Chapter 25
Oil Burner Flammability Test for Magnesium Alloy Seat Structure

25.1 Scope

25.1.1 Applicability

This test method evaluates the ignition resistance and flammability of magnesium alloy when used in the construction of aircraft seat primary structural components by using a high-intensity open flame to show the material adequately resists involvement in a postcrash fire.

25.2 Definitions

25.2.1 Magnesium Alloy

A magnesium alloy is defined as any solid form of magnesium containing a variety of alloying materials (e.g., zinc) or rare-earth elements (e.g. yttrium). Any component or material containing more than 10% elemental magnesium by weight shall be considered a magnesium alloy.

25.2.2 Sample Set

A sample set consists of three or more replicate test samples of a particular magnesium alloy used in the construction of an aircraft seat primary-load-path structural component.

25.2.3 Melting

Melting is defined as the point when the sample becomes elastic enough that a significant portion of the sample breaks free and falls into the catch pan. Bending, warping, or sagging alone does not constitute melting.

25.2.4 Ignition

Ignition is defined as the first observation of sparking of the magnesium alloy sample when subjected to the burner flames. The point of ignition is typically a very bright, intense, blue-white flame that can be differentiated from the surrounding yellow-orange flames being produced by the oil burner. Ignition is often times the precursor to burning, in which the material experiences sustained ignition.

25.2.5 Burning

Burning (sustained ignition) is defined as an ignition lasting for 10 consecutive seconds (i.e., the start time of an ignition lasting for more than 10 seconds shall be considered the beginning of the burning period, in the event that ignition stops and then re-starts).

25.2.5 Weight Loss

The sample weight loss is the amount of weight a sample loses during exposure to the burner flames, which includes any portion of the test sample that melts and falls into the catch pan. Molten pieces of the test sample must be retrieved from the catch pan following test completion once sufficient cooling has taken place. Molten/resolidified pieces of the test sample must be blown off with compressed air, to eliminate the inclusion of oxidized material or talc during the final weight measurement. The percentage weight loss for a sample is defined as the pre-test weight of the sample less the post-test weight of the sample and any droppings, expressed as the percentage of the pre-test weight.

25.3 Apparatus

25.3.1 Test Sample Apparatus

The test sample apparatus is shown in figures 25-1 and 25-2. The test sample apparatus must allow movement of the test sample so it can be positioned in front of the burner at the proper distance.

25.3.1.1 Catch Pan

The test sample apparatus must include a suitable catch pan lined with a layer of dry talc powder, capable of preventing back-splashing of molten magnesium alloy. The talc should be filled to a depth of 0.25 inch (6 mm), as measured from the highest point on the base of the catch pan. The catch pan should measure at least 8 inches (20 cm) wide by 16 inches (41 cm) long, and at least 1.5 inches (38 mm) deep. A test sample holder can be mounted directly to the sides of the catch pan.

25.3.1.2 Talc

Talc is a magnesium-silicate-based mineral. Talc should be kept dry between test runs and renewed as appropriate. Storage in a sealed plastic bag is recommended to avoid moisture pick-up.

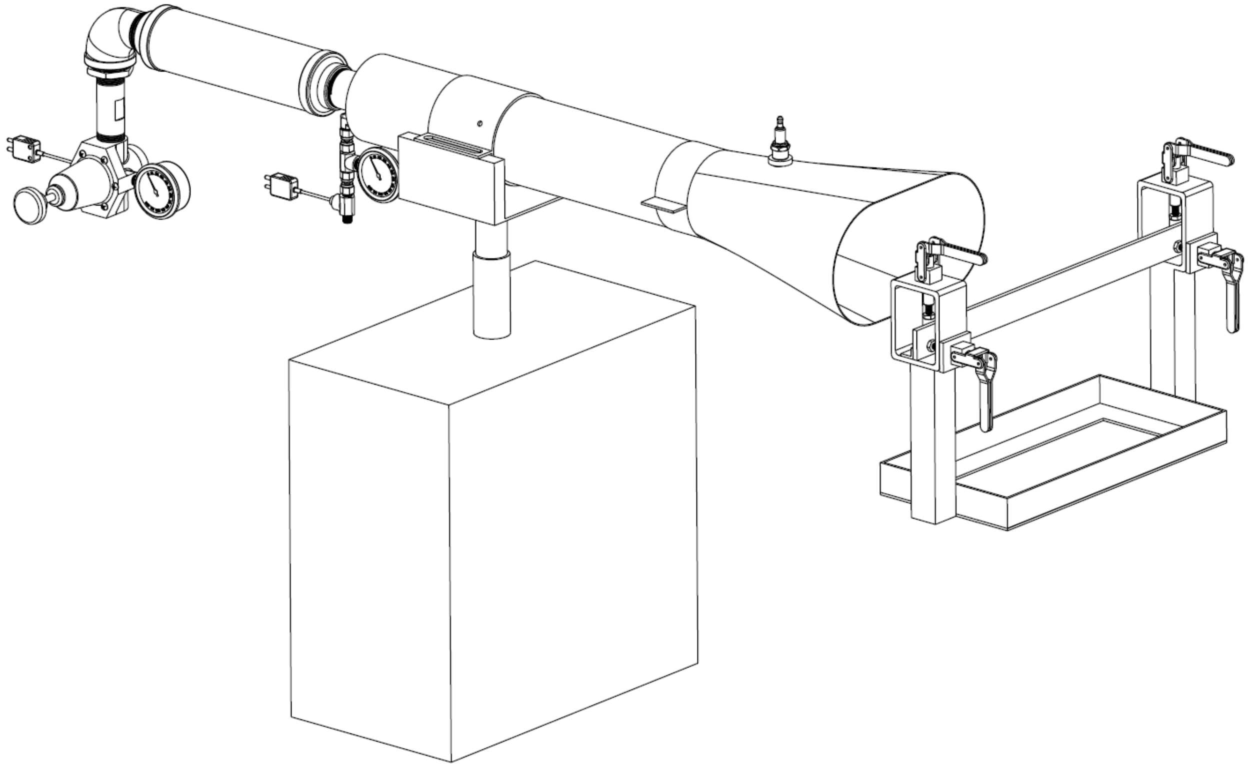


Figure 25-1. Magnesium Alloy Testing Apparatus

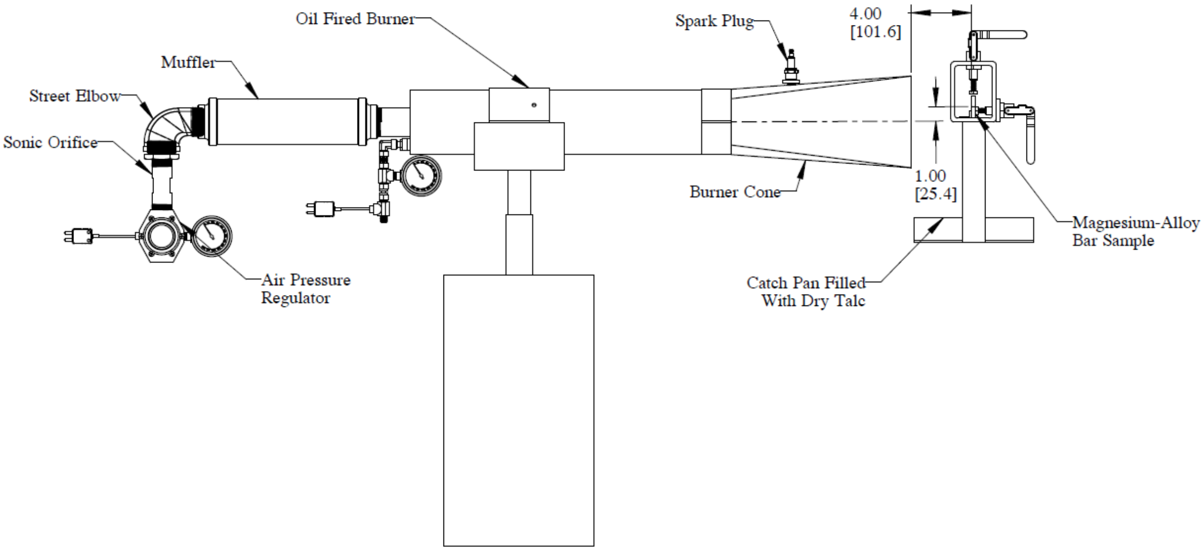


Figure 25-2. Magnesium Alloy Testing Apparatus

25.3.1.3 Test Sample Stand and Holder

A test sample mounting stand and holder must be used to rigidly mount the horizontal bar sample in the proper position with respect to the test burner (figure 25-3). A suitable sample holder can be fabricated using 2-inch (51 mm) lengths of 3- by 4- by 0.250-inch-thick (76- by 102- by 6 mm) steel box tubing Two sections of box tubing can be mounted on top of 1.5- by 1.5-inch (38- by 38- mm) box tubing uprights that are welded to the sides of the catch pan. The rectangular cross section sample holder segments can be drilled for insertion of push/pull style toggle clamps that hold the sample in the proper position (figure 25-4). The toggle clamps should have adjustable plungers to allow the proper amount of pressure against the sample.

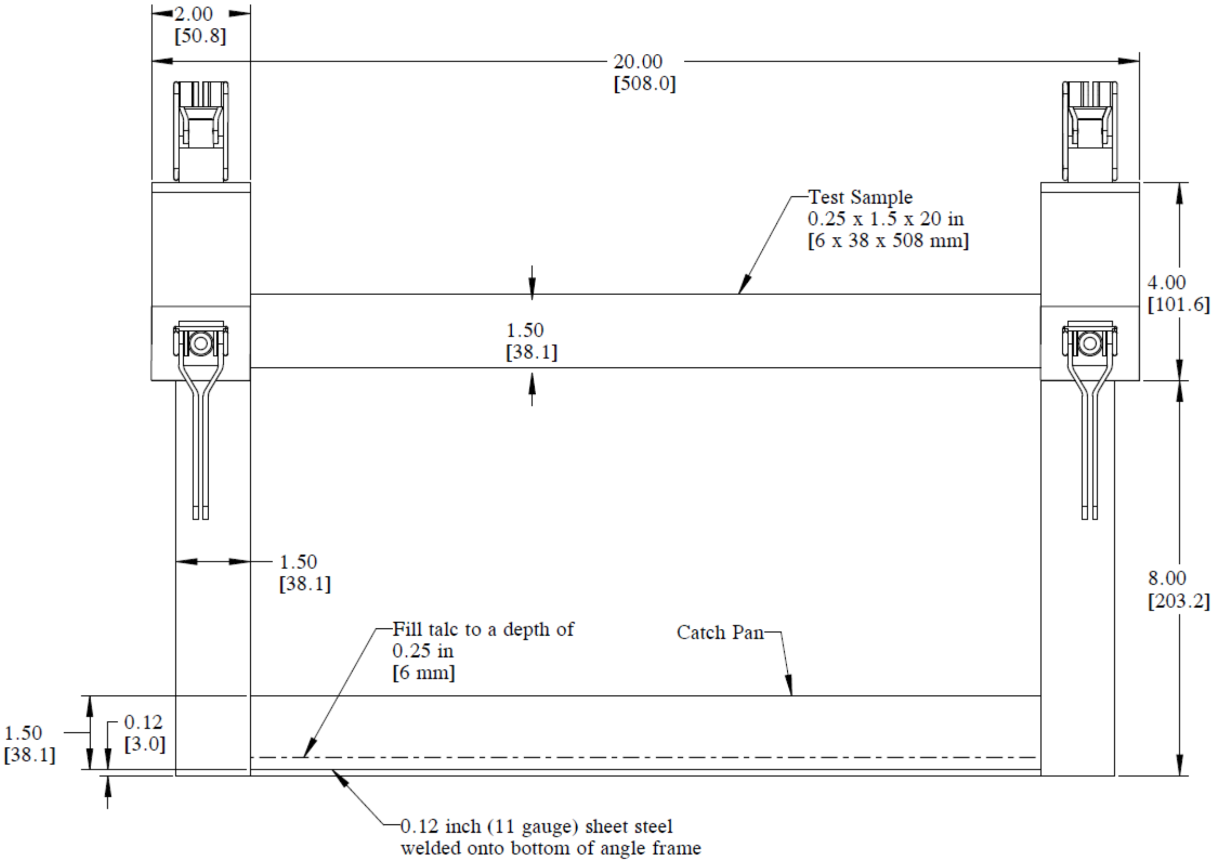


Figure 25-3. Magnesium Alloy Test Sample Mounting Stand and Holder (Front)

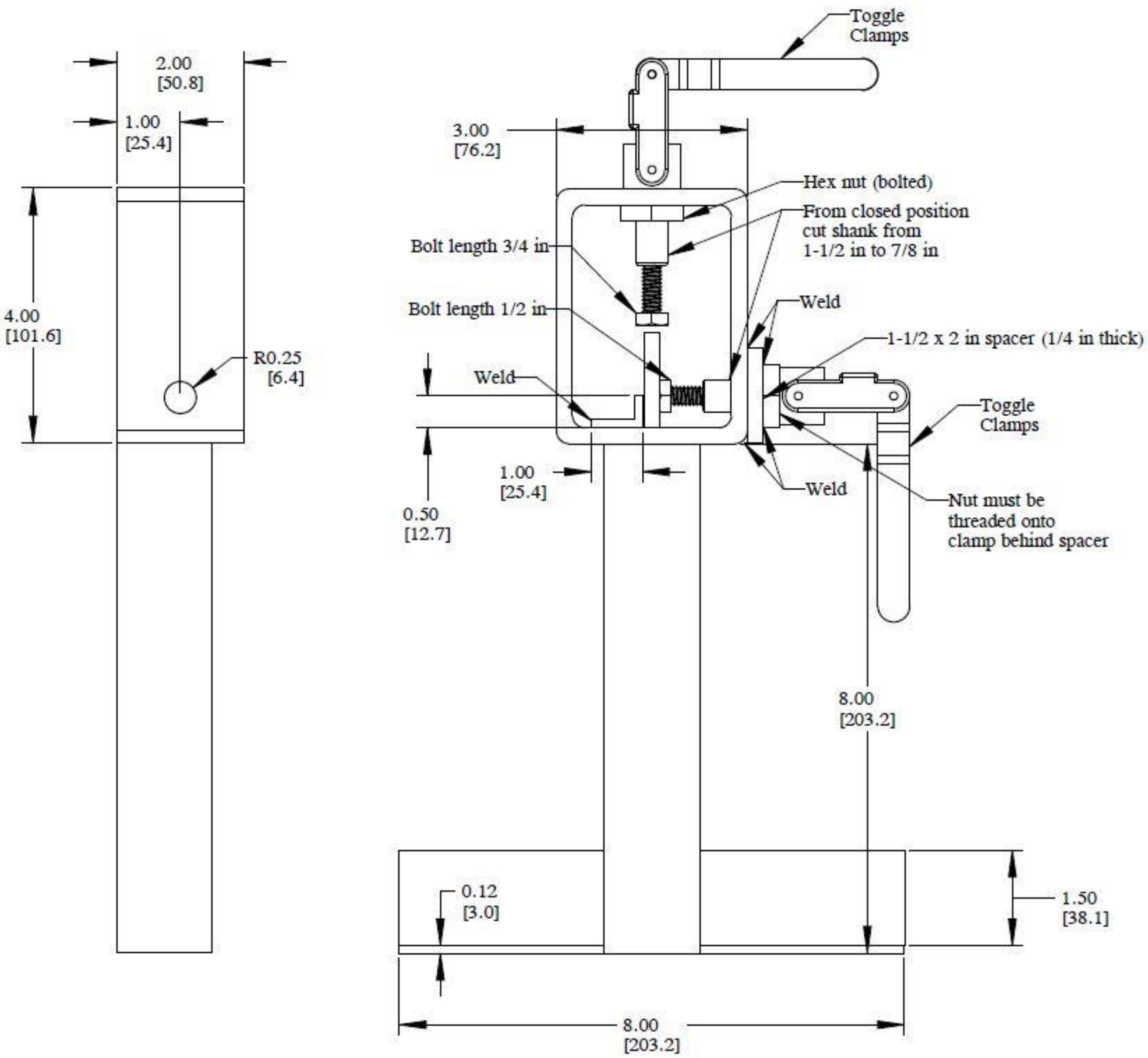


Figure 25-4. Magnesium Alloy Test Sample Mounting Stand and Holder (Side)

25.3.2 Test Burner

The test burner must be a gun-type, using a pressurized, sprayed kerosene-type fuel charge in conjunction with a ducted air source to produce the burner flames. An interchangeable, screw-in fuel nozzle must be used to produce the cone-shaped fuel charge from a pressurized fuel source. A pressurized air source controlled via a regulated sonic orifice must supply the combustion air. The combustion air is ducted through a cylindrical draft tube containing a series of diffusing vanes. The diffused combustion air will mix with the sprayed fuel charge in a bell-shaped combustion cone. The fuel/air charge is ignited by a high-voltage spark plug igniter positioned in the combustion cone in the vicinity of the fuel spray nozzle. Flame characteristics can be adjusted by varying the pressure of the regulated air into the sonic orifice. Refer to Chapter 25 Supplement section 25.3.2 for information on the components and construction of this burner.

25.3.2.1 Inlet Condition Measuring

To obtain an accurate measurement of the conditions entering the burner, the fuel pressure and temperature, and air pressure and temperature measurements must be made nearest to the burner inlet (figure 25-5). To minimize air-stream disruptions, the intake air temperature must be measured prior to the sonic orifice.

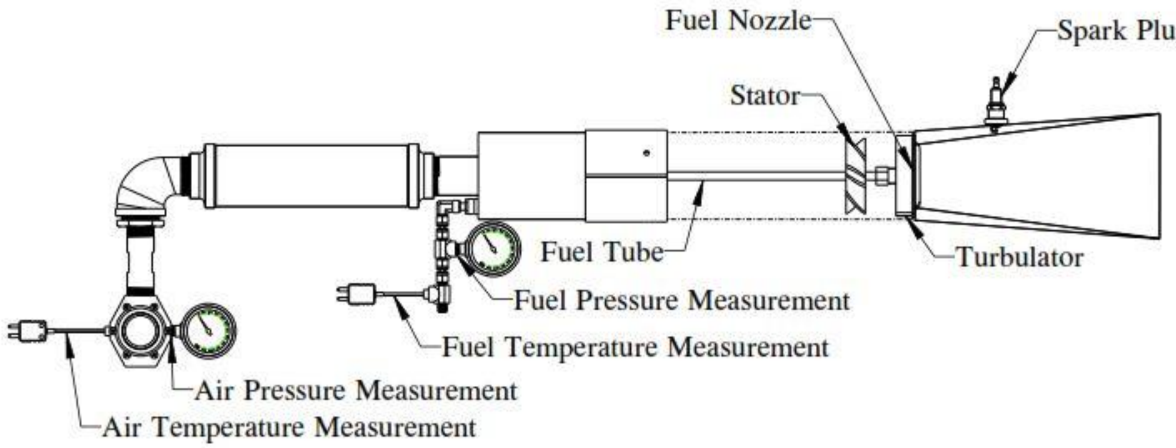


Figure 25-5 Inlet Condition Measurement Location (side view)

25.3.2.2 Fuel Nozzle

A screw-in style fuel nozzle is required to maintain a fuel pressure that will yield a 2 ± 0.1 gallons/hour (0.126 L/min ± 0.0063 L/min) fuel flow. A nozzle with an 80-degree solid spray angle nominally rated at 2.0 gal/hr (0.126 L/min) at 100 lb/in^2 (0.71 MPa) has been found to deliver the appropriate flow rate and produce the proper flame pattern. Actual flow rate measurements may deviate from the advertised flow rate. The actual flow rate must be measured manually using a flexible tube, graduated cylinder, and timing device as described in section 25.5.4.6. The fuel pressure must then be adjusted accordingly to produce the required fuel flow of 2 ± 0.1 gallons/hour (0.126 L/min ± 0.0063 L/min). For additional details, refer to Chapter 25 Supplement, section 25.3.2, Fuel Nozzle.

25.3.2.3 Fuel Pressure Regulation

The fuel must be properly pressurized to deliver the proper fuel flow. Ideally, this pressure must be in the range of 100 to 120 lb/in^2 (0.69 to 0.83 MPa). For details on fuel pressurization and regulation, refer to Chapter 25 Supplement, section 25.3.2, Fuel System.

25.3.2.4 Fuel Type

A kerosene-type fuel is used in the burner equipment. Jet A and JP-8 (military equivalent to Jet A) fuel is recommended; however other fuels are permissible if the flame temperature can be maintained according to Section 25.6.1.3. For additional details, refer to Chapter 25 Supplement, section 25.3.2, Fuel.

25.3.2.5 Burner Cone

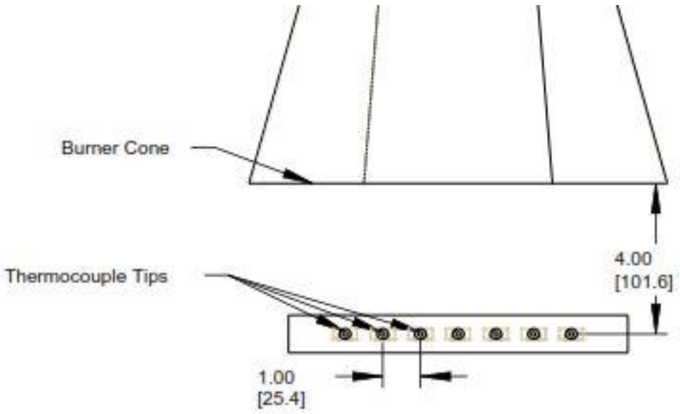
A 12 ± 0.125-inch (305 ± 3-mm) burner extension cone is fitted to the end of the burner draft tube. The opening must be 6 ± 0.125 inches (152 ± 3 mm) high and 11 ± 0.125 inches (280 ± 3 mm) wide. For additional details, refer to Chapter 25 Supplement, section 25.3.2, Burner Cone.

25.3.2.6 Spark Plug

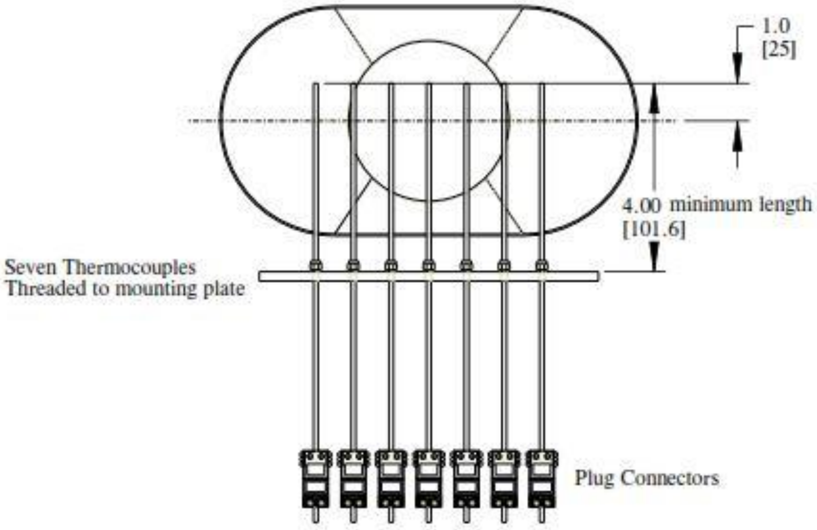
An automotive style spark plug is fitted into a threaded boss, which is welded to the burner extension cone. The threaded boss is centered on the upper surface of the burner cone, at a distance of 6 ± 0.125 inches (152 ± 3 mm) from the intake end of the burner cone. For additional details, refer to Chapter 25 Supplement, section 25.3.2, Ignition.

25.3.3 Burner Flame Consistency Validation Thermocouples

Seven thermocouples must be used to check the flame temperature of the burner. The thermocouples must be 0.125-inch (3.2-mm) diameter, ceramic packed, 310 stainless steel sheathed, type K (Chromel-Alumel), grounded-junction with a nominal 24 American Wire Gauge (AWG) size conductor. The seven thermocouples must be attached to a steel mounting plate to form a thermocouple rake for placement in the test stand during the burner flame consistency validation (figure 25-6). The thermocouple mounting plate should be a minimum of 4 inches (102 mm) away from the tips of the thermocouples.



Top View



Side View

Figure 25-6. Top and Side View of Thermocouple Rake Bracket

25.3.4 Instrumentation and Supporting Equipment

25.3.4.1 Data Acquisition

A calibrated recording device or a computerized data acquisition system with an appropriate range must be used to measure and record the outputs of the thermocouples.

25.3.4.2 Timing Device

A stopwatch or other device, accurate to within ± 1 second per 8 hours (± 3 seconds/day), must be used to measure the time of application of the burner flame, and the test sample ignition and extinguishment times.

25.3.4.3 Anemometer

A handheld vane-type or hot-wire type air velocity sensing unit must be used to monitor the flow of air inside the test chamber when the ventilation hood is operating.

25.3.4.4 Digital Weight Scale

A suitable weight scale must be used to determine the initial and final weights of the test sample, and weight of any molten /resolidified portions of the test sample captured in the catch pan. The scale must have a resolution of 0.02 lbs (0.01 kgs) and an accuracy of ± 0.02 lbs (± 0.01kgs).

25.3.4.5 Test Chamber

A suitable test chamber must be used to reduce or eliminate the possibility of test fluctuation due to air movement. The test chamber must have a minimum floor area of 10 feet by 10 feet (305 by 305 cm).

25.3.4.6 Ventilation Hood

The test chamber must have an exhaust system capable of removing the products of combustion expelled during the tests.

25.4 Test Samples

25.4.1 Sample Configuration

Test samples representing the primary seat frame components (e.g., leg, spreader, cross-tube, seat back frame, and lower baggage bar) must be constructed of the identical magnesium-alloy material to be used in service.

25.4.2 Sample Number

A minimum of three samples for each magnesium alloy type or design configuration must be prepared for testing. These samples must exclude any surface modifications such as intumescent paints or coatings, or any anodizing processes.

25.4.3 Sample Size

The samples to be tested must measure 0.25 ± 0.0063 inches (6.4 ± 0.16 mm) thick by 1.5 ± 0.03 inches (38.1 ± 0.8 mm) height by 20 ± 0.06 inches (508 ± 1.6 mm) in length. Test samples must be constructed according to the dimensions shown in figure 25-7.

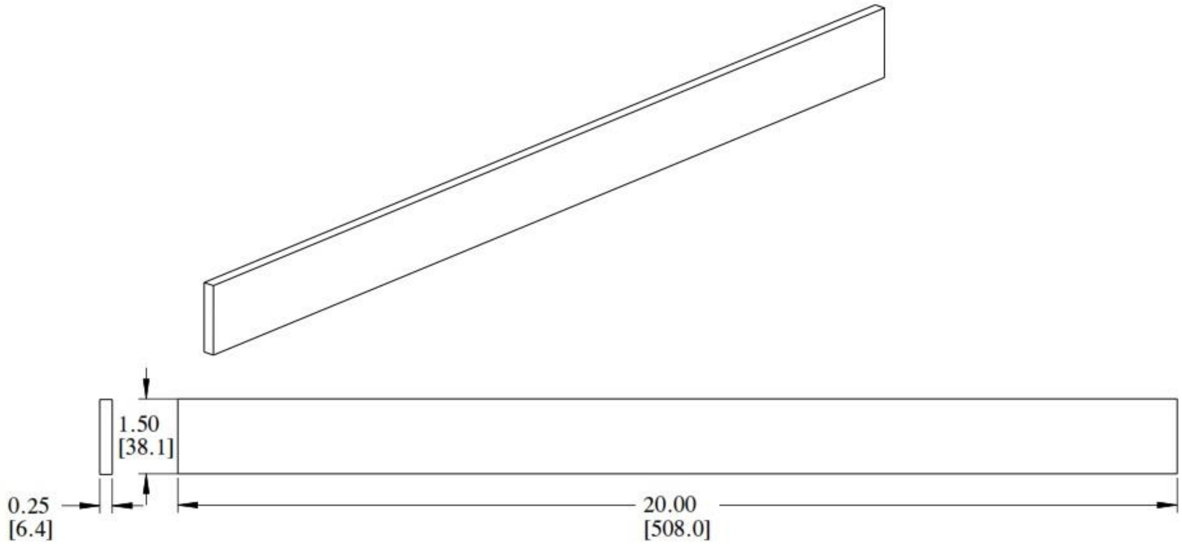


Figure 25-7 Test Sample Dimensions

25.4.4 Sample Orientation

The samples are mounted horizontally, with the midpoint of the sample's face located 4 inches (10.2 cm) from the vertical exit plane of the burner cone and 1 inch (2.5 cm) above the burner centerline (refer to figure 25-2).

25.4.5 Sample Finish

A machined surface finish to all faces is required for the test samples (e.g. an average roughness value Ra of less than 1.75 µm and typically 0.9 µm).

25.4.6 Sample Coatings

If a finish coating, anodizing, or other standard aerospace grade surface treatment is used on the alloy in service, it is sufficient to test the coated materials using the 12-second vertical Bunsen burner test method described in Chapter 1 of the Materials Fire Test Handbook (Vertical Bunsen Burner Test for Cabin and Cargo Compartment Materials)

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25.4.7 Sample Conditioning

The samples must be conditioned at 70° ± 5°F (21° ± 3°C) and 55% ± 10 % relative humidity for a minimum of 24 hours prior to testing.

25.5 Preparation of Apparatus

25.5.1 Alignment

Level and center the sample holder frame assembly to ensure alignment with the burner cone. Move the test sample mounting frame into position in front of the burner, and check for proper alignment (i.e., distance from exit of burner cone to face of test sample, proper sample height with respect to cone centerline, etc.). The movable assembly should incorporate mechanical stops or detents to ensure that the samples can be moved into position quickly without measurement during testing.

25.5.2 Chamber Ventilation

Turn on the ventilation hood for the test chamber. Do not turn on the pressurized burner air. Measure the airflow in the test chamber using a handheld vane-type anemometer or equivalent measuring device. The vertical air velocity within a 12-inch (30.5 cm) radius from any point on the horizontally-positioned sample must be less than 100 ft/min (50.8 cm/second). The horizontal air velocity within a 12-inch (30.5 cm) radius from any point on the sample must be less than 50 ft/min (25.4 cm/second).

25.5.3 Test Chamber Air Temperature

The temperature of the test chamber should be between 50^{o}F and 100^{o}F (10^{o}C and 38^{o}C) before the start of each test. The chamber air temperature should be measured at the same height as the center of the test sample, within 12 inches (30.5 cm) laterally.

25.5.4 Sonic Burner Configuration

25.5.4.1 Fuel Nozzle Location

The tip of the fuel nozzle, or fuel exit plane, must be located 0.1875 ± 0.020 inch (4.8 ± 0.5 mm) from the exit plane of the turbulator (figure 25-8).

25.5.4.2 Stator Adjustment

The stator is positioned by adjusting its translational position as well as its axial position on the fuel rod.

25.5.4.2.1 Stator Translational Position

The front face of the stator must be located 2.6875 ± 0.020 inches (68.3 ± 0.5 mm) from the exit plane of the turbulator (figure 25-8). This stator translational position is also 2.5 inches (63.5 mm) from the tip of the fuel nozzle.

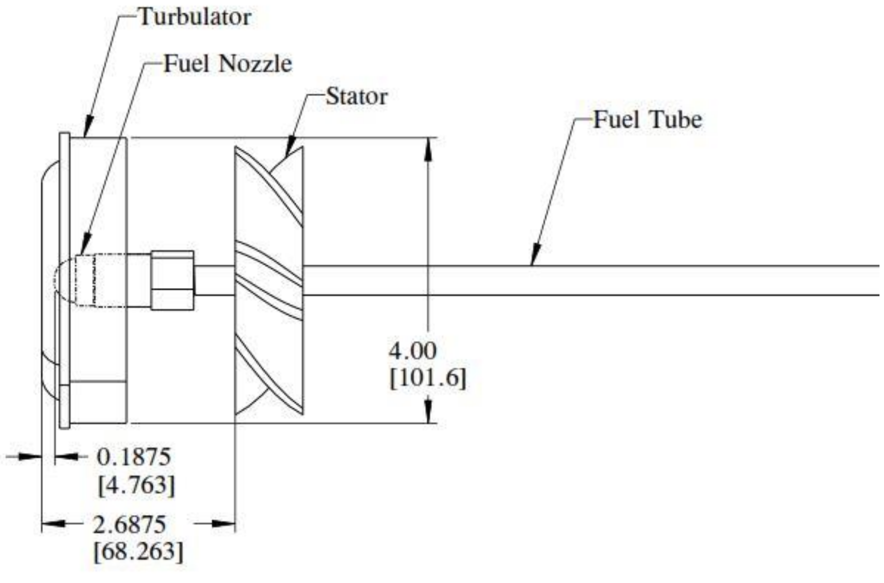


Figure 25-8 Fuel Nozzle and Stator Locations

25.5.4.2.2 Stator Axial Position

The line running through the geometric center of the stator and traversing through the center of the stator set screw can be used as a reference for properly orienting the rotational position of the stator. The stator must be positioned so the reference angle is 0 degrees from the zero position (figure 25-9).

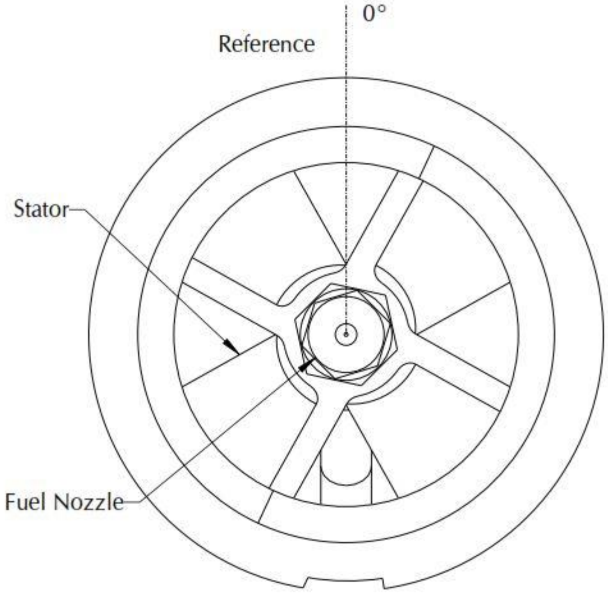


Figure 25-9 Stator Axial Position

25.5.4.3 Spark Plug

25.5.4.3.1 Spark Plug Location

The spark plug should be mounted in a threaded boss, located on the upper surface of the burner cone at a distance of 6 ± 0.125 inches (152 ± 3 mm) from the end (intake plane of burner cone) (figure 25-10).

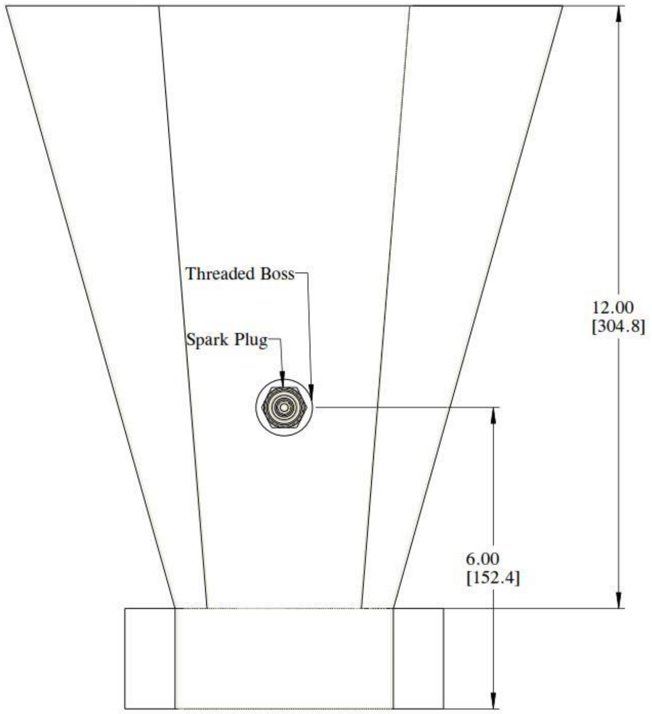


Figure 25-10. Spark Plug Location in Burner Cone

25.5.4.3.2 Spark Plug Gap

The spark plug gap (distance) between the two electrodes must be 0.100 inches (2.5 mm) as shown in figure 25-11

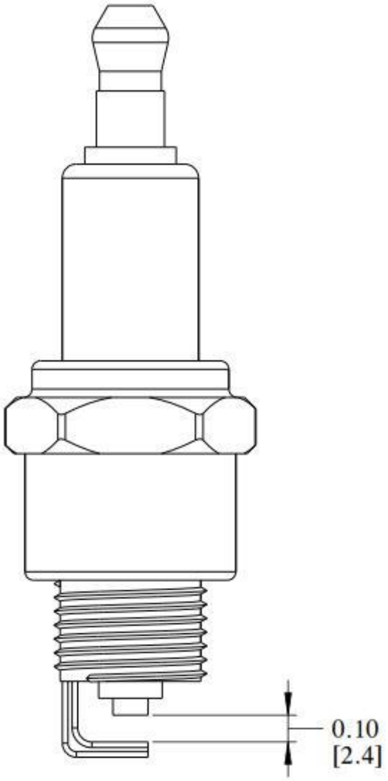
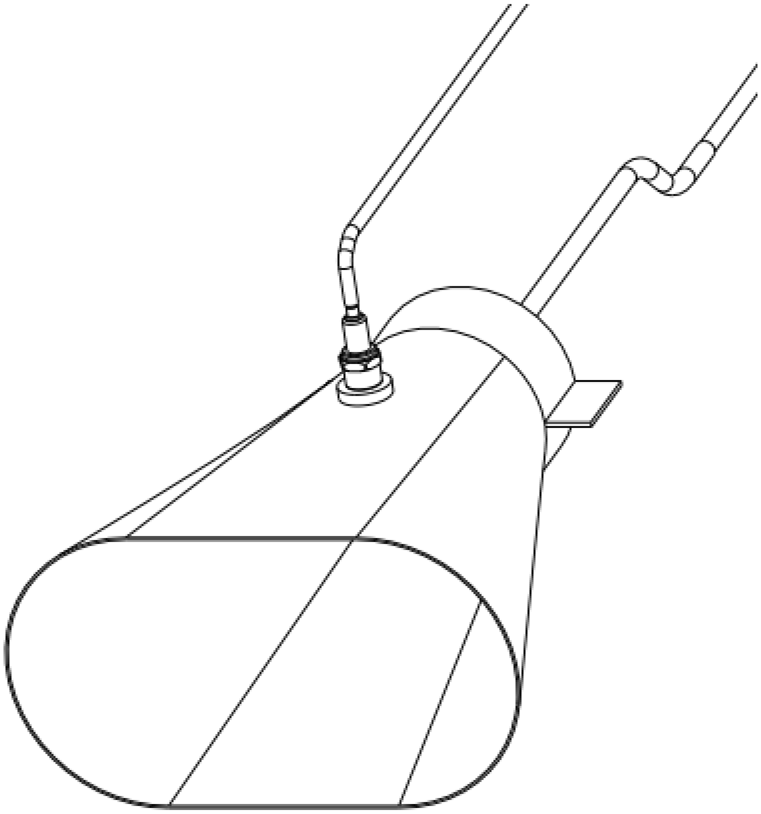


Figure 25-11. Spark Plug Gap Measurement

25.5.4.4 Spark Plug Wire Routing

The length and arrangement of the spark plug wire must be monitored to prevent heat damage during calibration and testing. Once the burner is ignited, the outside surface temperature of the burner cone will increase rapidly, becoming capable of damaging the wire if it comes in contact with the cone. The spark plug wire should be carefully routed to prevent contact with the cone or other hot surfaces, and should also be shielded in a heat resistant covering to further protect it from convective heat damage from the burner flames. The wire can be routed as shown in figure 25-12, in which it does not contact any components in the vicinity of the burner cone.



25-12. Proper Routing of the Spark Plug Wire

25.5.4.5 Volumetric Air Flow Control

The volumetric airflow is controlled via a regulated sonic orifice. Adjust the upstream supply air pressure to 45 lbs/in^2 $\pm$ 1 lbs/in^2 (310 $\pm$ 6.9 kPa). The intake air temperature must be maintained within the range of 40°F to 60°F (4°C to 16°C). For additional details, refer to Chapter 25 Supplement, section 25.3.2, Sonic Nozzle and Air Pressure Regulator.

25.5.4.6 Fuel Flow Calibration

If a calibrated flow meter is not available, measure the fuel flow directly using a length of Tygon® tubing and appropriately sized graduated cylinder. Slip the Tygon® tubing over the end of the fuel nozzle, making certain to establish a good seal. Direct the exit of the Tygon® tubing into a small bucket or other collection basin. Turn on the fuel solenoid, making sure the igniton system is off. After establishing a steady stream of fuel flow[1], simultaneously direct the tubing exit into the graduated cylinder while beginning the stopwatch or timing device. Collect the fuel for a 2-minute period, making certain to immediately direct the tubing exit away from the graduated cylinder at precisely 2 minutes. Calculate the flow rate and ensure that it is 2 ± 0.1 gal/hr (0.126 ± 0.0063 L/min). If the flow rate is not within the tolerance, adjust the fuel pressure accordingly. The temperature of the fuel must be maintained within the range of 32°F to 52°F (0°C to 11°C).

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[1] When collecting fuel, it is important to establish a steady stream of fuel before starting the measurement process. A 10-second period is recommended.

25.6 Burner Flame Consistency Validation

25.6.1 Sonic Burner

The sonic burner used in the test must be checked to ensure the proper flame temperature is being produced for consistent and accurate test results.

25.6.1.1 Move the apparatus from the test position to the warm-up position. Examine and clean the burner cone of any evidence of buildup of combustion products, soot, etc. Soot build-up inside the cone may affect the flame characteristics and cause calibration difficulties. Since the burner cone may distort with time, dimensions should be checked periodically.

25.6.1.2 Mount the thermocouple rake on a movable stand that is capable of being quickly translated into position in front of the burner. Move the rake into calibration position and check the distance of each of the seven thermocouples to ensure that they are located 4 ± 0.125 inch (102 ± 3 mm) from the vertical plane of the burner cone exit. Ensure that the horizontal centerline of the thermocouples are offset 1 ± 0.063 inch (25.4 ± 2 mm) above the horizontal centerline of the burner cone (see figure 25-6). Place the center thermocouple (thermocouple number 4) in front of the center of the burner cone exit. Note that the movable thermocouple rake stand must incorporate detents that ensure proper centering of the thermocouple rake with respect to the burner cone, so that rapid positioning of the rake can be achieved during the validation procedure. Once the proper position is established, move the thermocouple rake away, and move back into the calibration position to re-check distances. When all distances and positions are confirmed, move the thermocouple rake away from burner.

25.6.1.3 While the thermocouple rake is away from the burner, turn on the igniters, pressurized air and fuel flow, and light the burner. Allow burner to warm up for a period of 2 minutes. After warm-up, move the thermocouple rake into position and allow 1 minute for thermocouple stabilization, then record the temperature of each of the seven thermocouples once every second for a period of 30 seconds. Remove thermocouple rake from calibration position and turn off burner. Calculate the average temperature of each thermocouple over this period and record. Although not a requirement for testing, the recommended average temperature of each of the seven thermocouples should be 1700°F ± 100°F (927°C ± 55°C). The burner should be rechecked to ensure it is configured properly if temperatures are measured outside of this recommended range. A fine adjustment of the internal stator orientation and/or distance from the end of the draft tube may be necessary to achieve the required temperatures, provided the adjustments are within allowable tolerances. If no problems are found with the burner, any thermocouple reading outside of this range may require replacement. It is recommended that burner flame temperature be validated prior to running a series of tests to ensure test result consistency.

25.7 Test Procedure

25.7.1 Examine and clean the cone of soot deposits and debris.

25.7.2 Weigh the magnesium alloy test sample and record this initial weight.

25.7.3 Mount the magnesium alloy test sample in the test frame sample holder. Verify that the horizontal test sample is level, and that the center of the face of the sample being exposed is at a distance of 4 ± 0.125 inches (102 ± 3 mm) from the vertical exit plane of the burner cone. Ensure that the horizontal centerline of the test sample is offset 1 ± 0.063 inch (25.4 ± 2 mm) above the horizontal centerline of the burner cone (see figure 25-2).

25.7.4 Move the test frame assembly away from the burner to the standby position so that the flame does not impinge on the test sample during the warm-up period. The shortest measured distance between the burner cone and test sample should be 18 inches (46 cm) or greater when in the warm-up position. Turn on the burner and allow it to stabilize for a period of 2 minutes.

25.7.5 Move the test frame assembly into the test position, and simultaneously start the timing device when the test frame is fully in the test position.

25.7.6 Record the time for the sample to melt, and the time of burning (sustained ignition) of the sample.[2]

25.7.7 Expose the test sample to the flames for a period of 4 minutes, then slowly move the test frame assembly away from the burner to the standby position and turn off the burner.

25.7.8 Continue to observe the test sample remaining in the sample holder after removal from the test position. If the sample is still burning, measure the time when the burning ends.

25.7.9 When the test sample has cooled sufficiently, loosen the toggle clamps and remove the sample. Record the final weight. Also remove any sample remnants located in the catch pan, and record these weights after first removing any residual oxidation and talc powder.[3]

25.8 Report

25.8.1 Report a complete description of the material(s) being tested, including manufacturer, alloy content, trade name, etc.

25.8.2 For each of the three samples, report the time for the sample to melt (visual observation when sample center section separates from remaining test sample). Also report the time of burning (sustained ignition), and the time when the sample self-extinguishes.

25.8.3 Calculate and record the weight percentage loss of each test sample by combining the final weight of the sample remaining in the holder and any additional remnants removed from the catch pan. Ensure that the remnant weight includes only metallic components, and no oxidized material or talc. The combined weight of the tested sample and remnants can be subtracted from the initial weight of the sample. This value can then be divided by the initial weight, and the value multiplied by 100 to determine the percentage weight loss.

25.8.4 Record any observations regarding the behavior of the test sample during flame exposure, such as popping, explosions, smoke, etc., and the time each event occurred.

25.8.5 Provide a record of burner flame consistency validation.

25.9 Requirements

25.9.1 None of the three samples tested may burn (sustained ignition) in less than 2 minutes of burner exposure.

25.9.2 The calculated weight loss of each sample must not exceed 10%.

25.9.3 If one or more samples fail to meet the above requirements, it is possible to run additional recovery tests, if 80% or more of the total number of samples meet the requirements. For example, if one of the three original samples fails the test requirement, two additional passing tests can be conducted for a total of four passing tests in five opportunities (4/5 = 80%).

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[2] Burning (sustained ignition) is defined as an ignition lasting for 10 consecutive seconds (i.e., an ignition lasting for more than 10 seconds shall be considered the beginning of sample burning, in the event that ignition stops and then re-starts).

[3] Residual oxidation and talc powder can be removed from the sample and retrieved molten/resolidified pieces by blowing them off with compressed air. This process should be completed within 1 hour of the end of the test.

Chapter 25 Supplement

This supplement contains advisory material pertinent to referenced paragraphs

25.3 Apparatus

25.3.2 Test Burner

This section describes in detail the Federal Aviation Administration Next Generation Fire Test Burner, also known as the Sonic burner or the NexGen burner. The NexGen burner is specified in multiple FAA fire test methods, although certain burner adjustments differ according to each specific test method.

The burner is a gun-type, using a pressurized, sprayed fuel charge in conjunction with a ducted air source to produce the burner flames. An interchangeable, screw-in fuel nozzle will be used to produce the conically-shaped fuel charge from a pressurized fuel source. A pressurized air source controlled via a regulated sonic orifice will supply the combustion air. The combustion air will be ducted through a cylindrical draft tube containing a series of diffusing vanes. There are several types of internal vanes used to diffuse the combustion air. The diffused combustion air will mix with the sprayed fuel charge in a bell-shaped combustion cone. The fuel/air charge will be ignited by a high-voltage spark plug positioned in the top of the combustion cone in the vicinity of the fuel spray nozzle. Flame characteristics can be adjusted by varying the pressure of the regulated air into the sonic orifice. A schematic of the next generation fire test burner is displayed in figure 25-13.

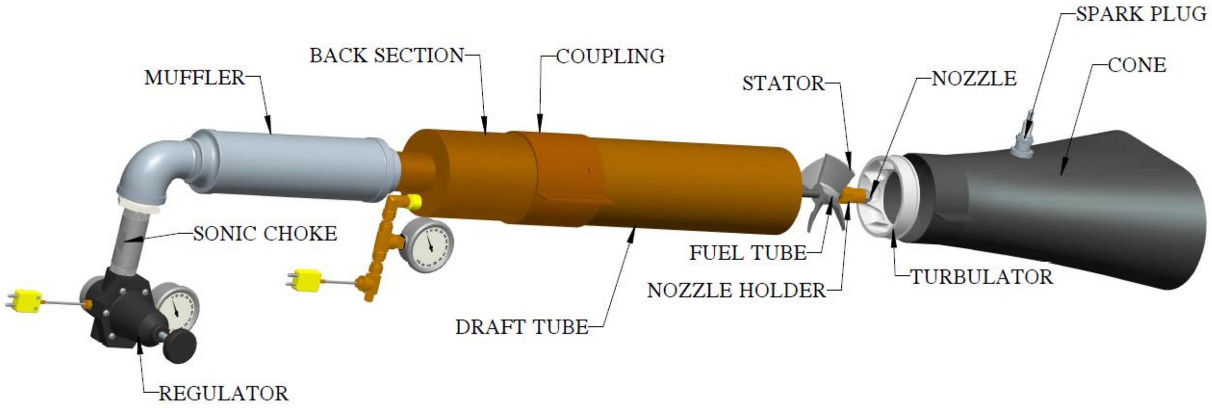

Figure 25-13. Schematic of the NexGen Burner - Exploded View

Burner Housing

The burner housing is comprised of three main sections, the draft tube, the coupling, and the back section. The draft tube is constructed of 4-inch inner diameter mild-seam steel tubing with a wall thickness of 0.125-inch. The length of the draft tube is 15 inches, with 3 inches of the tube inserted into the coupling, resulting in a coupling-to-tip distance of 12 inches (figure 25-14). The coupling is constructed of 4.25-inch inner diameter mild-seam steel tubing that is 4 inches long with an outer diameter of 4.75 inches. Three set-screw holes are 120 degrees apart and are drilled 1 inch in from the edge to hold the draft tube in place. The coupling has two mounting brackets welded to the sides for easy mounting and adjustment (figure 25-15). The back section is made of the same 4-inch tubing as the draft tube, but is 6 inches long, with 1 inch inserted into the coupling and welded in place (figure 25-16). A back plate is constructed of a 0.125-inch steel plate cut into a 4.25-inch diameter circle to cap the back section, with holes for the air inlet and fuel inlet (figure 25-17). A 1.5-inch National Pipe Thread (NPT) pipe nipple is cut to a length of 2.90 inches and welded into the recessed cut on the center of the back plate (figure 25-18).

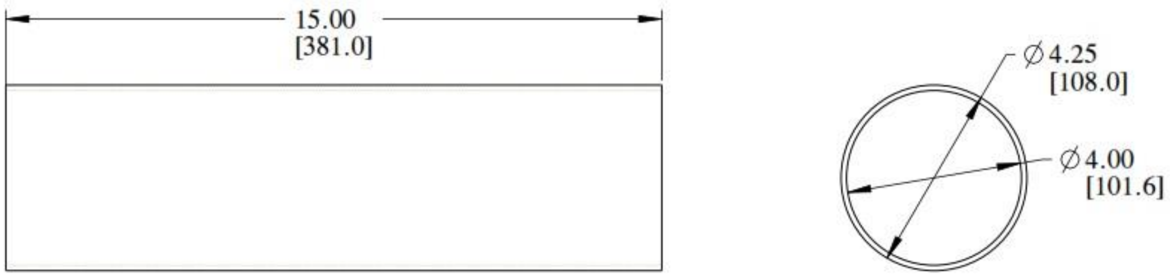

Figure 25-14. Dimensioned Drawing of the Draft Tube

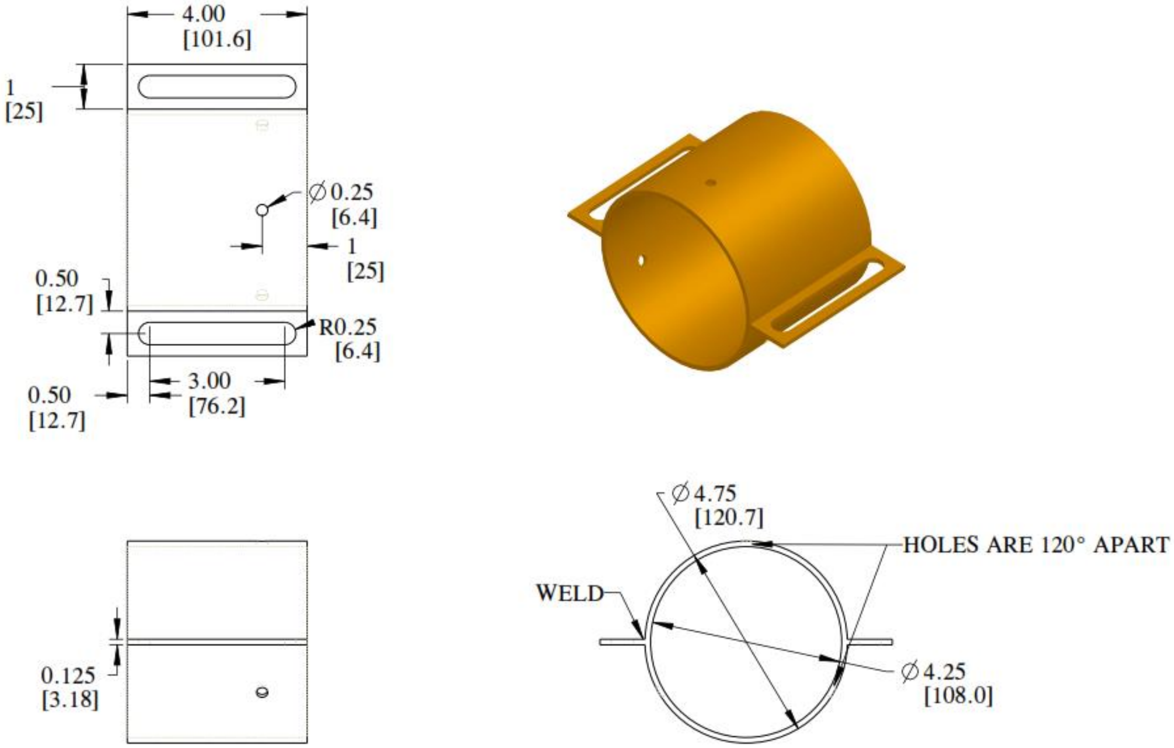

Figure 25-15. Dimensioned Drawing of the Coupling

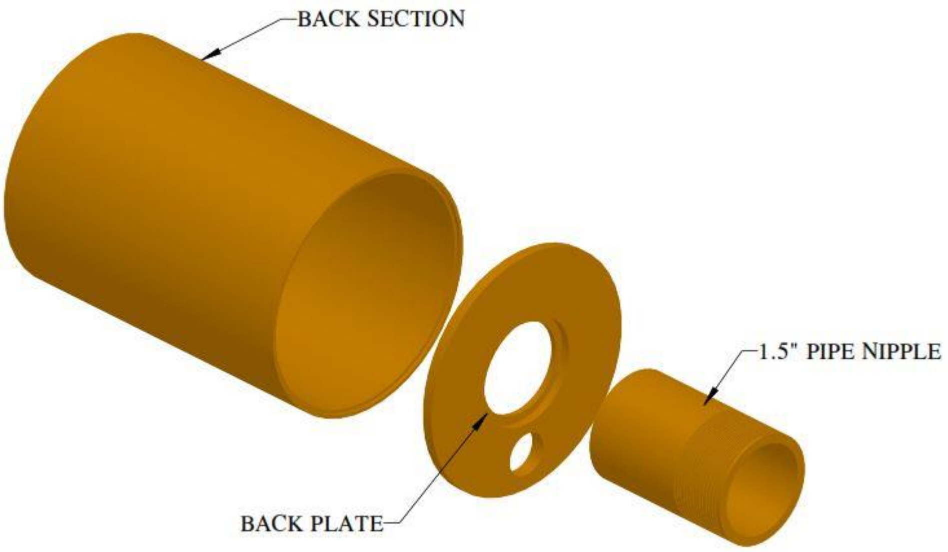

Figure 25-16. Back Section Components - Exploded View

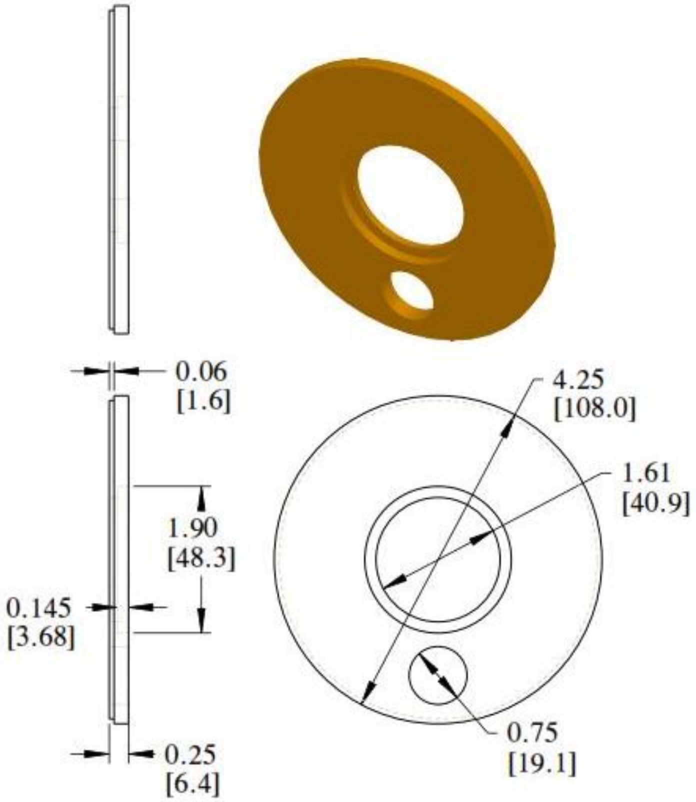

Figure 25-17. Dimensioned Drawing of the Back Plate

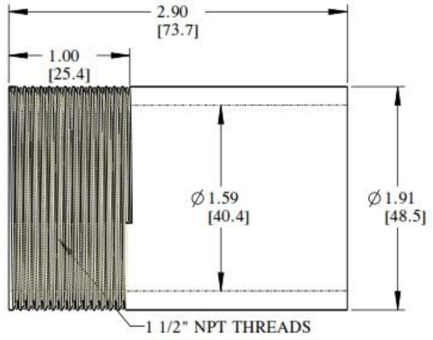

Figure 25-18. Dimensioned Drawing of the Pipe Nipple

Sonic Nozzle

The NexGen burner airflow is regulated with a sonic nozzle, which will deliver a constant mass flow rate depending on the supplied inlet air pressure (figure 25-19). The nozzle is constructed from stainless steel with 1-inch NPT male thread ends. The throat diameter must be 0.25 inches, which will deliver a mass flow rate, in standard cubic feet per minute, as a function of inlet pressure, in pounds per square inch gauge, at a rate of

$$\dot{m} = 0.89 * P_i + 12.43$$

The exact inlet air pressure, and hence mass flow rate, will be test-method specific and is described in the respective chapter. The nozzle that the FAA has used to develop the NexGen burner is manufactured by Fox Venturi Products of Dover, New Jersey, and is identified by part number 612021-8.

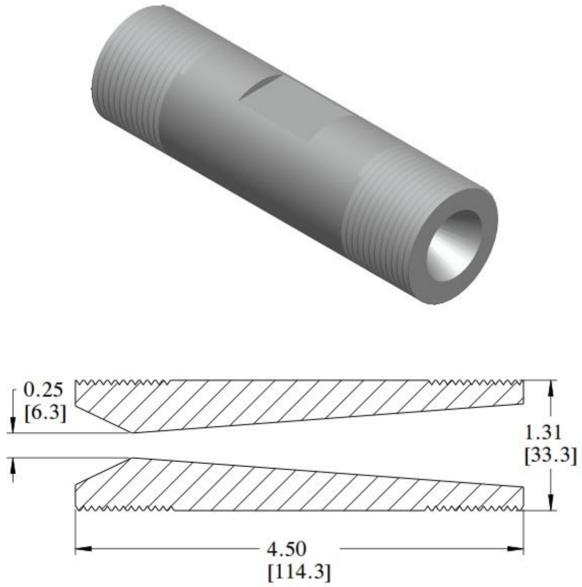

Figure 25-19. Schematic of the Sonic Nozzle with Cutaway View Showing Converging and Diverging Interior Sections

Air Pressure Regulator

The air pressure regulator is critical to maintaining the stability of the airflow supplied to the burner. The regulator should have 1-inch NPT female connections, at least one pressure tap for measurement of outlet pressure, and should regulate over the range at which the burner is normally operated. The regulator must also maintain the desired pressure for the length of a test (figure 25-20). A suitable regulator is available from Grainger, item number 4ZM10 (manufactured by Speedaire) with an adjustment range of 5-125 lbs/in^2. Another suitable regulator is available from MSC Industrial, part number 73535627, manufactured by Parker (model R119-08CG/M2) with an adjustment range of 2-125 lbs/in^2.

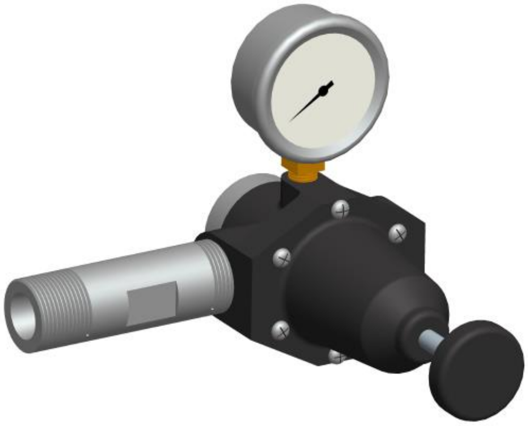

Figure 25-20. Schematic of Air Pressure Regulator with Sonic Nozzle Attached

Air Pressure Gauge

The outlet pressure of the regulator is critical for establishing the proper flow of air into the sonic nozzle. The pressure gauge must be NIST-certified, with a ± 2% accuracy or less. Digital gauges capable of reading in increments of 1 lbs/in^2 or less are recommended. If an analog gauge is used, it should be glycerin-filled to reduce needle flutter, and have an easily readable dial. The gauge must also have a working range appropriately suited for the range of air pressures typically used during tests. A suitable digital gauge is supplied Omega Engineering, part number DPG1001B-500G; a suitable analog gauge is supplied by McMaster-Carr, part number 4053K23 (figure 25-21).

Figure 25-21. Analog Pressure Gauge

Muffler

An air flow muffler is used to reduce the high frequency noise created by the air expanding from the sonic nozzle throat. The 3-inch outside diameter muffler has 1.5-inch NPT female thread connections, an overall length of 12 inches, and has no internal baffles or tubes. A suitable muffler is supplied by McMaster-Carr, part number 5889K73 (figure 25-22). Low pressure-drop polyurethane foam must be used to further reduce the noise issuing from the burner. The foam can be cut into a cylinder 3 inches in diameter by 12 inches long and should have a density of approximately 1.20-1.50 lbs/ft^3 with a porosity of approximately 20 pores/inch. It is necessary to affix two pieces of safety wire to the muffler's internal steel mesh at the outlet end, to prevent the foam cylinder from moving out of position into the burner housing. The two wires should be arranged perpendicular to each other in a cross pattern. The male outlet of the sonic nozzle connects to a 1-inch NPT female to 1.5-inch male hex bushing. The hex bushing male outlet connects to the intake side of the muffler via a 1.5-inch NPT female to 1.5-inch NPT male 90-degree street elbow.

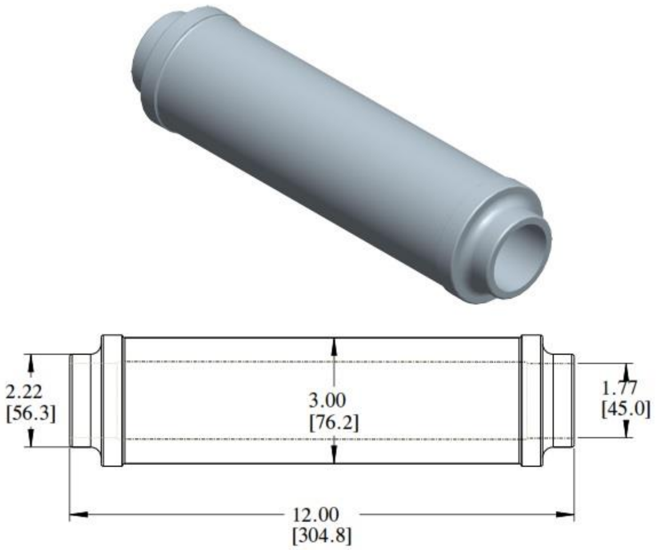

Figure 25-22. Schematic of the Muffler

Air Temperature

The air temperature must be maintained at 50 ±10°F for the duration of a test. This can be achieved by constructing a heat exchange system as described later in this section.

Air Diffusion Using Stator and Turbulator

Various components can be used to deflect and diffuse the airflow within the NexGen burner. The most common are the stator and turbulator. Three-dimensional drawing files can be used to fabricate the components on a Computer Numerical Control (CNC) milling machine. These files can be downloaded from the Fire Safety Website:

http://www.fire.tc.faa.gov/materials/burnthru/nexgen.stm

Stator

The stator is a four-vane internal component that creates a swirling flow aligning the fuel tube with the center axis of the draft tube. The stator is 4 inches in diameter and should have a snug fit when placed inside the draft tube (figure 25-23). A suitable stator is supplied by Marlin Engineering, part number ME1513-3.

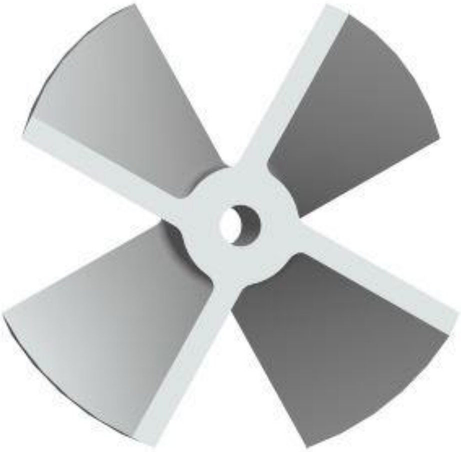

Figure 25-23. Stator

Turbulator

The turbulator is a 4-inch diameter swirling component placed in the end of the draft tube. The center hole is 2.75 inches in diameter (figure 25-24). A suitable turbulator is supplied by Marlin Engineering, part number ME1512-1.

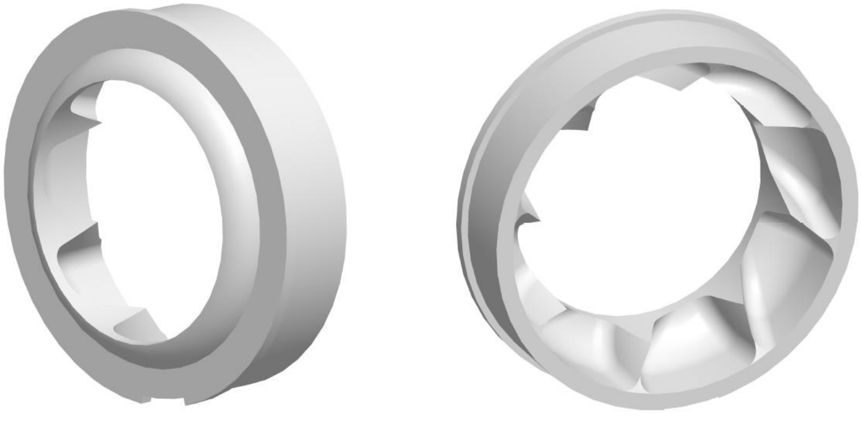

Figure 25-24. Turbulator, Front and Back

Stator and Turbulator Configuration

The stator slides onto the fuel rail, is oriented in the proper direction, and is locked into place with a set screw (figure 25-25). The turbulator is placed on the end of the draft tube with the tab located at the six o'clock position (figure 25-26). The typical configuration positions the face of the stator approximately 2.6875 inches from the exit plane of the turbulator (figure 25-27). Refer to the Preparation of Apparatus section for the exact positioning of the stator and turbulator.

Figure 25-25. Location of the Stator on the Fuel Tube

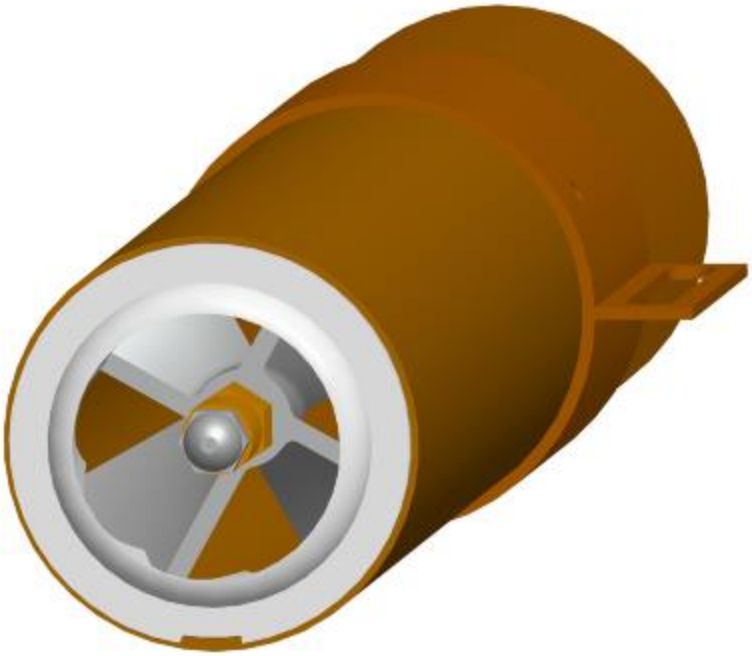

Figure 25-26. Position of Turbulator at the end of the Draft Tube

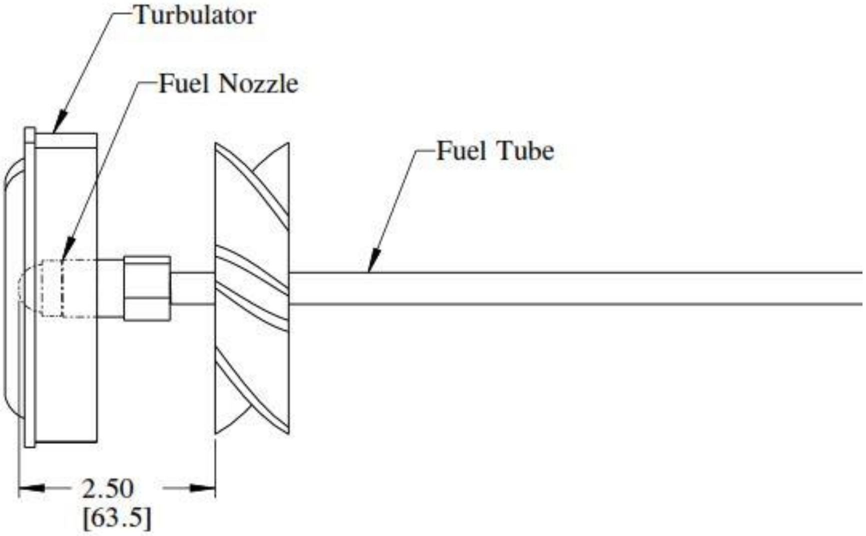

Figure 25-27. Typical Configuration of the Stator and Turbulator

Fuel System

A method of fuel pressurization is required to deliver the proper amount of fuel to the spray nozzle for consistent atomization. The delivered fuel pressure is typically in the range of 100 – 120 lbs/in^2, and must maintain the desired pressure for the duration of a test. A suitable method of fuel pressurization is a pressurized fuel tank (figure 25-28). Alternatively, a fuel pump may be used provided it can maintain the required pressure for the duration of a test with minimal fluctuation.

A pressure vessel, such as McMaster-Carr part number 1584K7 with a 15-gallon capacity, measuring 12 inches in diameter and 33 inches tall can be used to contain the fuel. The tank has various fittings on the top, bottom, and sides to allow for connection of pipe fittings for filling, discharging, fuel quantity level, pressure measurement, pressurization, and venting. Nitrogen is used to pressurize the headspace of the fuel tank. Solenoid or manual valves can be used to start and stop the flow of fuel, nitrogen, and vent gas. The headspace gas pressure is controlled by a precision regulator, and monitored using a fuel pressure gauge. A high pressure translucent tube can be used for indicating the fuel level in the tank.

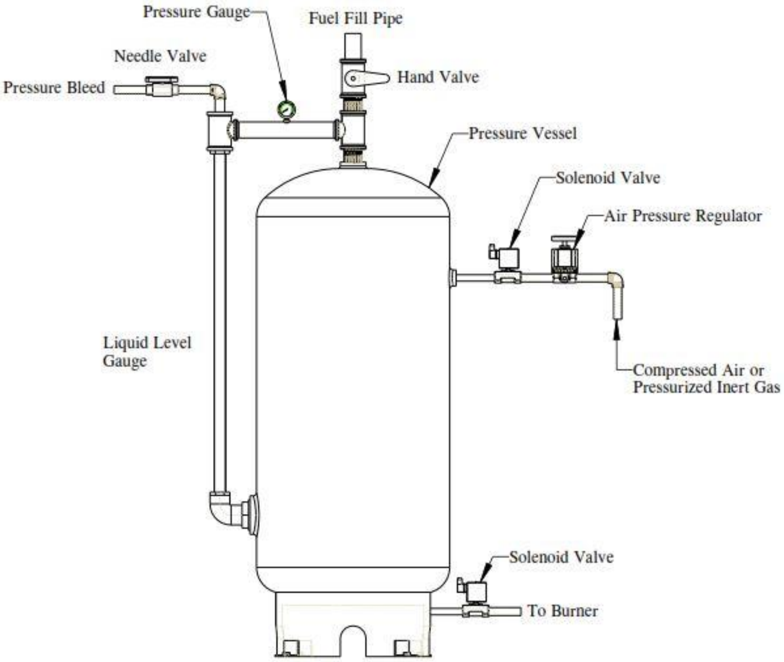

Figure 25-28. Schematic of Pressurized Fuel Tank System

Fuel Pressure Gauge

A suitable pressure gauge must be used to monitor the pressure inside the fuel tank, which is critical for establishing the proper flow of fuel into the fuel nozzle. The pressure gauge must be NIST-certified, with a ± 2% accuracy or less. Digital gauges capable of reading in increments of 1 lbs/in^2 or less are recommended. If an analog gauge is used, it should be glycerin-filled to reduce needle flutter, and have an easily readable dial. The gauge must also have a working range appropriately suited for the range of fuel pressures typically used during tests. A suitable digital gauge is supplied Omega Engineering, part number DPG1001B-500G; a suitable analog gauge is supplied by McMaster-Carr, part number 4053K23 (figure 25-29).

Figure 25-29. Analog Pressure Gauge

Fuel Temperature

The fuel temperature must be maintained at 42 ±10°F for the duration of a test. This can be achieved by constructing a heat exchange system as described later in this section.

Fuel Tube

The fuel tube in the NexGen burner is designed to allow both the fuel nozzle and the airflow to be aligned with the axis of the draft tube. This is accomplished by creating two bends in the section of the fuel tube that enters the back of the burner (figure 25-30). The tube is constructed from 0.125-inch steel pipe with an outside diameter of 0.405-inch, an inside diameter of 0.215-inch, and a wall thickness of 0.095-inch. The pipe is cut to a length of approximately 21.5 inches; a section of the outer wall is removed on a lathe to fit the pipe through the keyless bushing that holds the tube in place. The outer diameter of the fuel tube is reduced to approximately 0.3750 inch for a length of 4 inches at one end. The tube is then shaped with a pipe bender according to the dimensions in the drawing. A die is used to thread both ends of the tube with 1/8-inch NPT pipe threads. Heavy duty 0.004-inch-thick thread seal tape is wrapped on the pipe threads to prevent fuel leakage. A 1.375-inch-long brass fuel nozzle adapter is threaded onto the front end of the fuel tube where the fuel nozzle will be attached. A keyless bushing (Fenner Drives p/n 6202109) is used to hold the back end of the fuel tube in place. A pipe fitting is attached to the back end of the fuel tube to connect the pressurized fuel system to the fuel tube.

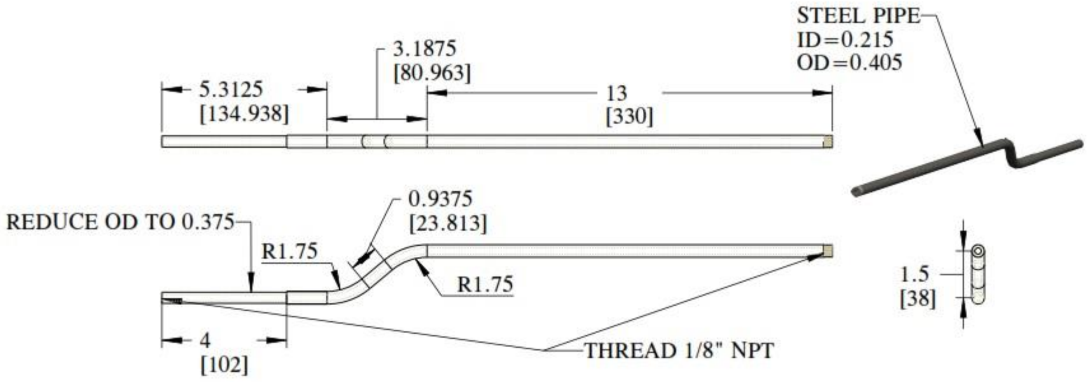

Figure 25-30. Schematic of the Fuel Tube

Fuel Nozzle

The fuel nozzle for the NexGen burner should be an 80-degree conical spray pattern oil burner nozzle. The nozzle flowrate will depend on the test method. The rated flow rate provided by the manufacturer is achieved when applying a 100 lb/in^2 pressure to the nozzle. If a different flow rate is desired, the pressure can be adjusted accordingly to achieve a wide range of flow rates. In general, the flow rate is related to the pressure by:

$$F_d = F_r \sqrt{P_d / P_r}$$

Where F_d is the desired flow rate, F_r is the rated flow rate, P_d is the desired pressure, and P_r is the rated pressure, typically 100 psig. For example, if a 5.5-gallon/hr-rated nozzle is operated at 120 lb/in^2, a flow rate of 6.0 gallon/hr will be achieved. A Delavan 2.0 gallon/hour 80-degree solid spray pattern (B-type) spray nozzle has been found suitable for this application.

Nozzle Adapter

The fuel nozzle adapter is a brass fitting 1.375 inches in length with a 1/8-inch NPT thread on the inlet side and 0.5625-inch 24 Unified Fine Thread (UNF) thread where the nozzle attaches (figure 25-31).

Figure 25-31. Fuel Nozzle and Brass Adapter

Fuel

Use jet fuel (JP-8, Jet A, or their international equivalent), or ASTM K2 fuel (Number 2 grade kerosene) to yield the desired fuel flow rate within the specified pressure range for the test method being performed. Diesel fuel may also be used, however the test condition may be more severe.

Ignition

A high voltage oil burner ignition transformer with an output of 10 kilovolts is used to create an arc across an automotive-type spark plug mounted in the burner extension cone. The spark plug uses a standard 14 mm diameter thread size with a thread pitch of 1.25 mm. The threaded segment of the spark plug is 0.36 inches (9 mm) in length. The exposed portion of the central insulator measures 0.70 inches in length. The spark plug gap must be opened to 0.100 inches (2.5 mm) in order to consistently ignite the fuel/air charge in the burner cone (figure 25-32). A suitable spark plug is manufactured by Champion Products, manufacturer part number RJ19LM, and can be purchased through Grainger (www.Grainger.com), part number 12U891.

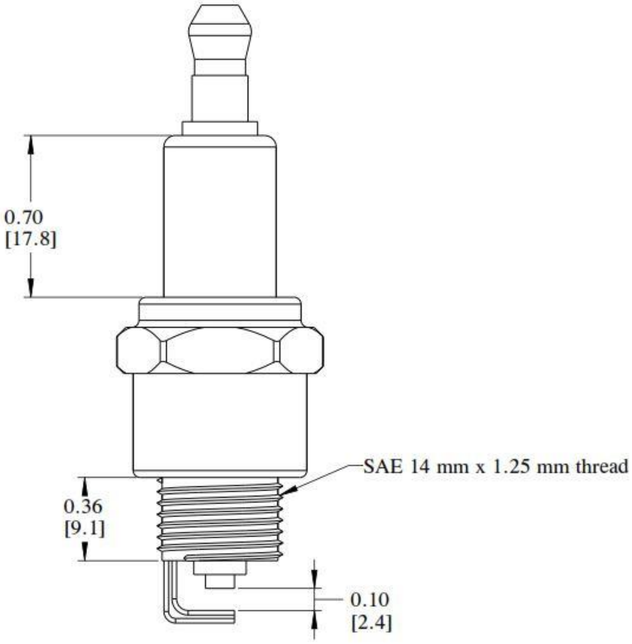

Figure 25-32. Dimensioned Drawing of a Spark Plug

Heat Exchange System

A heat exchange system is used to regulate the temperature of the burner inlet air and fuel as the flow rate of each is dependent upon the density of the air and fuel. A schematic of a suitable heat exchange system is displayed in figure 25-33. The ice bath can be constructed from an insulated cooler or a chest freezer with temperature control capability. The fuel travels through coiled copper tubing in the ice bath and out to the burner. The air is cooled in a heat exchanger, such as McMaster-Carr part number 43865K78, which has ice water traveling through the outer shell, removing heat from the air. The ice water is circulated in a closed-loop from the cooler to the heat exchanger by means of a submersible pump. The exact dimensions of the copper coils and the flowrate of the water pump will be dependent upon the particular conditions in the laboratory. Alternate methods such as active heating and cooling systems can be used, allowing greater precision, but may be more costly.

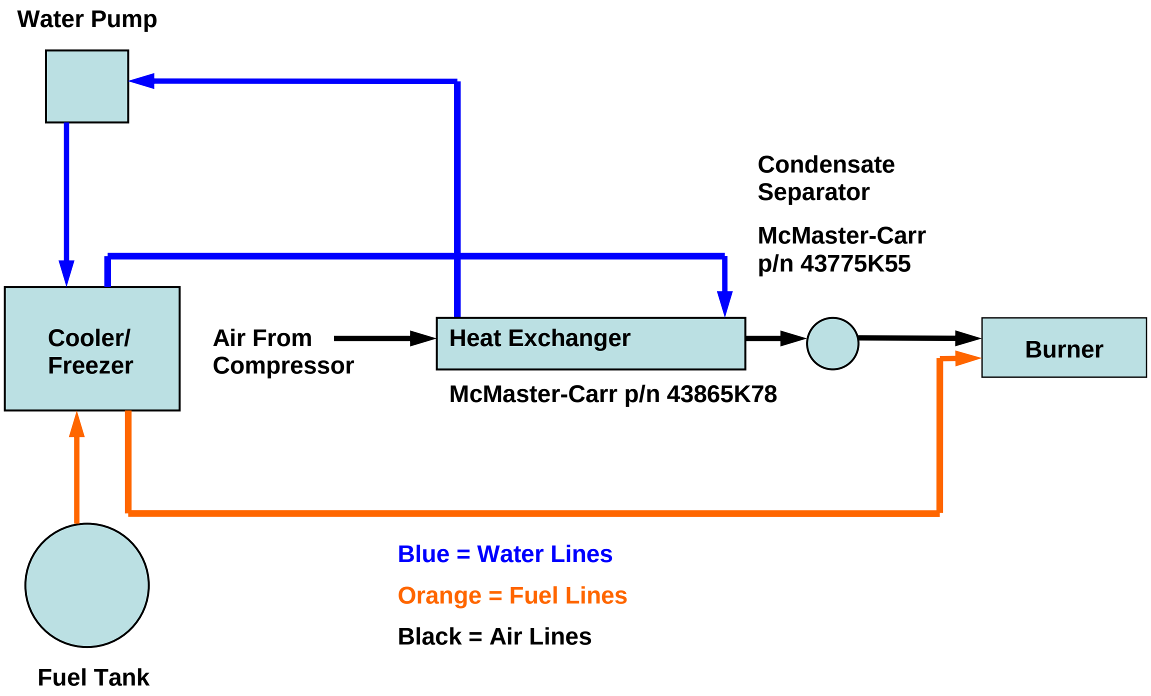

Figure 25-33. Schematic of Air/Fuel Heat Exchange System

Burner Cone

A 12 ± 0.125-inch (305 ± 3-mm) burner extension cone is fitted to the end of the draft tube. The cone is constructed from 16 gauge American Iron and Steel Institute (AISI) type 310 stainless steel. The cone exit plane must be 6 ± 0.250 inches (152 ± 6 mm) high and 11 ± 0.250 inches (280 ± 6 mm) wide, with a thickness of 0.065 ±0.015 inch (1.65 ± 0.375 mm). See figures 25-34 and figure 25-35 for detailed drawings. The hot and cold cycling that occurs during typical testing can cause the cone exit plane dimensions to shift due to warpage. It is critical to check the exit plane dimensions to ensure they remain within the specified tolerances.

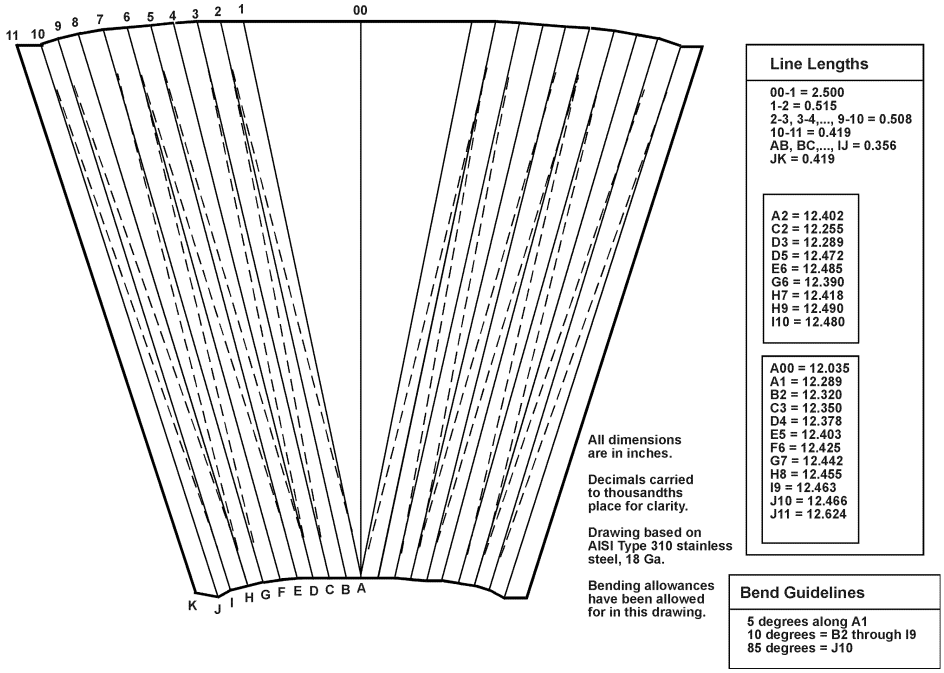

Figure 25-34. Burner Cone Layout and Bending Pattern

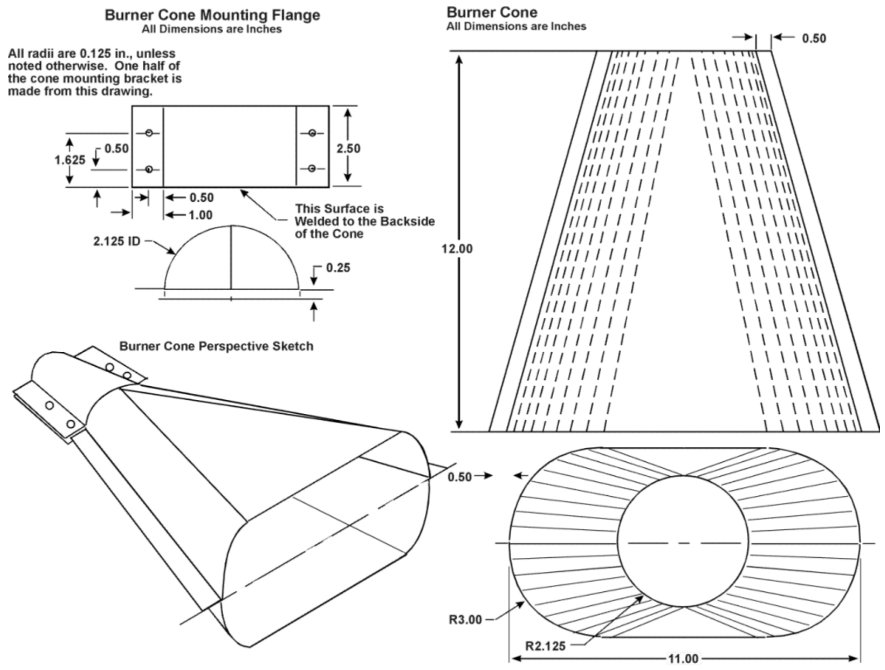

Figure 25-35. Burner Cone Details

Threaded Boss for Spark Plug

A threaded boss must be welded to the upper side of the burner extension cone for acceptance of the spark plug used to ignite the fuel charge. The threaded boss must be fabricated from American Iron and Steel Institute (AISI) type

310 stainless steel. The cylindrical boss must measure 1.125 inches (28 mm) in diameter, with a thickness of 0.250 inches (6.4 mm). The boss must be threaded using an SAE standard 14 mm x 1.25 mm spark plug tap (figure 25-36).

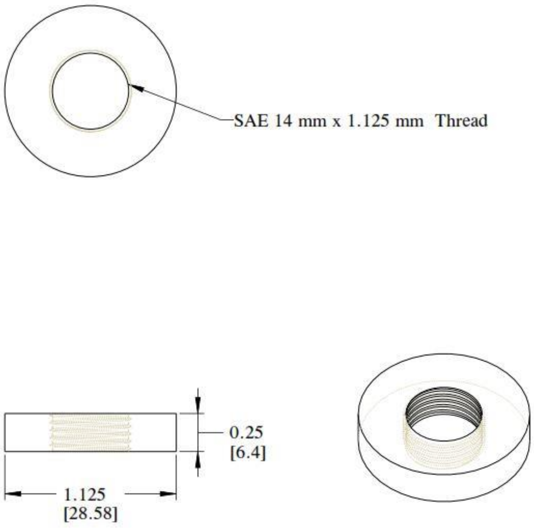

Figure 25-36. Threaded Boss

Burner Measurement Locations

Accurate measurements of the burner inlet parameters are critical to proper operation. The measurement locations of the burner air and fuel supply are indicated in figure 25-37.

Air Pressure

The sonic choke inlet pressure is measured with a suitable pressure gauge mounted just upstream of the sonic choke, preferably at the outlet pressure tap on the pressure regulator. The gauge should measure accurately in the range of 0-60 lb/in^2, with an accuracy of ± 2% maximum. Bourdon type gauges and pressure transducers have proven to be suitable for this measurement (see details in Air Pressure Gauge above).

Air Temperature

The burner air temperature is measured with a 0.125-inch diameter, ceramic packed, 310 stainless steel sheathed, type K (Chromel-Alumel) grounded junction thermocouple with a nominal 24 AWG conductor. The thermocouple should be inserted into the air stream just upstream of the sonic nozzle. In some testing situations, flame radiation may be incident upon the inlet air lines, causing heating of the air and possible bursting of flexible hoses. It is important to shield all air lines with thermal wrapping to prevent an unsafe condition and maintain steady air temperature.

Fuel Pressure

The burner fuel pressure is measured with a suitable pressure gauge (see Fuel Pressure Gauge above) mounted in a T-connection in the fuel inlet line near the back of the burner. It is important that the measurement location be as close to the back of the burner as possible to accurately measure the fuel pressure at the point it enters the burner.

Fuel Temperature

The burner fuel temperature is measured with a 0.125-inch diameter, ceramic packed, 310 stainless steel sheathed, type K (Chromel-Alumel) grounded junction thermocouple with a nominal 24 AWG conductor. The thermocouple should be mounted in a T-fitting such that the probe tip is located near the center of the fuel tube. In some testing situations, flame radiation may be incident upon the inlet fuel lines, causing heating of the fuel and possible bursting of flexible hoses. It is important to shield all fuel lines with thermal wrapping to prevent an unsafe condition and maintain steady air temperature.

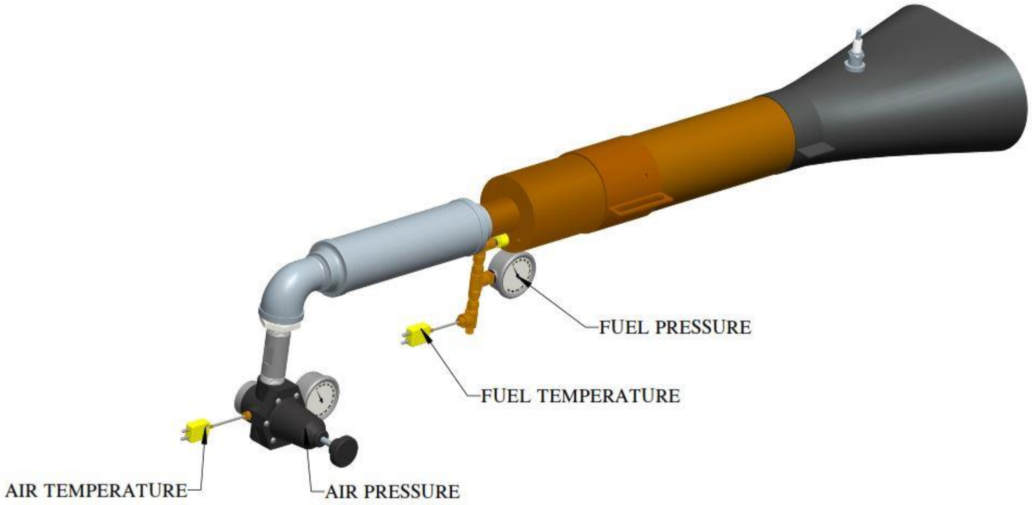

Figure 25-37. Burner Schematic Showing Inlet Measurement Locations

25.5 Preparation of Apparatus

25.5.3 Thermocouples

The thermocouples used for measuring the burner flame temperature have been known to degrade over time. This is due to the transient nature of the burner flame, which produces rapid increases and decreases in temperature during measurement. These instantaneous fluctuations in temperature cause a reduction in the sensitivity of the instrument, resulting in a lower indicated reading. The difficulty with this degradation process is that it occurs gradually over a period of time, and currently there are no recommended guidelines for replacing the instruments after a specific number of exposure hours. This occurrence can often lead to suspicion that the burner is malfunctioning, thereby triggering unnecessary adjustment of the burner equipment to compensate for the erroneous low temperature readings.

25.6 Burner Flame Consistency Validation

25.6.1 Sonic Burner

The objective of the burner flame consistency validation is to ensure the burner is producing the required flame output, in order to subject the test samples to the proper intensity. The NexGen burner is specialized equipment, using precision components that are assembled in a very specific configuration. This level of accuracy is a departure from previous burners, in which the internal components and configuration were not as tightly controlled. For this reason, previous burners used for flammability testing required time-consuming calibration procedures to help ensure the multitude of possible burner configurations were still producing the required flame intensity. With the NexGen burner, there is more reliance on the internal components and precise configuration to produce the correct flame output, thereby minimizing lengthy calibration procedures.

25.7.9 Test Procedure

To expedite the sample mounting and testing process, several sample holder/catch pans can be incorporated. The catch pan can use pins or other quick-release mechanisms to facilitate quick removal following each test. Once the test is complete, the entire sample holder and catch pan, including talc and sample remnants, can be removed from the testing area, and a new sample holder, catch pan, and test sample replaced. Ensure that the new test sample is properly aligned with respect to the burner.

25.9 Pass/Fail Requirements

Self Extinguishment

Measuring the exact time of flame extinguishment of the test sample is difficult and subjective, given the nature of a burning magnesium alloy. The transition of the alloy from burning to self-extinguishment typically happens gradually rather than instantaneously, as is the case with most traditional cellulosic materials. For this reason, a maximum allowable time until self-extinguishment of the test sample is not required, per se. However, if new magnesium alloys become available that exhibit extended burn periods prior to self-extinguishment, but still pass the weight loss criteria, it may be necessary to incorporate a maximum time requirement for the alloy to self-extinguish.

25.9 Pass/Fail Requirements

25.9.3 Recovery Process

The “80% Rule” recovery process is intended for materials that typically meet the test requirements, but experienced an unexpected failure for unknown reasons. These failures, often referred to as rogue failures, are unanticipated and cannot be explained. The recovery process should not be viewed as a technique for meeting the requirement with inferior materials.