Ignition System Measurements Procedure — SAE J973a

SAE RECOMMENDED PRACTICE

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1. INTRODUCTION - This procedure is intended to provide any technical person or group interested in ignition system design and/or evaluation with the specific equipment, conditions, and methods which will produce test results definitive and reproducible for his own work and yet sufficiently standardized to be acceptable to other groups working on battery ignition systems for automotive engines.

2. D-C Source-The source of d-c voltage to be used in ignition system measurements shall be a variable d-c power supply having a 10-90% transient recovery time of not more than 50 over the load range encountered in use. It must have no more than 10 mV variation in average voltage from no load to full ignition system load and no more than 50 mV peak-to-peak ripple over the same load range. This power supply shall be shunted by a suitably tapped automotive-type lead acid battery and be positioned immediately adjacent to the test area so that the source impedance of a vehicle is simulated as closely as possible.

3. IGNITION SYSTEM DEFINITION - The ignition system as defined for the tests tabulated in this report shall consist of:

(a) A coil. This can be the conventional induction coil or an air or magnetic core transformer.

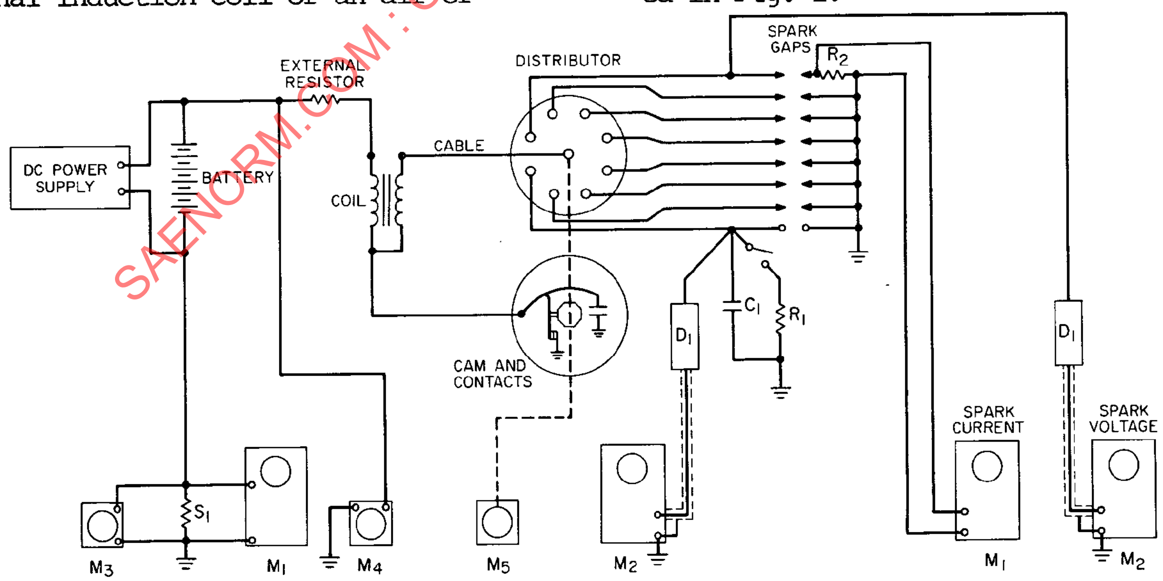
(b) A coil external resistor or resistors if the coil being tested requires an external resistor.

(c) A distributor. This is defined as any device which incorporates a timing mechanism, a spark advance mechanism or mechanisms, and a spark distribution mechanism, all of which have a proper angular interrelationship to themselves and, through a mechanical drive, to the engine.

(d) High voltage, metal conductor ignition cables: coil to distributor - 18 in (455 mm) long, distributor to spark gap - 24 in (610 mm) long. Metal conductor cables are specified to eliminate the varying effects of the different kinds of cable with high impedance conductors. Resistance per foot, as well as inductance of spark plug cables built to suppress radiation, can be quite different from manufacturer to manufacturer.

(e) Any auxiliary switching means implicit with the system being tested such as a transistorized control unit.

The above devices shall be interconnected as the manufacturer recommends or similar to the conventional system illustrated in Fig. 1.



M_1 = CURRENT MEASURING OSCILLOSCOPE
M_2 = VOLTAGE MEASURING OSCILLOSCOPE
M_3 = DC AMMETER
M_4 = DC VOLTMETER
M_5 = TACHOMETER

C_1 = SHUNT CAPACITY ($C_1 + D_1$ = 50 MMF)
S_1 = 0.1 OHM METER SHUNT
D_1 = VOLTAGE DIVIDER
R_1 = 1.0 MEGOHM, 10 WATT
R_2 = SECONDARY CURRENT SENSING RESISTOR 100 OHM, 1/2 WATT - CARBON ±1%

FIG. 1

4. SYSTEM LOAD - The load connected to the ignition system shall be a multigap spark gap test stand, each gap being individually variable, the number of gaps used being the same as the number of towers on the distributor cap. Using an 8-cylinder distributor as an example, seven gaps will be set to fire at a nominal 12 kV, the remaining gap will be opened to the point where it never can fire. Attached to the nonfiring gap, by not less than 1 ft (305 mm) of secondary ignition cable, will be a high quality (dissipation factor of 3% or less), high voltage, 50 pico farad capacitor (this can be a section of shielded ignition cable) to simulate the capacitance of the cables and spark plugs as normally encountered on a vehicle, and at suitable times a low voltage coefficient (0.0005%/V max), noninductive approximately 10 W, 1.0 MΩ resistor. The resistor simulates lead or carbon fouled spark plugs.

For certain tests, as designated in paragraph 5, the capacitive and resistive loads will be directly connected to the coil high voltage tower with the coil not firing.

5. MEASUREMENTS TO BE MADE

5.1 GROUP A

5.1.1 *Available Voltage at Spark Plug* - This measurement is fundamental to spark ignition. Comparing available voltage to voltage required to fire spark plugs (in a given engine) determines the adequacy of the ignition system. (See Fig. 2A.)

5.1.2 *Peak Coil Primary Current* - This measurement indicates energy into the coil ($E = \frac{1}{2} Li^2$) and must be controlled to insure adequate distributor contact life. (See Fig. 2B.)

5.1.3 *Average Coil Primary Current* - This measurement determines the average current draw of the system with respect to the d-c source (alternator generator, battery, etc.).

5.1.4 *Spark Duration* - Within limits, this measurement is indicative of the igniting capability of a spark under marginal fuel conditions. It also is an indication of the amount of erosion which will occur on spark plug electrodes due to electrical means. Because of the complexity of both of these areas, however, experience is required to use this information effectively. (See Fig. 2C.)

5.1.5 *Spark Voltage* - This is the instantaneous voltage observed across the spark gap halfway through the discharge. (See Fig. 2E.)

5.1.6 *Spark Current* - This is the instantaneous current from the secondary winding of the ignition coil flowing through the spark gap after breakdown. (See Fig. 2E.)

5.1.7 *Spark Energy* - This is the inductive portion of energy dissipated in the spark after breakdown. It is calculated as shown:

$$E_{spark} = \frac{V_a(t_f-t_o)\ (i_f+i_o)}{2}$$

where:

t_o and i_o = initial values of time and current of the spark after breakdown

t_f and t_f = final values of time and current of the spark after breakdown

V_a = spark voltage at $(t_f - t_o)/2$

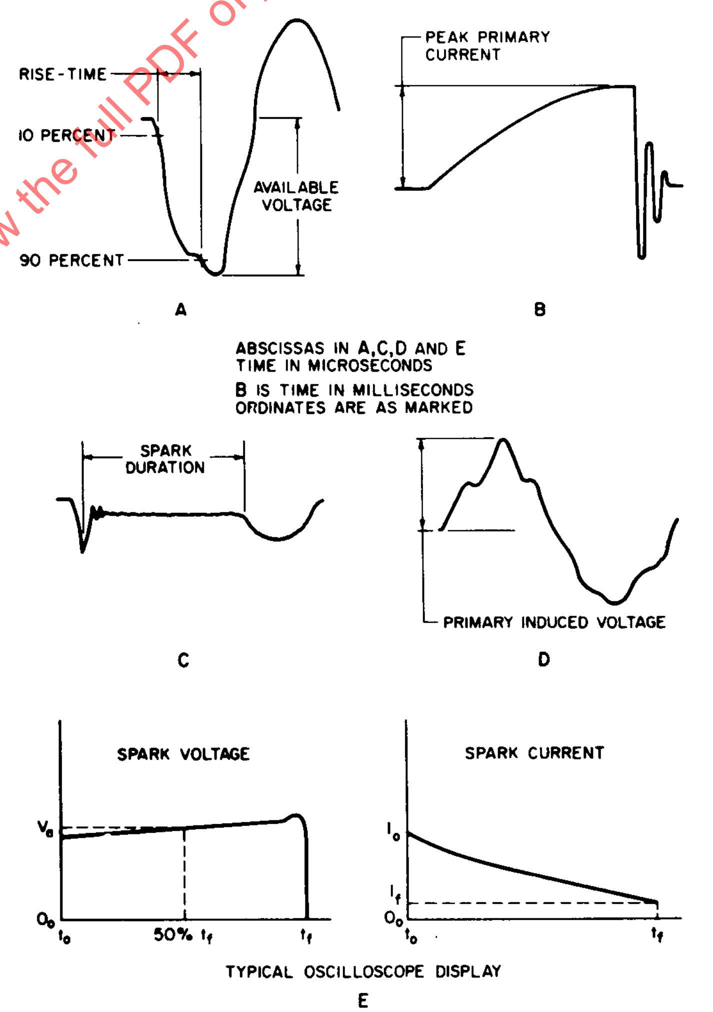


FIG. 2

5.2 GROUP B

5.2.1 Coil Secondary Voltage Risetime- This measurement is an indication of the ability of an ignition system to fire shunted (fouled) spark plugs. The shorter the risetime, the less system energy is lost across the fouled shunt and the more voltage is available to fire the plug. (See Fig. 2A.)

5.2.2 Coil Primary Induced Voltage - This measurement is useful with respect to distributor contact life on conventional ignition systems and is a measure of the stress on a semiconductor power switch in inductive energy storage ignition systems. (See Fig. 2D.) This measurement is not applicable to capacitor discharge ignition systems.

6. TEST EQUIPMENT

6.1 A voltage divider and oscilloscope for measuring high voltage as defined in SAE AIR 84 should be used to measure available voltage, risetime, and spark duration.

6.2 An oscilloscope with a maximum risetime of 0.035 μS and with a minimum band pass of 10MC (Ref. Tektronix 535A with a type L plug-in unit) with its input connected across a noninductive meter shunt which is in series with the coil primary for peak coil primary current measurements. The sensing resistor shall not have a resistance greater than 0.1 Ω. The oscilloscope must have a minimum deflection sensitivity of 50mV/cm.

6.3 A good quality d-c ammeter of the permanent magnet-moving coil type should be used for average coil primary current measurements. The meter range selected should easily allow reading resolutions of at least 0.1 A.

6.4 The same oscilloscope required in paragraph 6.2 should be used to measure primary induced voltage.

6.5 A good quality d-c voltmeter with an input resistance of at least 1000Ω/V and with sufficient resolution to easily indicate differences of 0.1 V. To achieve this resolution the full scale deflection should be appropriate to the voltage rating of the ignition system being tested.

6.6 A distributor drive stand and attached tachometer which will have:

(a) An eccentricity between the mounting fixture and drive of 0.003 in (0.076 mm) maximum.

(b) A continuously variable speed adjustment with a total speed variation between 15 and 3500 rpm possible.

(c) Speed stability within 5% at any given speed.

(d) A tachometer accurate within 3% of indicated speed and independent of the electrical portion of the ignition system.

7. PROCEDURES

7.1 GROUP A TESTS - The conventional circuit arrangement as shown in Fig. 1 with instrumentation in place, or modified with an auxiliary switching unit connected as the manufacturer intended, can be used to measure available voltage, peak primary coil current, average primary coil current, spark duration, spark voltage, and spark current at the distributor speeds and input voltages listed in Table 1.

TABLE 1

Distributor rpm	Primary Volts	Environment Temperature °F	Environment Temperature °C	Operating Condition
20	5.0	−20 ±2	−29 ±1	Cold starting
30	5.0	−20 ±2	−29 ±1	Cold starting
40	5.0	−20 ±2	−29 ±1	Cold starting
50	11.0	80 ±5	27 ±3	Hot starting
60	11.0	80 ±5	27 ±3	Hot starting
70	11.0	80 ±5	27 ±3	Hot starting
250	14.0	80 ±5	27 ±3	Running
500	14.0	80 ±5	27 ±3	Running
750	14.0	80 ±5	27 ±3	Running
1000	14.0	80 ±5	27 ±3	Running
1250	14.0	80 ±5	27 ±3	Running
1500	14.0	80 ±5	27 ±3	Running
1750	14.0	80 ±5	27 ±3	Running
2000	14.0	80 ±5	27 ±3	Running
2250	14.0	80 ±5	27 ±3	Running
2500	14.0	80 ±5	27 ±3	Running
2750	14.0	80 ±5	27 ±3	Running
3000	14.0	80 ±5	27 ±3	Running

The calculation described in paragraph 5.1.7 plus the procedure described here determines the inductive portion of the spark energy dissipated in a 12 kV spark gap under the conditions shown in Table 1. Spark currents and voltages can be measured and spark energy calculated equally well under other conditions and with different spark gaps. This procedure can be used in relating the effective amount of spark energy required to ignite a given fuel mixture.

If 6V ignition systems are to be tested, divide the primary voltages listed in Table 1 by two; for 24V systems by two.

Allow the ignition system to soak at least 1 h at the temperatures listed in Table 1 before beginning tests. Before any readings are recorded at any of the test points, the system should be allowed to come to a thermally stable operating condition (typically, this takes about 2 min).

Output voltage amplitudes vary due to contact arcing and other small but accumulative factors. It is recommended that the