALLY, THE ENGINE SHOULD BE CRANKED WITH THE SPARK PLUG PORTS OPEN. THIS SHOULD BLOW-OUT ANY OF THE DEBRIS FROM THE CLEAN-OUT AND TAPPING PROCEDURES. ONLY AFTER THIS HAS BEEN DONE IS THE ENGINE READY FOR THE INSTALLATION OF THE SPARK PLUGS.

PROCEDURE 4

FITTING THE SPARK PLUGS

Now that the spark plug ports have been cleaned and have been verified as to their compliance, or non-compliance, with the SAE specifications, the spark plugs can be installed.

The spark plug installation should be accomplished in this sequence of steps

1. Each one of the Stitt “S-___-2” series spark plugs (in this instance, the S-AG10-2) should be checked for gap dimension before its installation.

Even though our factory prides itself on packaging spark plugs that have been properly gapped, we recommend that the operator use the accompanying gap gauge, except for Annular Gap designs, to verify that the gaps are to the proper dimension.

Once the proper spark gap dimensions have been verified, the spark plugs are ready for fitting into the spark plug ports.

2. **Do Not Apply Thread Lubricant To The Spark Plugs.** With spark plug ports clean and in compliance with the SAE specifications there should be no need for any compound to be applied to these spark plug threads.

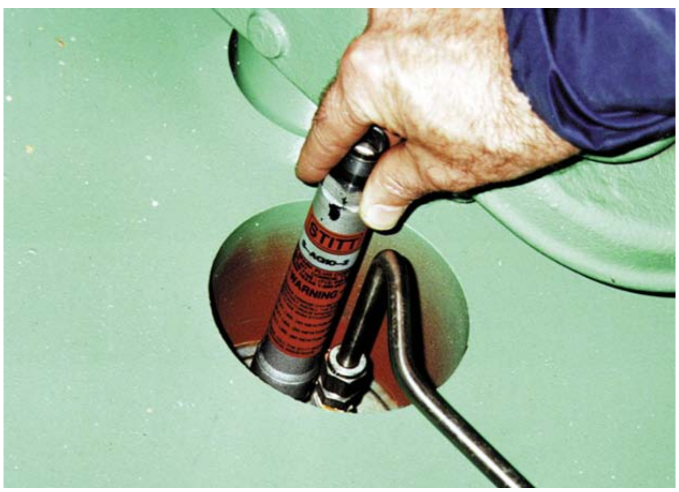
Regular STITT Black Oxide Finish

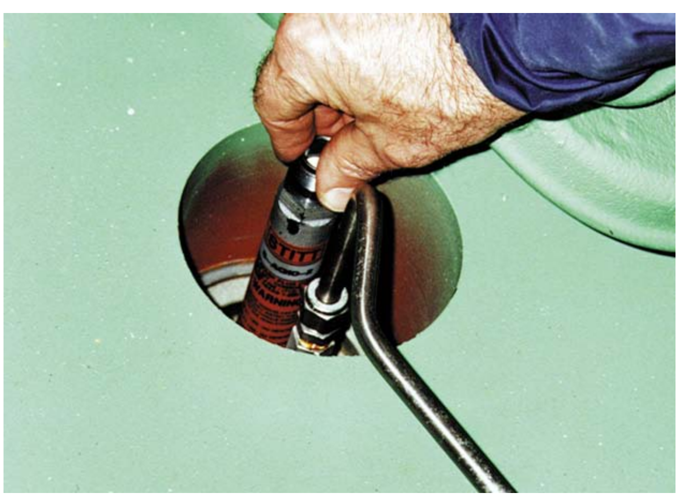
“NP” suffix-designated surface for enhanced anti-galling properties. This vacuum-deposited preparation consists of a tribological linear bearing surface.of nickel-silver-palladium.

But, if an extra measure of anti-galling protection is desired, then we can only recommend that our factory-applied, ion-implanted, nickel-silver-palladium, linear bearing, surface finish, spark plugs be installed. We consider this surface finish to be the only anti-galling treatment currently available for spark plug threads. No electroless nickel, no zinc chromate, no electrolytic copper-nickel methods of surface finishing offer any equivalent level of anti-galling protection to this uniquely Stitt process.

If this style of anti-galling surface finish is desired, the spark plugs must be ordered with a “NP” suffix specified. In this instance, the proper spark plug part number would be S-AG10-2NP.

3. The proper procedure for fitting a spark plug is to thread it to the external seat gasket position by hand. For the deep spark plug well cylinder head, only Stitt offers a spark plug that allows this proper installation procedure.





4. After all the spark plugs have been fitted hand-tight, the spark plugs should be given time to thermally normalize with the warm engine. Only then are the spark plugs ready to be final torqued into the engine.

STANDARDS FOR SPARK PLUGS, J548d

Spark Plug Thread Size	Required Installation Torque	
	Cast Iron Cylinder Head	Aluminum Cylinder Head
7/8" - 18 (FS-78 external seat gasket)	50 - 60 ft. lbs. 68 - 81 Newton Meters	
18mm x1.5mm (FS-18 external seat gasket)	32 - 38 ft. lbs. 43 - 53 Newton Meters	28 - 34 ft. lbs. 38 - 46 Newton Meters
14mm x1.25mm (FS-14 external seat gasket)	26 - 30 ft. lbs. 35 - 40 Newton Meters	15 - 22 ft. lbs. 20 - 30 Newton Meters

CONICAL / TAPER SEAT

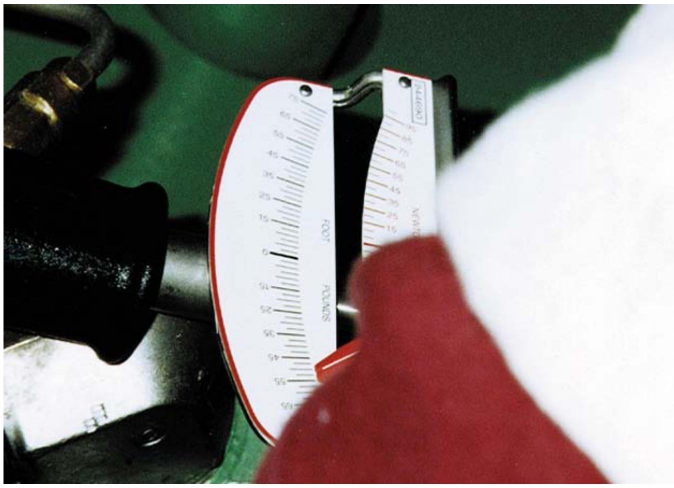
Spark Plug Thread Size	Required Installation Torque	
	Cast Iron Cylinder Head	Aluminum Cylinder Head
18mm x 1.5mm	15 - 20 ft. lbs. 20 - 27 Newton Meters	15 - 20 ft. lbs. 20 - 27 Newton Meters
14mm x 1.25mm	7 - 15 ft. lbs. 9 - 20 Newton Meters	7 - 15 ft. lbs. 9 - 20 Newton Meters

This procedure is a very critical one and must be performed in compliance to the SAE Standard For Spark Plugs J548d.

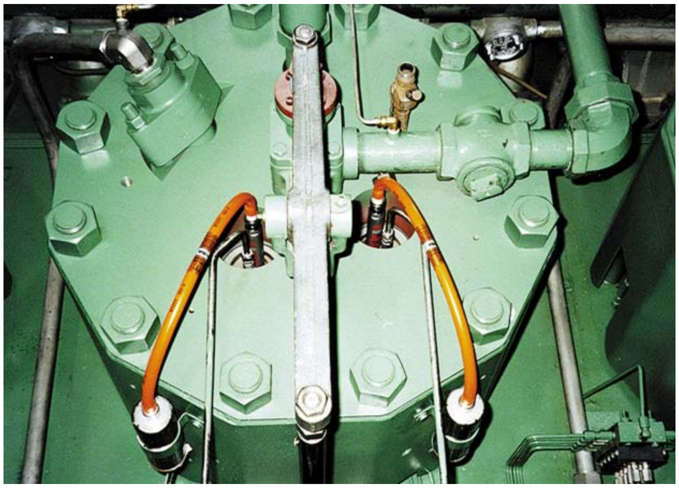
The only tool that is acceptable for this procedure is an indicating torque wrench of known accuracy. We cannot recommend any other tool.

The STITT recommended style of torque wrench.

Furthermore, we strongly recommend that only a balance-beam style of torque wrench be used. This style of indicating torque wrench assures a smoother, more accurate level of torque than any “click” style(dial type) of torque wrench. The Stitt part number for a wrench of this style that is calibrated so as to handle all the conventional industrial thread sizes is our TW487.



5. After the spark plugs have been secured into the cylinder heads by the application of proper installation torque, then the STITT silicone-insulated, Safety-Shielded Secondary Leads (USL2, ESL2, RSL2 series) can be connected to the spark plugs and the ignition coils.



STITT S-AG10-2 Spark Plugs and the STITT USL2A-18A Safety-Shielded Secondary Leads installed and ready for start-up

6. At this stage, the professional spark plug installation has been completed. Every other aspect of the engine being ready, the engine can be started according to the operator's recommended start-up procedures.

PROCEDURE 5

ENGINE START-UP

After notification to gas control that the engine was ready for being put on line, it was put on line.

All ignition components functional (even though the primary wiring still needed to be optimized), the engine took the 112% load that was immediately asked of it.

PORT CLEANING BRUSH RECOMMENDATIONS FOR SPECIFIC ENGINES

1. AJAX (ALL MODELS): BR78

2. ARROW “C” SERIES (18mm PORTS): BR18
   ARROW “L” SERIES (7/8-48 PORTS): BR78
   ARROW “VR” SERIES (14mm PORTS): BR14
   ARROW “VR” SERIES (18mm PORTS): BR18

3. CATERPILLAR (ALL EXCEPT 3400, 3500, 3600, SERIES): BR14 (Use With 2 BX6 Extensions)
   CATERPILLAR (3400 SERIES): BR14 (Use With 2 BX6 Extensions)
   CATERPILLAR (3500, 3600 SERIES): BR18 (Use With 3 BX6 Extensions)

4. CLARK (ALL MODELS): BR78 (Use With 2 BX6 Extensions)
   CLARK (CAST-IN PRECHAMBERS): BR78 (Use With 1 BX6 Extensions)
   CLARK (SIPC PRECHAMBERS): BR14 (Use With 2 BX6 Extensions)

5. COOPER-BESSEMER (GMX SERIES): BR78
   COOPER-BESSEMER (GMW, GMV SERIES): BR78 (Use With 1 BX6 Extensions)
   COOPER-BESSEMER (W330, Z330 SERIES): BR78 (Use With 2 BX6 Extensions)
   COOPER-BESSEMER (LS, LSV SERIES, 7/8-18 PORTS): BR78 (Use With 3 BX6 Extensions)
   COOPER-BESSEMER (JET-CELL PRECHAMBERS): BR78 (Use With 1 BX6 Extension)

6. CUMMINS (14mm HEADS EXCEPT B. C SERIES): BR14 (Use With 3 BX6 Extensions)
   CUMMINS (B, C SERIES): BR14

7. DEERE (ALL CURRENT PRODUCTION MODELS): BR14

8. DELAVAL (ALL7/8-18 HEADS): BR78 (Use With 3 BX6 Extensions)

9. DETROIT DIESEL (S30G): BR14 (Use With 1 BX6 Extensions)
   DETROIT DIESEL (S50G, S60G): BR14 (Use With 2 BX6 Extensions)

10. FAIRBANKS-MORSE (ALL “OP” MODELS): BR18

11. FORD (ALL 14mm PORTS): BR14
    FORD (ALL 18mm PORTS): BR18

12. GEMINI (ALL MODELS): BR14 (Use With 1 BX6 Extensions)

13. GENERAL MOTORS: BR14

14. HERCULES (1600, 2300, 3400 SERIES): BR14
    HERCULES (4800 SERIES): BR14 (Use With 1 BX6 Extensions)

15. INGERSOLL-RAND (ALL MODELS): BR78

16. SUPERIOR (ALL HISTORICAL MODELS): BR18
    SUPERIOR (ALL MITSUBISHI CONVERSIONS): BR18 (Use With 2 BX6 Extensions)

17. WAUKESHA (1197, 1905, 2475, 3711): BR18
    WAUKESHA (817, 220, 330): BR14
    WAUKESHA (2895, 3521, 5108, 5790, 7042, 9390): BR18 (Use With 2 BX6 Extensions)
    WAUKESHA (F18, H24, L36, P48): BR18 (Use With 2 BX6 Extensions)
    WAUKESHA (AT25, AT27): BR18 (Use With 3 BX6 Extensions)
    WAUKESHA (F11): BR14 (Use With 1 BX6 Extensions)

18. WORTHINGTON (SLHC, UTC, SUTC, ML, MLV): BR78 (Use With 4 BX6 Extensions)

FULL BOTTOM TAP RECOMMENDATIONS FOR SPECIFIC ENGINES

1. AJAX (ALL MODELS): FBT78

2. ARROW “C” SERIES (18mm PORTS): FBT18
   ARROW “L” SERIES (7/8-48 PORTS): FBT78
   ARROW “VR” SERIES (14mm PORTS): FBT14
   ARROW “VR” SERIES (18mm PORTS): FBT18

3. CATERPILLAR (ALL EXCEPT 3400, 3500, 3600, SERIES): FBT14X9
   CATERPILLAR (3400 SERIES): FBT14X16
   CATERPILLAR (3500, 3600 SERIES): FBT18X20

4. CLARK (ALL MODELS): FBT78X16
   CLARK (CAST-IN PRECHAMBERS): FBT78X8
   CLARK (SIPC PRECHAMBERS): FBT14X9

5. COOPER-BESSEMER (GMX SERIES): FBT78
   COOPER-BESSEMER (GMW, GMV SERIES): FBT78X6
   COOPER-BESSEMER (W330, Z330 SERIES): FBT78X14)
   COOPER-BESSEMER (LS, LSV SERIES, 7/8-18 PORTS): FBT78X20
   COOPER-BESSEMER (JET-CELL PRECHAMBERS): FBT78X8

6. CUMMINS (14mm HEADS EXCEPT B. C SERIES): FBT14X16
   CUMMINS (B, C SERIES): FBT14

7. DEERE (ALL CURRENT PRODUCTION MODELS): FBT14

8. DELAVAL (ALL7/8-18 HEADS): FBT78X20

9. DETROIT DIESEL (S30G): FBT14X19
   DETROIT DIESEL (S50G, S60G): FBT14X16

10. FAIRBANKS-MORSE (ALL “OP” MODELS): FBT18

11. FORD (ALL 14mm PORTS): FBT14
    FORD (ALL 18mm PORTS): FBT18

12. GEMINI (ALL MODELS): FBT14X9

13. GENERAL MOTORS: FBT14

14. HERCULES (1600, 2300, 3400 SERIES): FBT14
    HERCULES (4800 SERIES): FBT14X9

15. INGERSOLL-RAND (ALL MODELS): FBT78

16. SUPERIOR (ALL HISTORICAL MODELS): FBT18
    SUPERIOR (ALL MITSUBISHI CONVERSIONS): FBT18X16

17. WAUKESHA (1197, 1905, 2475, 3711): FBT18
    WAUKESHA (817, 220, 330): FBT14
    WAUKESHA (2895, 3521, 5108, 5790, 7042, 9390): FBT18X16
    WAUKESHA (F18, H24, L36, P48): FBT18X16
    WAUKESHA (AT25, AT27): FBT18X24
    WAUKESHA (F11): FBT14X9

18. WORTHINGTON (SLHC, UTC, SUTC, ML, MLV): FBT78X28

THREAD GO - NO GO GAUGE RECOMMENDATIONS FOR SPECIFIC ENGINES

1. AJAX (ALL MODELS): GNG78

2. ARROW "C" SERIES (18mm PORTS): GNG18
   ARROW "L" SERIES (7/8-48 PORTS): GNG78
   ARROW "VR" SERIES (14mm PORTS): GNG14
   ARROW "VR" SERIES (18mm PORTS): GNG18

3. CATERPILLAR (ALL EXCEPT 3400, 3500, 3600, SERIES): GNG14X9
   CATERPILLAR (3400 SERIES): GNG14X16
   CATERPILLAR (3500, 3600 SERIES): GNG18X20

4. CLARK (ALL MODELS): GNG78X16
   CLARK (CAST-IN PRECHAMBERS): GNG78X8
   CLARK (SIPC PRECHAMBERS): GNG14X9

5. COOPER-BESSEMER (GMX SERIES): GNG78
   COOPER-BESSEMER (GMW, GMV SERIES): GNG78X6
   COOPER-BESSEMER (W330, Z330 SERIES): GNG78X14
   COOPER-BESSEMER (LS, LSV SERIES, 7/8-18 PORTS): GNG78X20
   COOPER-BESSEMER (JET-CELL PRECHAMBERS): GNG78X8

6. CUMMINS (14mm HEADS EXCEPT B. C SERIES): GNG14X16
   CUMMINS (B, C SERIES): GNG14

7. DEERE (ALL CURRENT PRODUCTION MODELS): GNG14

8. DELAVAL (ALL7/8-18 HEADS): GNG78X20

9. DETROIT DIESEL (S30G): GNG14X9
   DETROIT DIESEL (S50G, S60G): GNG14X16

10. FAIRBANKS-MORSE (ALL "OP" MODELS): GNG18

11. FORD (ALL 14mm PORTS): GNG14
    FORD (ALL 18mm PORTS): GNG18

12. GEMINI (ALL MODELS): GNG14X9

13. GENERAL MOTORS: GNG14

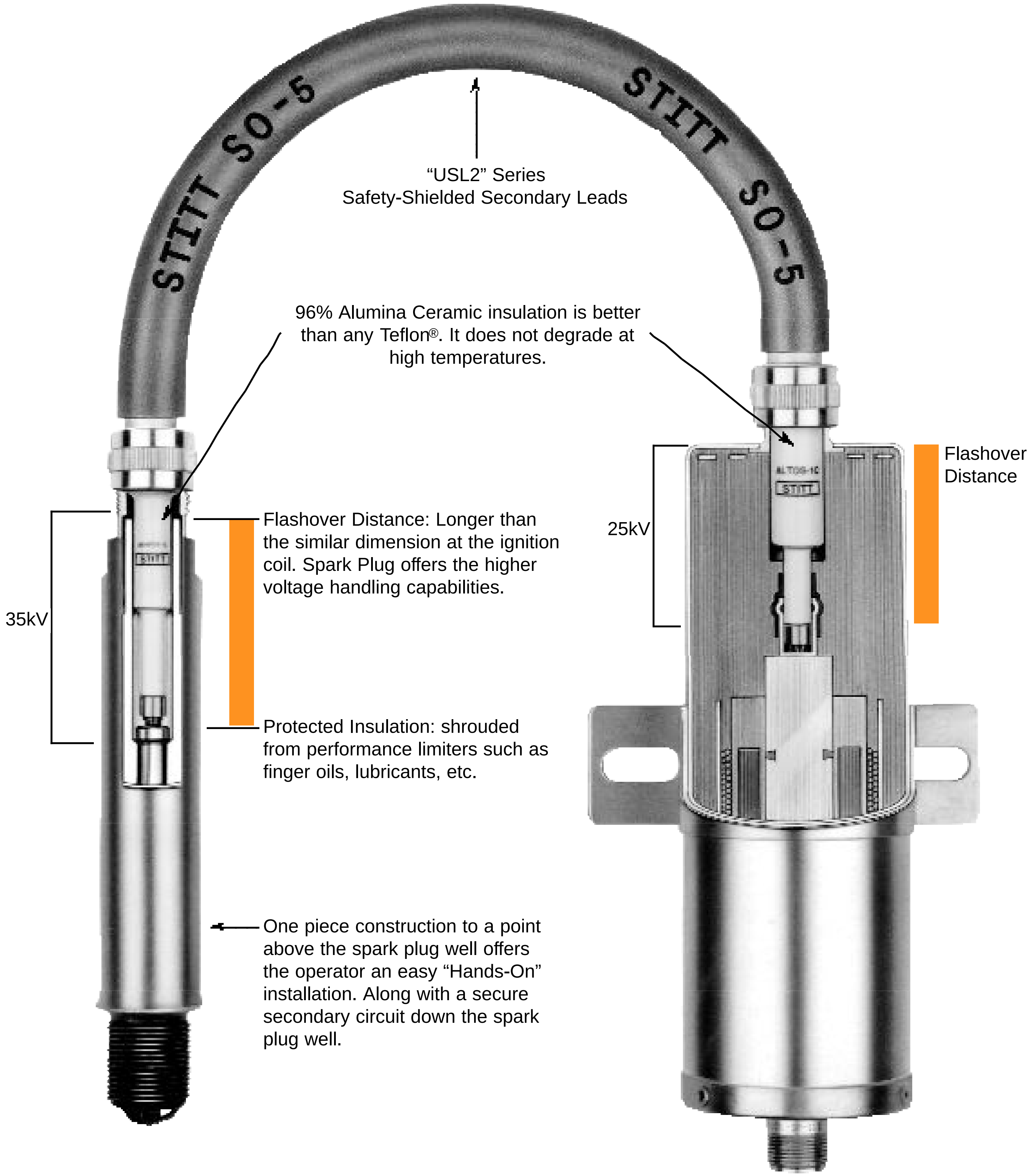
14. HERCULES (1600, 2300, 3400 SERIES): GNG14
    HERCULES (4800 SERIES): GNG14X9

15. INGERSOLL-RAND (ALL MODELS): GNG78

16. SUPERIOR (ALL HISTORICAL MODELS): GNG18
    SUPERIOR (ALL MITSUBISHI CONVERSIONS): GNG18X16

17. WAUKESHA (1197, 1905, 2475, 3711): GNG18
    WAUKESHA (817, 220, 330): GNG14
    WAUKESHA (2895, 3521, 5108, 5790, 7042, 9390): GNG18X16
    WAUKESHA (F18, H24, L36, P48): GNG18X16
    WAUKESHA (AT25, AT27): GNG18X24
    WAUKESHA (F11): GNG14X9

18. WORTHINGTON (SLHC, UTC, SUTC, ML, MLV): GNG78X28



STITT S-R707-2
Spark Plug

STITT USL2A-12A
Safety-Shielded Secondary Lead

Altronic® 291001S, 591001S, 591010S
Ignition Coil

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