EI 1597

Aircraft misfuelling prevention

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AIRCRAFT MISFUELLING PREVENTION

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FOREWORD

This Recommended Practice has been prepared by the EI's Aviation Committee. It provides recommendations to ensure that the correct aviation fuel (product and grade) is always delivered to an aircraft. Delivering the incorrect aviation fuel/grade to an aircraft can have catastrophic consequences for flight safety, potentially leading to fatalities.

This publication provides recommendations for safe practice, rather than prescriptive guidelines. Users of this publication shall be aware that due consideration shall be given to the effect of any unusual or abnormal circumstance, on which it is not possible to generalise within the scope of this publication. Specialist advice shall be sought in these cases.

The recommendations contained in this publication are intended for pilots, aircraft owners and all those involved in overwing fuelling operations of civil aircraft.

This is the third edition of this publication (previously titled *Procedures for overwing fuelling to ensure delivery of the correct fuel grade to an aircraft*). It has been significantly updated to provide misfuelling prevention controls that are suitable following the industry introduction of more than one grade of avgas. The key changes from the previous edition are:

– Mandating fuel grade-specific aircraft decals.
– Mandating fuel grade-specific marking on aircraft fuelling equipment and recommending fuel grade-specific colour banding is also included.
– Mandating the use of a 'three-way cross-check' for fuel grade confirmation before fuelling commences.
– Deleting the concept of using two out of three controls, in recognition that the fuelling nozzle spout does not provide a misfuelling prevention control due to the introduction of grades of unleaded avgas.
– Amending terminology from 'wing decal' to 'fuel grade decal' to emphasise their critical role in identifying the required fuel grade.
– Inclusion of example Fuel Order Forms (one for jet fuel, one for avgas).

For the purposes of demonstrating compliance with this publication the words 'shall', 'should' and 'may' are used to qualify certain requirements or actions. The specific meaning of these words is as follows:

– 'shall' is used when the provision is mandatory;
– 'should' is used when the provision is recommended as good practice, and
– 'may' is used where the provision is optional.

In addition, in some areas local or national statutory regulations also apply. This publication is intended to be complementary to these established controls and practices.

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Suggested revisions are invited and should be submitted to the Technical Department, Energy Institute, 61 New Cavendish Street, London, W1G 7AR (e: technical@energyinst.org).

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1 INTRODUCTION – ALL MISFUELLING INCIDENTS ARE PREVENTABLE

1.1 DELIVERING THE CORRECT GRADE OF FUEL TO AN AIRCRAFT

Critical terms:

Misfuelling: delivering the incorrect fuel grade into an aircraft.

Aviation fuel: a general term referring to any grade of jet fuel (aviation turbine fuel) or any grade of aviation gasoline, which meets defined fuel specifications.

Product (type): generic term applied to any liquid hydrocarbon, used in EI aviation fuel handling publications for both aviation and non-aviation fuels (e.g. jet fuel, avgas, diesel, motor gasoline etc.).

Grade: term for a specific aviation fuel meeting the criteria defined by a governing specification (e.g. Jet A and Jet A-1 are different grades of jet fuel).

For the safe operation of aircraft **IT IS CRITICAL** that the correct fuel grade is always delivered, which is the responsibility of both the pilot and the into-plane fuel provider.

Delivering the incorrect grade of fuel into an aircraft is termed a 'misfuelling', which can have **SEVERE CONSEQUENCES THAT MAY RESULT IN ENGINE FAILURE AND POTENTIAL FATALITIES**.

For piston engine aircraft misfuelling includes:

– delivery of jet fuel to a spark ignition piston (e.g. avgas) engine aircraft, or
– delivery of avgas fuel into a compression ignition (e.g. diesel) piston engine, or
– delivery of avgas into a spark ignition piston engine where the octane level of the delivered avgas is lower than the required octane level for the engine (e.g. delivering UL91 or UL94 to aircraft that require 100 or 100LL).

For jet turbine-powered aircraft this includes:

– delivery of avgas to a turbine-powered aircraft.

The serious consequences of misfuelling include:

– Total engine failure due to knock damage if jet fuel is delivered into a spark ignition piston engine powered aircraft that requires avgas.
– Ignition failure if avgas is delivered into a compression ignition (diesel) piston engine powered aircraft that requires jet fuel.
– Vapour lock and engine failure due to fuel starvation if avgas is delivered into a turbine-powered aircraft that requires jet fuel. Many turbine engines are capable of operating on avgas, but such operation is strictly controlled as described in the Pilot's Operating Handbook.
– Potential engine failure or power loss if an avgas grade is delivered that is below the minimum specified octane level for that engine type.

The risk of misfuelling exists because the design of the aircraft fuel orifice and fuelling equipment used cannot always prevent it (it is possible to use the same fuelling equipment for delivery of either jet fuel or avgas).

Investigations into past misfuelling incidents have identified a variety of causes. These have included:

– Lack of communication and confirmation between the pilot and the fuel supplier over the grade of fuel required for a specific aircraft.
– The grade of fuel required not being clearly identified on the aircraft at the fuelling point.
– The grade of fuel being supplied not being clearly identified on refuelling equipment.
– Refuelling operators not systematically following misfuelling prevention procedures during aircraft refuelling.
– The similarity in appearance between aircraft even when they require different grades of fuel. Examples include the Piper Mirage (avgas) and Piper Meridian (jet fuel), and the Cessna 404 Titan (avgas) and 441 Conquest (jet fuel), where visual appearance of the aircraft alone cannot be relied on to identify which grade of fuel the aircraft requires (see also example in Figure 1).

Cirrus – jet fuel

Cirrus - avgas

Figure 1: Example of two similar aircraft requiring different grades of fuel

The history of aircraft misfuelling incidents demonstrates that at every location a comprehensive system of procedures and equipment is required to prevent the many possible causes of misfuelling.

Overwing fuelling: overwing fuelling distinguishes the operation from underwing pressure fuelling. It refers to an aircraft fuelling operation utilising a hose end fuelling nozzle of a design similar to that used for dispensing ground fuels. The term is not limited to aircraft fitted with a filler port on the upper surface of a wing (e.g. it also applies to filler ports located on fuselage).

1.2 FUEL SYSTEM ICING INHIBITOR

Some aircraft require the mandatory use of jet fuel containing the additive fuel system icing inhibitor (FSII). The lack of FSII, improper dosage rate, or improper FSII injection into the jet fuel can be a risk to those types of aircraft. Recommended guidelines for the handling and delivery of jet fuel containing FSII are provided in EI 1538 *Handling of fuel system icing inhibitor and aviation fuel containing fuel system icing inhibitor*.

1.3 INCREASING DEPLOYMENT OF UNLEADED AVGAS

The aviation industry is working to eliminate the use of tetraethyl lead from avgas. Therefore, the availability of unleaded (UL) grades of avgas at airports is likely to increase in the near future. There may be a transition period where multiple avgas grades are offered at the same location. The increased availability of multiple avgas grades with varying octane ratings

presents an increased risk of misfuelling for spark ignition piston engine aircraft and reinforces the need for a comprehensive misfuelling prevention programme.

Current designs of fuelling nozzle spouts cannot prevent misfuelling between the different grades of avgas.

At the time of writing, the compatibility between unleaded grades of avgas is unclear. It is the responsibility of the pilot/authorised aircraft representative to ensure that the grade of avgas ordered is acceptable for use in the aircraft and also compatible with any residual avgas on the aircraft.

1.4 APPLICATION OF EI 1597

This edition of EI 1597 has been significantly updated to provide a means of ensuring that the correct grade of avgas is always delivered to aircraft. The new requirements apply at **all locations**, including those that continue to supply only one grade of avgas (aircraft may arrive requiring another grade of avgas).

Misfuelling incidents have occurred at single fuel locations when aircraft have landed and requested fuel, unaware that the grade they require is unavailable. That is why this publication applies to **all locations**, including those that supply only jet fuel or only a single grade of avgas, as well as those locations that supply multiple grades.

2 MISFUELLING PREVENTION PROGRAMME SUMMARY

A misfuelling prevention programme consists of the fuel order process and fuel grade confirmation checks (also called the 'misfuelling prevention triangle' and the 'three-way cross-check').

Fuel order process: this requires a clear, well-defined communication between the pilot and into-plane fuel service operator to define the fuel grade required on every occasion that an aircraft is fuelled.

Instructions to or between refuelling staff relating to the fuel order shall always specify the grade of fuel required, the aircraft registration, and the quantity of fuel to be delivered into each fuel tank.

Fuel grade confirmation checks: **under no circumstances shall refuelling staff assume what grade of fuel is required**. Before fuelling starts the operator **SHALL** confirm that the aircraft is marked with a fuel grade decal that clearly matches the grade on the Fuel Order Form and the aircraft fuelling equipment (this is referred to as the 'three-way cross-check').

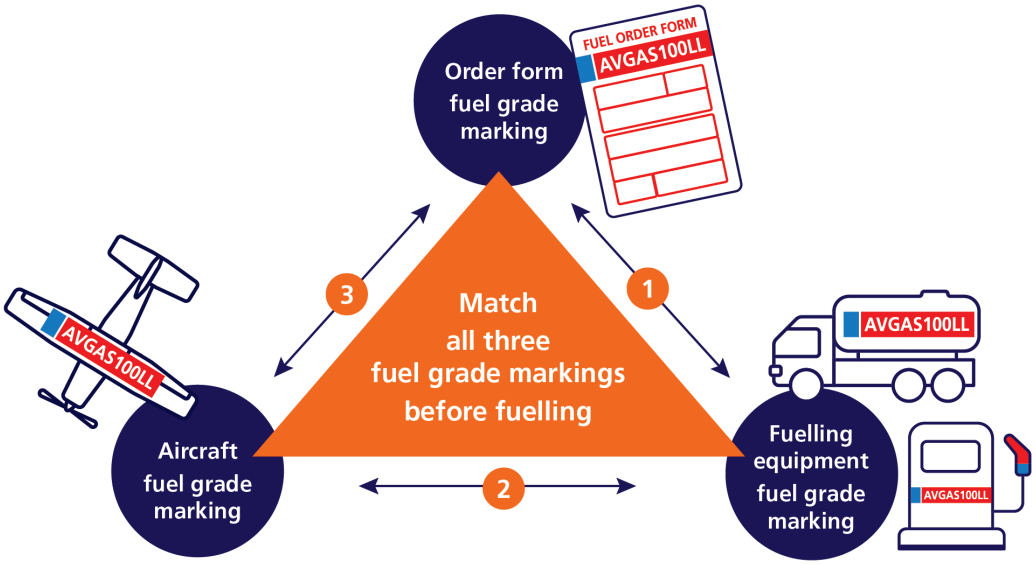


Figure 2: Schematic of fuel grade confirmation (the 'three-way cross-check'), in this example for avgas 100LL

Refuelling staff **SHALL NOT** attempt to fuel an aircraft purely on their knowledge of the aircraft type. It is critically important that all refuelling staff comply with fuel grade confirmation procedures and do not assume the fuel grade required.

The requirements of EI 1597 third edition apply at all locations, including those that continue to supply only one grade of avgas (aircraft may arrive requiring another grade of avgas).

3 FUEL ORDER PROCESS

3.1 COMMUNICATION FROM PILOT[1]

A pilot has a critical role in misfuelling prevention. The first step in misfuelling prevention is good communication between a pilot and those they entrust to refuel their aircraft. This requires a pilot to state (and refuelling operators to confirm) the grade of fuel every time a fuel order is placed.

A pilot/authorised aircraft representative **SHALL NEVER** use any unclear/ambiguous terms, e.g. '200 US gallons/litres a side', 'fill it up', 'top it off', 'aviation fuel' or 'gasoline', including at locations or with refuelling operators with whom they are very familiar.

For all fuel orders, the pilot/authorised aircraft representative shall clearly communicate:

– fuel grade;
– aircraft registration, and
– quantity of fuel to be delivered into each fuel tank.

Note: It is the responsibility of the pilot/authorised aircraft representative to ensure that the grade of avgas ordered is acceptable for use in the aircraft and also compatible with any residual avgas on the aircraft.

3.2 FUEL ORDER RECEIPT/PROCESSING

All fuel orders shall contain:

– fuel grade;
– aircraft registration, and
– quantity of fuel to be delivered into each fuel tank.

The Fuel Order Form shall include the fuel grade decal. Example Fuel Order Forms are provided in Annex B. Forms shall be printed in colour so the fuel grade decal is always obvious. Consideration may also be given to printing the forms on coloured paper to match the fuel grade (e.g. blue for 100LL).

Any order received without the fuel grade being specified, e.g. where a pilot/authorised aircraft representative places an order for, e.g. '200 US gallons/litres a side', 'fill it up', 'top it off', 'aviation fuel' or 'gasoline', **SHALL NOT BE ACCEPTED**.

The pilot shall be asked to specify the fuel grade required (never recommend a fuel grade to the pilot).

The fuel grade stated by the pilot shall be repeated back to them.

The pilot shall be asked to confirm it is correct.

A fuel order received verbally shall be repeated in full to the pilot for confirmation.

1 It may not always be the aircraft pilot that places a fuel order. The requirement for clear communications applies to any other authorised aircraft representative.

Fuel orders shall be written down immediately on receipt (e.g. on a Fuel Order Form, or directly into an electronic fuel ordering system).

Orders passed on verbally within the into-plane operation (e.g. from office staff to refuelling personnel) shall be repeated in full by the refuelling personnel for confirmation and should also be written down by the refuelling personnel.

4 FUEL GRADE CONFIRMATION

4.1 THREE-WAY CROSS-CHECK

Under no circumstances shall refuelling staff assume what grade of fuel is required.

Before fuelling commences the Fuelling Operator **SHALL** complete three checks:

1. Confirm that the fuel grade documented on the Fuel Order Form **CLEARLY MATCHES** the fuel grade marked on the aircraft fuelling equipment (refueller, fuelling nozzle).
2. Confirm that the fuel grade marked on the aircraft fuelling equipment (refueller, fuelling nozzle) **CLEARLY MATCHES** the fuel grade on the aircraft fuel placard/fuel grade decal.
3. Confirm that the fuel grade documented on the aircraft fuel placard/fuel grade decal **CLEARLY MATCHES** the fuel grade on the Fuel Order Form.

This is referred to as the 'three-way cross-check', as shown in Figure 3.

The order of the three checks is intentional. It reflects the sequence of receiving an order, selecting the correct fuelling equipment, and verifying the aircraft's fuel placard/fuel grade decal.

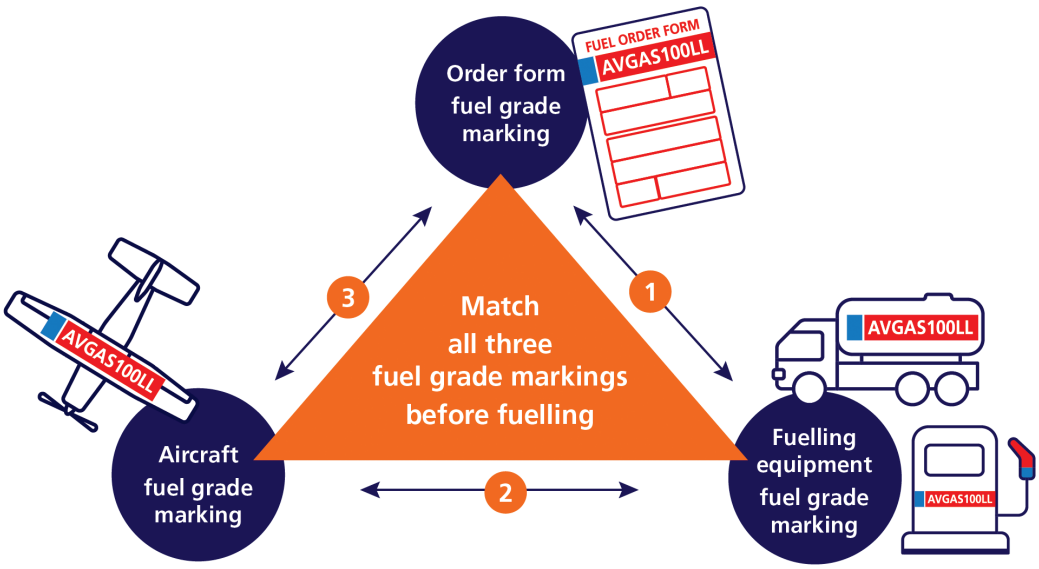


Figure 3: Schematic of fuel grade confirmation (the 'three-way cross-check'), in this example for avgas 100LL

Where the three-way cross-check cannot positively identify the required fuel grade, a Fuel Grade Confirmation Form (see 4.5) shall be used.

4.2 FUEL PLACARD

There are regulatory requirements (e.g. defined by the Federal Aviation Administration (FAA), and European Union Aviation Safety Agency (EASA) under 'Miscellaneous markings and placards') for fuel filler (ports) markings or placards at or near the filler (port) cover. These markings/fuel placards are required to show the type of fuel used by the aircraft (avgas, jet fuel) and the permissible fuel grade(s) designations, or reference the Airplane Flight Manual (AFM) for permissible fuel designations. The provision of these markings/fuel placards is the responsibility of the original equipment manufacturer (OEM) and owner/operator of the aircraft to meet and maintain (including in the event of a retrofit to an engine requiring a different fuel grade).

If such regulatory markings/fuel placards are present and clearly show the type and grade of fuel the aircraft requires, they may be used as part of the three-way cross-check.

Some examples of OEM markings/fuel placards are shown in Figure 4.

Figure 4: Examples of OEM markings/fuel placards

4.3 FUEL GRADE DECAL

Additional to the regulatory marking/fuel placard is the fuel grade decal. Requirements for fuel grade decals are provided in Annex D of this publication. Note that fuel grade decals are not intended to fulfil the OEM and owner/operators' legal obligation of having markings/fuel placards.

4.3.1 Decals for avgas

With the introduction of several unleaded grades of avgas, the requirement of EI 1597 second edition to have a product-specific decal (stating only 'avgas') is no longer sufficient and has had to be enhanced.

All decals referring to avgas shall be fuel grade specific (e.g. stating avgas 100LL, UL94 etc.), see Figure 5. Any existing generic avgas decals on aircraft (e.g. those that specify only 'avgas', see Figure 6) shall be replaced with grade-specific ones.

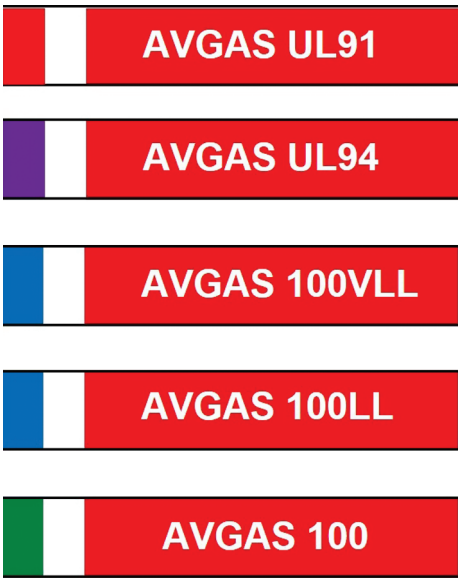


Figure 5: Avgas fuel grade decals (taken from EI 1542 10th edition)

Figure 6: Generic product decal that is no longer acceptable

If regulatory markings/fuel placards are not present, nor clearly show the type and grade of fuel the aircraft requires, then 'fuel grade decals' that show the grade(s) of fuel required by the aircraft, that have been previously applied to the aircraft, shall be used as part of the three-way cross-check.

As aircraft are certified to run on unleaded grades of avgas, those fuel grade decals shall be applied (aircraft will then have more than one fuel placard/fuel grade decal). The fuel grade that has been requested by the customer shall be clearly marked on the aircraft.

4.3.2 Decals for jet fuel

For aircraft that require jet fuel, it is acceptable for the decal to be for the generic product only (e.g. stating 'jet fuel'), rather than the specific grade (Jet A, Jet A-1, Jet B).

4.3.3 Procedures

If fuel placards/fuel grade decals are either absent, or do not clearly identify the fuel grade, or in the case of fuel grade decals, are applied by the aircraft owner/operator during fuel grade confirmation, then the three-way cross-check cannot be completed. A Fuel Grade Confirmation Form shall be completed.

To encourage the adoption of fuel grade decals, they shall be readily available at all airport locations. Jet fuel and avgas grade-specific decals should be offered (even when only one grade of fuel is available at the location) so that the aircraft pilot/owner/operator/maintenance provider can select and apply the correct decal to the aircraft. Refuelling staff shall not apply fuel grade decals.

4.4 FUEL GRADE MARKINGS FOR AIRCRAFT FUELLING EQUIPMENT

Airports may have similar looking fuelling vehicles or kerbside fuelling equipment supplying jet fuel or for grades of avgas.

Large and clearly visible colour-coded fuel grade markings shall be applied to all fuelling storage and handling equipment. The markings used shall conform with EI Standard 1542 *Identification markings for dedicated aviation fuel manufacturing and distribution facilities, airport storage and mobile fuelling equipment*.

4.4.1 Aviation fuelling vehicles

Fuel grade markings shall be applied to the front, back, and sides of the vehicle, at the control/fuelling panel, at the bottom loading adapter and also be prominently displayed inside the driving compartment.

4.4.2 Stationary/fuelling trailer or kerbside fuelling cabinets

Fuel grade markings shall be applied to each side, and outside and inside the main access doors. The fuel grade dispensed in any area should be as obvious/clearly marked as possible (e.g. by painting on the ground). See examples in Figure 7.

Figure 7a: Examples of fuel grade markings at stationary/fuelling trailer or kerbside fuelling cabinets

Figure 7b: Examples of fuel grade markings at stationary/fuelling trailer or kerbside fuelling cabinets

4.4.3 Overwing nozzles

The overwing nozzle handle or body shall be colour-coded black for jet fuel or red for avgas by either the manufacturer or locally applied paint or coating; components of the nozzle, which come in contact with fuel or aircraft connectors, such as the spout, shall not be painted.

In addition to the red nozzle handle/body, avgas grade-specific lettering and EI 1542 colour-coding shall be included on some part of the nozzle or as a detachable hose sleeve/tag etc. See examples in Figure 8.

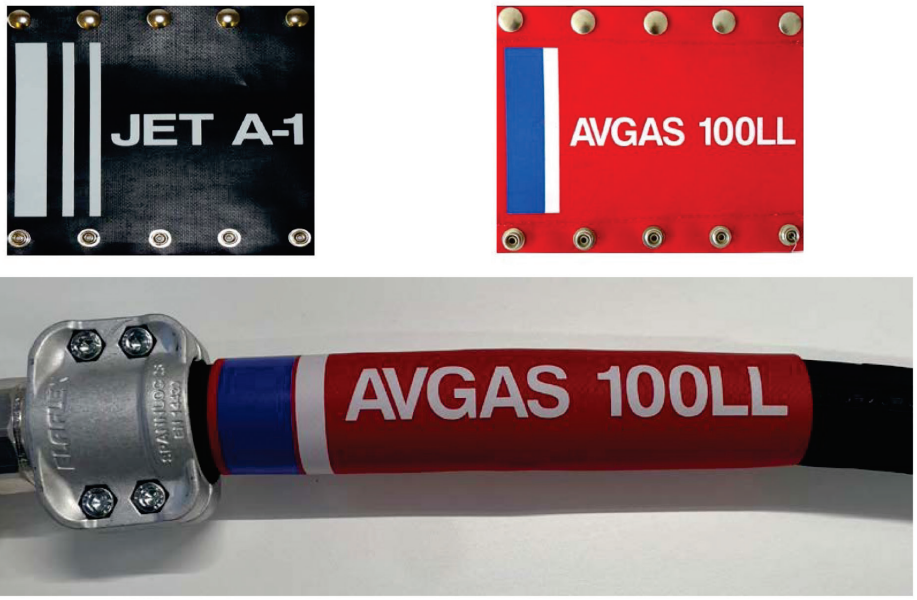


Figure 8: Example of coloured grade-specific decal sleeves for use on overwing delivery hose adjacent to the overwing nozzle

4.4.4 Overwing nozzle product-selective spout

With the introduction of several unleaded grades of avgas, the requirement of EI 1597 second edition to have a product-selective spout (a wide (selective) spout for jet fuel (also known as the duckbill nozzle) and a smaller diameter spout for avgas), is no longer an effective barrier for misfuelling between the different grades of avgas. The product-selective spout is still an important barrier to prevent misfuelling when using jet fuelling equipment.

Current designs of fuelling nozzle spouts cannot prevent misfuelling between the different grades of avgas.

4.4.4.1 Overwing nozzle for jet fuel

Aircraft fuelling equipment for jet fuel shall be fitted with a wide (selective) spout with a major axis minimum of 67,6 mm (2,66 in.), (in accordance with SAE AS 1852), and a maximum nozzle spout width of 29,7 mm (1,17 in.). See example in Figure 9.

Figure 9: Wide (selective) jet fuel nozzle spout

Using the wide (selective) jet fuel nozzle spout is intended to create a physical barrier to prevent its insertion into an avgas fuelling port. This is only the case if the correct airframe fuelling port per SAE AS 1852 is installed.

Some aircraft requiring avgas still have large diameter fuel ports that can accommodate the wider jet fuel nozzle spout. In such cases, pilots and aircraft owners should be encouraged to fit the selective fuel port modification kits that are available for most avgas powered aircraft.

Some aircraft requiring jet fuel and helicopters have fuelling ports that are too small to accept the wider jet fuel nozzle spout. In these cases the wide (selective) jet fuel nozzle spout has to be removed and a smaller nozzle (non-selective) spout fitted. Where this is required, a Fuel Grade Confirmation Form (see 4.5) shall be used.

4.4.4.2 Overwing nozzle for avgas

Aircraft fuelling equipment for avgas shall be fitted with a smaller diameter spout with a spout diameter of maximum 50 mm (1,97 in.), (in accordance with SAE AS 1852). See example in Figure 10.

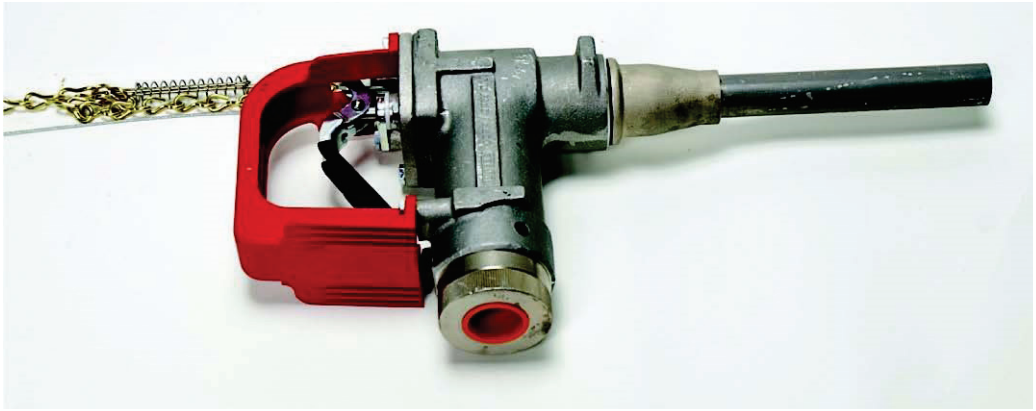


Figure 10: Avgas nozzle with small diameter spout

4.4.4.3 Overwing nozzle stowage

The fuelling vehicle for jet fuel shall include a brake interlock system that ensures that the vehicle can only be moved if the selective jet fuel nozzle spout is correctly stowed.

Where it is necessary to store a smaller diameter (non-selective) nozzle spout on a fuelling vehicle, the nozzle stowage arrangements shall be modified such that the brake interlock system prevents the vehicle from driving away unless both spouts are stowed.

The larger selective jet fuel nozzle spout shall be attached to the fuelling nozzle and the smaller diameter (non-selective) jet fuel spout shall also be in an interlocked stowage elsewhere on the vehicle. Both interlock locations shall only be capable of being deactivated by the correct shaped spout, e.g. the interlock for the overwing hose stowage shall only be deactivated when selective spout is fitted. A site risk assessment of installing such equipment on existing vehicles should be performed by the fuelling operator.

If the smaller diameter (non-selective) spout is not stored on the vehicle (e.g. at locations that use the non-selective small diameter infrequently), it shall be stored in a secure place (e.g. line supervisor's office). Written procedures shall be implemented to ensure that after fuelling, the smaller diameter (non-selective) spout is removed and replaced by the larger (selective) jet fuel nozzle spout. The smaller diameter (non-selective) spout shall be returned to its storage location. It is recommended that smaller diameter (non-selective) jet fuel nozzle spouts are signed out when used and their return is recorded. The reattachment of the wide (selective) jet fuel nozzle spout after fuelling shall be documented using a Fuel Grade Confirmation Form (see Annex E).

4.5 FUEL GRADE CONFIRMATION FORM

A Fuel Grade Confirmation Form is different from a Fuel Order Form and is used where:

– The three-way cross-check cannot be completed (see 4.1).
– The non-selective spout was required for aircraft fuelling with jet fuel.

When a Fuel Grade Confirmation Form is required, the pilot/authorised aircraft representative

shall complete the fuel grade selection and sign the form accordingly.

Fuel Grade Confirmation Forms should be designed so they cannot be confused due to any loss of colour-coding when photocopied.

An example of a Fuel Grade Confirmation Form is provided in Annex E.

The use of customer confirmation records (i.e. meter tickets and other documentation that are used routinely to initiate normal fuelling or billing processes) **shall not** be confused with the use of the Fuel Grade Confirmation Form.

5 FUELLING WITHOUT THE AIRCRAFT PILOT OR AUTHORISED AIRCRAFT REPRESENTATIVE PRESENT

Fuelling an aircraft without the aircraft pilot or authorised aircraft representative present (referred to as an unattended delivery) is discouraged.

Where the fuel placard/fuel grade decals are either absent, or do not clearly identify the fuel grade, the three-way cross-check cannot be completed. Therefore, a Fuel Grade Confirmation Form shall be completed (requiring input from the aircraft pilot or authorised aircraft representative). The fuelling shall not continue as an unattended delivery.

On completion of the fuelling, the fuelling operator shall attach a colour-coded fuel tag to a suitable position on the aircraft, the position to be agreed with the aircraft operator (prior to the fuelling). The tag shall be visible to the pilot upon return to the aircraft and shall clearly state the fuel grade and quantity of fuel delivered to the aircraft.

Examples of suitable tags are shown in Figure 11 (in this example the avgas grade delivered was avgas 100LL: different tags are required for each avgas grade).

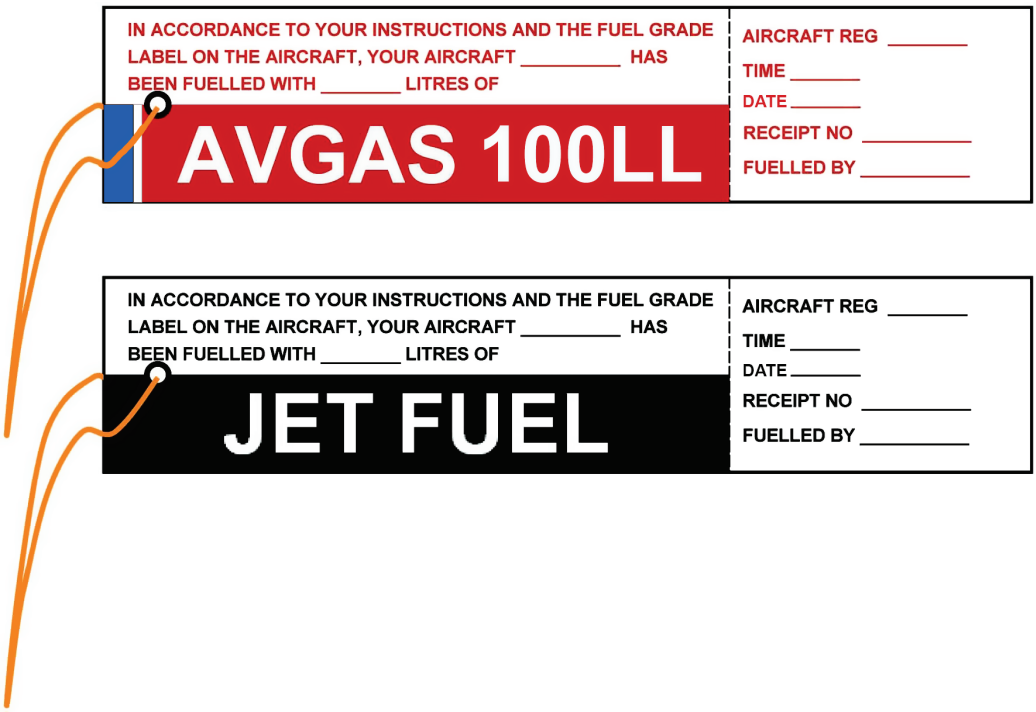


Figure 11: Examples of tags for use in unattended fuelling

6 SELF-SERVICE FUELLING

6.1 THREE-WAY CROSS-CHECK FOR SELF-SERVICE FUELLING

Self-service fuelling is performed by the pilot or customer without a representative of the fuel company present. A three-way cross-check can also be applied in this situation, with the Fuel Order Form being replaced by the conscious thought of the 'fuel order' that is in the pilot/authorised aircraft representative's mind only). This is shown schematically in Figure 12.

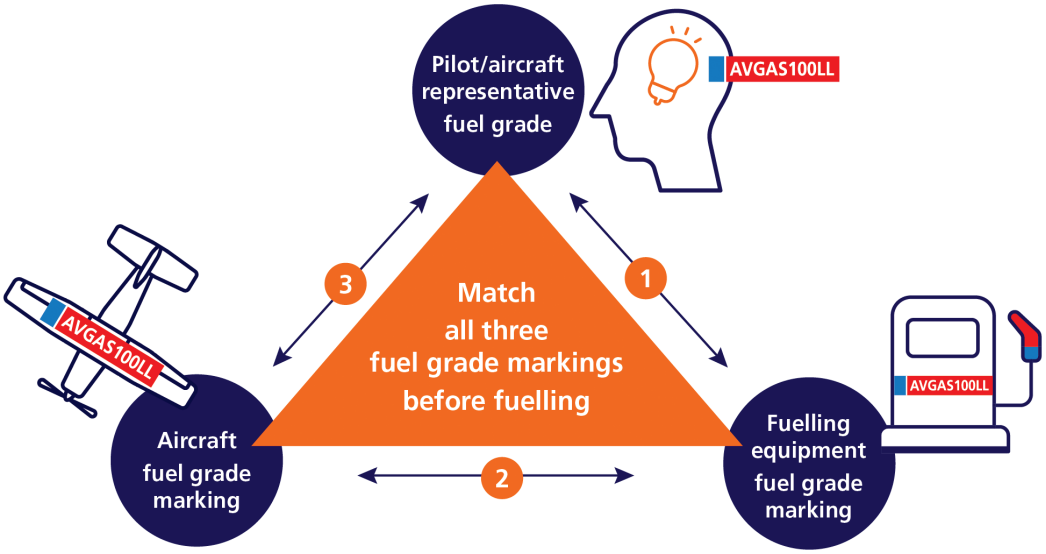


Figure 12: Schematic of the 'three-way cross-check' that applies to a self-service fuelling, in this example for avgas 100LL

Under no circumstances shall the grade of fuel required be assumed.

Before fuelling commences the pilot/authorised aircraft representative **SHALL** complete three checks:

1. Confirm that the fuel grade they intend to dispense (the fuel order in their mind) **CLEARLY MATCHES** the fuel grade marked on the aircraft fuelling equipment (kerbside dispenser).
2. Confirm that the fuel grade marked on the aircraft fuelling equipment (kerbside dispenser) **CLEARLY MATCHES** the fuel grade on the aircraft fuel placard/fuel grade decal.
3. Confirm that the fuel grade on the aircraft fuel placard/fuel grade decal **CLEARLY MATCHES** the fuel grade they intend to dispense (the fuel order in their mind).

The order of the three checks is intentional. It reflects the sequence of deciding what grade of fuel is required, selecting the correct fuelling equipment, and verifying the aircraft's fuel placard/fuel grade decal.

6.2 OVERWING NOZZLE SPOUTS (ON SELF-SERVICE EQUIPMENT)

For self-service fuelling equipment used in jet fuel service it is not feasible for the wide (selective) spout to be fitted (as required by 4.4.4.1) as there is no representative of the fuel company present to control the use of the non-selective spout and ensure that the selective spout is refitted after fuelling.

6.3 ADDITIONAL REQUIREMENTS FOR SELF-SERVICE EQUIPMENT

In addition to the self-service three-way cross-check process, additional controls are required to ensure the correct fuel grade is delivered. Therefore, at least (a), (b) or (c) below shall be in place:

(a) A fuel grade-dedicated customer fuelling card, achieved by either having the grade coded into the magnetic strip of the fuelling card (checked by the payment terminal software, thus preventing the wrong grade selection) or the grade would be checked at the payment terminal (via the internet) against the customer account details.

(b) At the payment terminal the pilot/customer is asked by the system to select the grade of fuel required, and is also separately required to confirm the correct fuel grade has been selected. The second question does not need to immediately follow grade selection: it may be more effective if it comes later in the process. Consideration should also be given to changing the button used to confirm the grade (or location on a touch screen) to avoid a person clicking through the process as quickly as possible.

(c) At the payment terminal the pilot/customer is required to enter a data point (e.g. their account number or aircraft registration), which is then used to confirm the grade (via the internet) against a database.

All locations shall have protocols in place to ensure misfuelling prevention controls are maintained in the event of the normal payment terminal failing.

7 FUELLING PROCEDURES AND TRAINING

It is essential that all personnel involved in overwing fuelling understand the consequences of any lapse in following correct procedures. It is therefore essential that personnel are fully trained to ensure the correct grade of fuel is always delivered to aircraft. Note that the introduction of unleaded avgas grades necessitates the revision of existing training resources and the retraining of all personnel.

Local staff shall develop a comprehensive site-specific training programme to address site training needs (note the site training programme may also address health/safety issues, airport and national and local regulations and requirements etc.).

Local staff shall develop a written, risk assessed, job task, which contains a step-by-step procedure on how to overwing fuel an aircraft or helicopter, which shall include the fuel ordering process.

Training aides, such as posters or bulletins describing the requirements contained in this Recommended Practice, which can be located on walls/doors/bulletin boards, are useful reminders to refuelling staff of the need for vigilance in preventing misfuelling.

Additional information on developing a site training programme can be found in:

– National Air Transportation Association Safety 1st Program (see www.preventmisfueling.com).

– Joint Inspection Group (JIG) Health, Safety, Security and Environmental Management System (HSSEMS).

ANNEX A (NORMATIVE)
GLOSSARY OF TERMS, ABBREVIATIONS AND ACRONYMS

A.1 GLOSSARY OF TERMS

For the purposes of this publication, the following interpretations apply irrespective of any other meanings the words may have in other connections.

aviation fuel — A general term referring to any grade of jet fuel (aviation turbine fuel) or any grade of aviation gasoline, which meet defined fuel specifications.

fuel grade confirmation form — A document completed by a pilot/authorised aircraft representative to record information when fuel grade decals are either absent, or do not clearly identify the fuel grade, or are applied by the aircraft owner/operator during fuel grade confirmation.

fuel grade decal — A sticker that provides a means of identifying a fuel grade, in addition to the regulatory requirements for a fuel placard, that is usually positioned in proximity to the aircraft filler (port) cover, that conforms to the requirements of Annex B of this publication.

fuel order form — A document in which a fuel order from the pilot/authorised aircraft representative is recorded by the into-plane operation.

fuel placard — Markings required by regulation, at or near the aircraft filler (port) cover, to show either the type of fuel used by the aircraft (avgas, jet fuel) and the permissible fuel grade(s), or to reference the Airplane Flight Manual (AFM) for permissible fuel designations. Provision of the fuel placard is the responsibility of the original equipment manufacturer (OEM) and owner/operator of the aircraft to meet and maintain.

grade — Term for a specific aviation fuel meeting the criteria defined by a governing specification (e.g. Jet A and Jet A-1 are different grades of jet fuel).

misfuelling — Delivering the incorrect fuel grade into an aircraft.

overwing fuelling — Overwing fuelling distinguishes the operation from underwing pressure fuelling. It refers to an aircraft fuelling operation utilising a hose end fuelling nozzle of a design similar to that used for dispensing ground fuels. The term is not limited to aircraft fitted with a filler port on the upper surface of a wing (e.g. it also applies to filler ports located on fuselage).

placard — See *fuel placard*.

product — Generic term applied to any liquid hydrocarbon, used in EI aviation fuel handling publications for both aviation and non-aviation fuels (e.g. jet fuel, avgas, diesel, motor gasoline etc.). Also referred to as *type*.

self-service fuelling	Fuelling that is performed by the pilot or customer without a representative of the fuel company present.
three-way cross-check	A process followed by the fuelling operator to confirm that: (1) the fuel grade documented on the Fuel Order Form clearly matches the fuel grade marked on the aircraft fuelling equipment (refueller, fuelling nozzle); (2) the fuel grade on the aircraft fuel placard/fuel grade decal clearly matches the fuel grade marked on the aircraft fuelling equipment, and (3) the fuel grade documented on the Fuel Order Form clearly matches the fuel grade on the aircraft fuel placard/fuel grade decal.
unattended delivery	Fuelling an aircraft without the aircraft pilot or authorised aircraft representative present.

A.2 ABBREVIATIONS AND ACRONYMS

AFM	Airplane Flight Manual
Avgas	aviation gasoline
DiEGME	diethylene glycol monomethyl ether
EASA	European Union Aviation Safety Agency
EI	Energy Institute
FAA	Federal Aviation Administration
FSII	fuel system icing inhibitor
GAMA	General Aviation Manufacturers Association
HSSEMS	health, safety, security and environmental management system
JIG	Joint Inspection Group
LL	low lead
MON	motor octane number
OEM	original equipment manufacturer
PIN	personal identification number
PMS	Pantone matching system
RON	research octane number
UL	unleaded

ANNEX B (INFORMATIVE)
EXAMPLE FUEL ORDER FORMS

The following Fuel Order Forms are provided as examples. As mandated in 3.2, Fuel Order Forms shall be printed in colour.

RADIO / TELEPHONE FUEL ORDER FORM – JET A-1

The purpose of this form is to assist with ensuring fuel **grade** is accurately captured when receiving verbal (telephone / radio) orders from customers and when transferring refuelling instructions between operators.

The form is **not to be supplied to customers.** When fuel placards or fuel grade decals are not present, or are ambiguous a **Fuel Grade Confirmation Form** is to be completed by the customer before refuelling can occur.

The operator refuelling the aircraft shall verify the grade at the aircraft immediately prior to refuelling.

AIRCRAFT REGISTRATION:	
Fuel Type	Quantity Required
JET A-1	
Aviation Turbine Kerosene	Litres or Gallons (specify which)

Instructions (e.g. FSII required):

Date:

Time Fuel Required:

Order Received by (name):

Name of refuelling operator:

Signature of refuelling operator:

Figure B.1: Example Fuel Order Form for jet fuel (in this case Jet A-1)

RADIO / TELEPHONE FUEL ORDER FORM – AVGAS 100LL

The purpose of this form is to assist with ensuring fuel **grade** is accurately captured when receiving verbal (telephone / radio) orders from customers and when transferring refuelling instructions between operators.

The form is **not to be supplied to customers.** When fuel placards or fuel grade decals are not present, or are ambiguous, a **'Fuel Grade Confirmation Form'** is to be completed by the customer before refuelling can occur.

The operator refuelling the aircraft shall verify the grade at the aircraft immediately prior to refuelling.

AIRCRAFT REGISTRATION:

Fuel Type	Quantity Required
AVGAS 100LL	
Aviation Gasoline 100LL	Litres or Gallons (specify which)

Instructions:

Date:

Time Fuel Required:

Order Received by (name):

Name of Refuelling Operator:

Signature of Refuelling Operator:

To be printed in colour

Figure B.2: Example Fuel Order Form for avgas (in this case 100LL)

ANNEX C (INFORMATIVE)
RISKS OF MOTOR GASOLINE USE IN AVIATION APPLICATIONS

C.1 INTRODUCTION

Aircraft are designed and certified to operate on designated fuel types to ensure safety, reliability and performance. The Aviation Industry has worked diligently over many decades to develop aviation turbine fuel/jet fuel and aviation gasoline specifications specifically for this purpose. Use of fuels developed for other applications, such as for ground transport, can represent a hazard to flight. Equally important are the fuel handling practices that are deployed from refineries to into-aircraft operations to prevent cross-contamination of aviation fuel with other products and to maintain the fuel's cleanliness. In this annex the potential risks associated with motor gasoline use in aviation are highlighted.

C.2 RISKS

There are significant risks associated with motor gasoline use in aircraft, as described in C.2.1 to C.2.5.

C.2.1 Volatility

For good combustion, a gasoline engine requires a well-mixed combination of fuel and air for ignition by a spark. Fuel must be sufficiently 'volatile' to vaporise in the induction system (even when the engine is cold) but not be so volatile that it causes bubbles in fuel supply lines that could cause the engine to falter and stop.

The volatility of avgas is very tightly controlled by fuel specifications to ensure that it can perform effectively over the extreme ambient conditions of aircraft operations (e.g. +30 °C on an airfield to –15 °C at 15 000 feet (where air pressure falls by 45 %)).

Motor gasoline has a much broader vapour pressure specification than avgas (see Figure C.1) and volatility specifications are regularly changed to suit local climates.

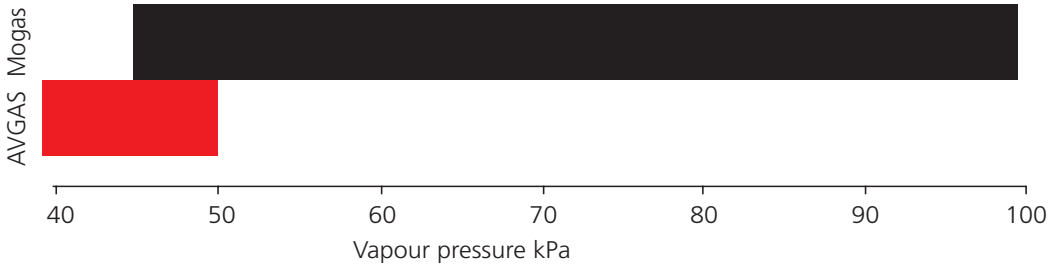


Figure C.1: A comparison of the vapour pressure specifications for motor gasoline and avgas

C.2.2 Additives

Motor gasoline, particularly premium grades, may contain a wide range of additives to enhance performance – what some of those additives may do to aircraft systems and engines is largely untested or unknown.

Additives for aviation applications are required to be assessed in accordance with the stringent procedures of ASTM D7826 and formally approved for use by aircraft/engine OEMs (an additive approval process typically takes >5 years to complete). Only a limited number of chemical types are approved for aviation use and are strictly controlled.

C.2.3 Ethanol content

Motor gasoline regulations/specifications may permit or mandate the use of oxygenated fuel components such as ethanol. While acceptable for ground use (having been endorsed by the automotive industry) such components can be a potential hazard to aircraft, being corrosive to fuel system hardware and having a low energy content, which reduces aircraft range. In addition, water condensing in wing tanks combined with low ambient temperature can cause the fuel to separate into two layers – a corrosive water/alcohol layer and a hydrocarbon layer of reduced volume and quality.

C.2.4 Fuel octane quality

For a gasoline engine to work correctly, the fuel/air mixture must wait for the ignition spark before starting to combust and then burn smoothly to provide power. If the fuel is of poor combustion quality, it may start to explode uncontrollably, a situation known as 'detonation', which could damage the engine. The fuel's ability to resist detonation is measured in terms of octane quality. There is a significant difference between high octane avgas grades 100 and 100LL when compared to motor gasoline. Leaded avgas offers a minimum of 99,6 motor octane number (MON) while super-unleaded motor gasoline is typically only 88 MON. Also, the less severe analytical test of research octane number (RON) often quoted for motor gasoline at dispensers, typically in the range 95 to 98 RON, is not used. Avgas features supercharge, a much more challenging test seeking to maximise power from the fuel, with grades 100/130 and 100LL having a minimum quality of 130 performance number.

C.2.5 Supply chain quality assurance

Aviation fuel supply chains incorporate specific hardware and procedures to prevent cross-contamination of aviation fuel with other products and to remove dirt and free water, which can block aircraft filters, cause corrosion and impact engine operation. Filtration systems are deployed at various stages in supply chains, using cartridges that are qualified to Energy Institute specifications. Fuel suppliers typically work to the quality assurance requirements and recommendations provided in EI/JIG Standard 1530 *Quality assurance requirements for the manufacture, storage and distribution of aviation fuels to airports*.

It is for these, and other technical reasons, that many aviation fuel suppliers will only ever supply aviation fuels for aircraft operations as part of their commitment to flight safety.

ANNEX D (NORMATIVE)
FUEL GRADE DECALS

D.1 INTRODUCTION

Fuel grade decals are important safeguards for misfuelling prevention. However, they are not intended to fulfil the legal obligations of OEMs and owners/operators regarding markings/fuel placards, and shall not be used as such.

Fuel grade decals are designed to clearly indicate the correct fuel grade for use in the aircraft.

Fuel grade decals may be obtained from commercial sources.

D.2 DESIGN

The preferred design/size for fuel grade decals is shown in Figures D.1 to D.5. Other designs/sizes may be acceptable. Fuel grade decals for avgas shall be colour-coded in accordance with EI 1542 (see also Figure 4 in this publication). Colours used for fuel decals require:

– Red background with white lettering for avgas.
– Black background with white lettering for jet fuel.

The recommended font is Univers 45 Light and the recommended text size is 54 point.

Figures D.1 to D.3 provide the decals to be used on aircraft approved to use avgas, grades UL91, UL94 or 100LL respectively. Depending on aircraft fuel grade requirements, other grades may be substituted (e.g. avgas 100VLL).

Figure D.4 provides the decal to be used on aircraft approved to use jet fuel.

Figure D.5 provides the decal to be used on aircraft approved to use jet fuel with the mandatory addition of FSII.

Figure D.1: Decal to be used on aircraft approved to use avgas, grade UL91

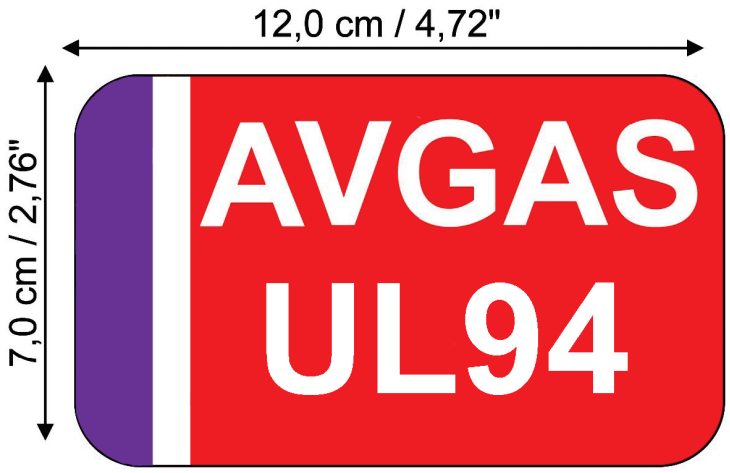


Figure D.2: Decal to be used on aircraft approved to use avgas, grade UL94

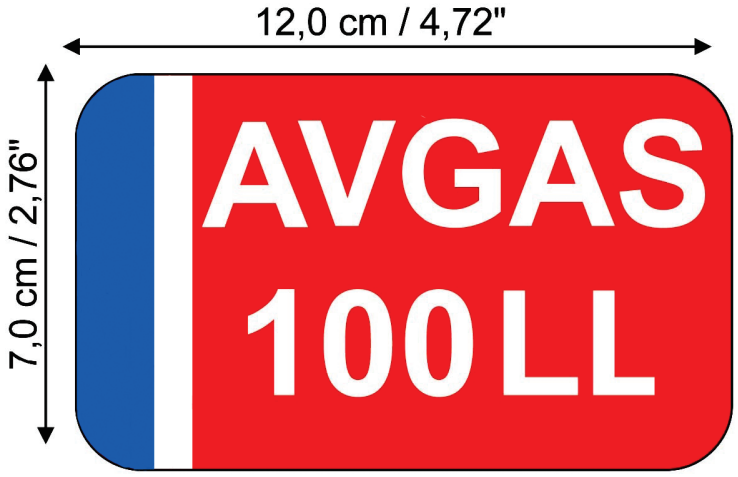


Figure D.3: Decal to be used on aircraft approved to use avgas, grade 100LL

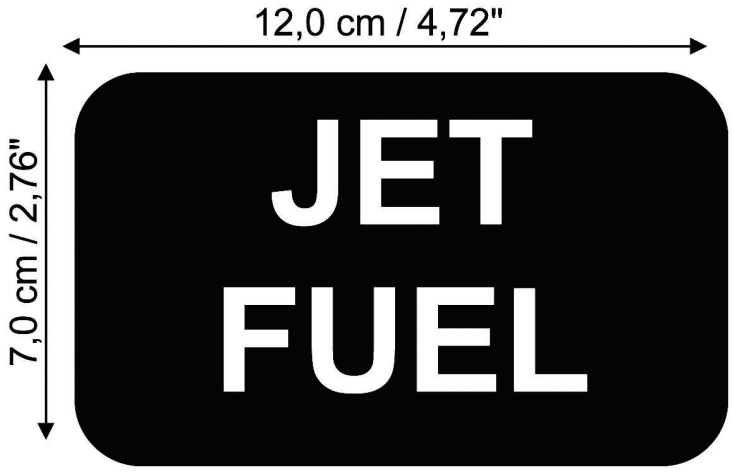


Figure D.4: Decal to be used on aircraft approved to use jet fuel

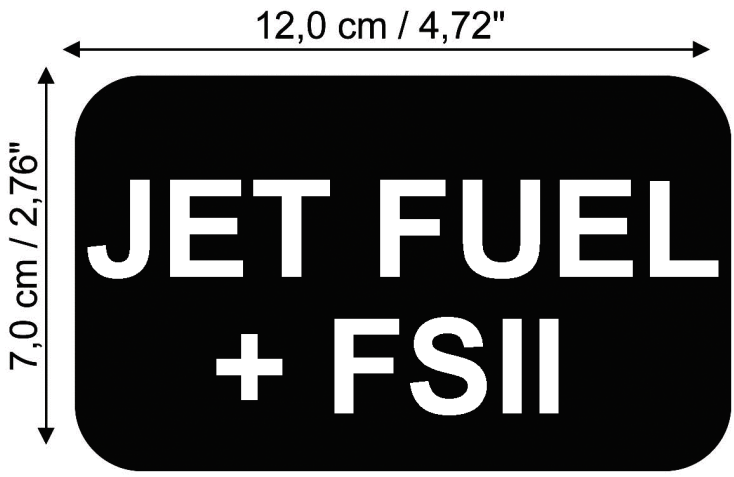


Figure D.5: Decal to be used on aircraft approved to use jet fuel with the mandatory addition of FSII

D.3 MATERIAL SPECIFICATION

D.3.1 Overview

Decals should conform to the detailed requirements of General Aviation Manufacturers Association (GAMA) Specification #3 to ensure satisfactory performance. Decals meeting that specification were developed to withstand the extreme conditions aircraft are exposed to, such as temperature, moisture, ultra-violet radiation and fuel spillage without excessive deterioration to provide years of functional service.

D.3.2 Composition

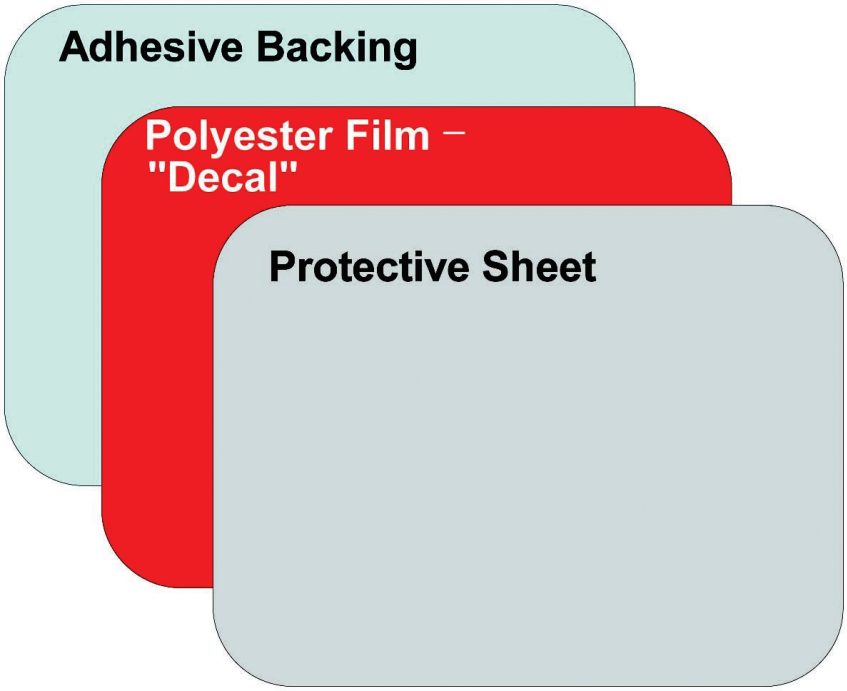
The material shall consist of a smooth, uniform, pigmented polyester plastic film without pinholes or other defects in the film surface. A pressure sensitive adhesive shall be applied to the unmarked side of the film.

D.3.3 Colour

The colour of the pigmented plastic marking material shall be either inherent in the basic film or overlaid on the base film. The decal background shall be red for avgas and black for jet fuel. All text is white. Pantone matching system (PMS) #200 is the preferred red colour; however, equivalent colours may be used. No PMS number is available for black or white.

D.3.4 Configuration

A protective transfer sheet shall be applied to the marked side of the polyester film. The transfer sheet shall be paper suitably treated with a low tack, pressure sensitive adhesive on the surface in contact with the face side of the decal. The adhesive backing shall be protected by a suitable liner, treated paper or other material, which shall be easily removed without the use of water or other solvents for fast, distortion-free application of the decal.



D.3.5 Film thickness

Finished markings, including adhesive but not including backing paper, shall not be thicker than 0,0125 cm (0,005 in.).

D.4 DECAL STORAGE

The shelf-life of decals is not known. Therefore, to preserve the decals in good condition during long-term storage, they should be kept in a clean, dry location away from extreme heat or cold and direct sunlight. Every decal should be inspected carefully for any sign of deterioration or manufacturing flaw before being given to a pilot, especially if the decals have been in storage for an extended period.

D.5 APPLICATION

The correct fuel decal, when used, should be placed adjacent to all fuel filler ports on the aircraft by the pilot/aircraft owner or maintenance provider such that it is clearly visible, but should not interfere with existing markings/fuel placards or aircraft operation.

WARNING: The pilot/aircraft owner is usually very knowledgeable regarding the approved fuel for the aircraft. However, if there is any doubt, the decal should only be placed on the aircraft by the pilot/aircraft owner after they have contacted the original equipment manufacturer to confirm the correct fuel grade.

ANNEX E (INFORMATIVE)
EXAMPLE FUEL GRADE CONFIRMATION FORM

This form shall be completed before each fuelling when one of the following applies (tick the box that applies):

☐ Fuel placards/fuel grade decals are either absent, or do not clearly identify the fuel grade, or in the case of fuel grade decals, are applied by the aircraft owner/operator during fuel grade confirmation.

☐ The fuelling nozzle spout or the aircraft fuel tank port do not correspond to the norm for the particular product, i.e. for jet fuel a wide selective nozzle spout and large aircraft port, and for avgas a small circular spout and narrow aircraft port.

☐ For overwing fuelling during air shows.

TO BE COMPLETED BY AUTHORISED AIRCRAFT REPRESENTATIVE

To: ..... (Into-plane service)

At: ..... (Airport)

Aircraft Registration Number: .....

The aviation fuel required for this aircraft is as follows:

	FUEL GRADE (*)	QUANTITY
JET FUEL		
Jet A-1 or Jet A		
Fuel system icing inhibitor/anti-icing additive required?		
AVGAS		
☐ **AVGAS UL91**		
☐ **AVGAS UL94**		
☐ **AVGAS 100VLL**		
☐ **AVGAS 100LL**		
☐ **AVGAS 100**		

(*) For jet fuel write either Jet A-1, Jet A in the appropriate box AND whether FSII is required. For avgas, write the specific grade of avgas in the appropriate box.

I confirm that the above fuel grade is suitable for use in the aircraft referred to above.

Name: ..... Signature:.....

Position: ..... Date:..... Time:.....

TO BE COMPLETED BY FUELLING OPERATOR IF JET FUEL WAS DELIVERED BY NON-SELECTIVE SPOUT

I confirm that the product-selective spout was reattached to the nozzle after completion of fuelling.

Name: ..... Signature:.....

ANNEX F (INFORMATIVE)
EXAMPLE TASK FLOW CHARTS

Figure F.1 provides an example task flow chart for the receipt of a verbal Fuel Order in the depot office. Figure F.2 is an example task flow chart for the receipt of a written Fuel Order in the depot office. Figure F.3 is an example task flow chart for the receipt of a verbal Fuel Order airside.

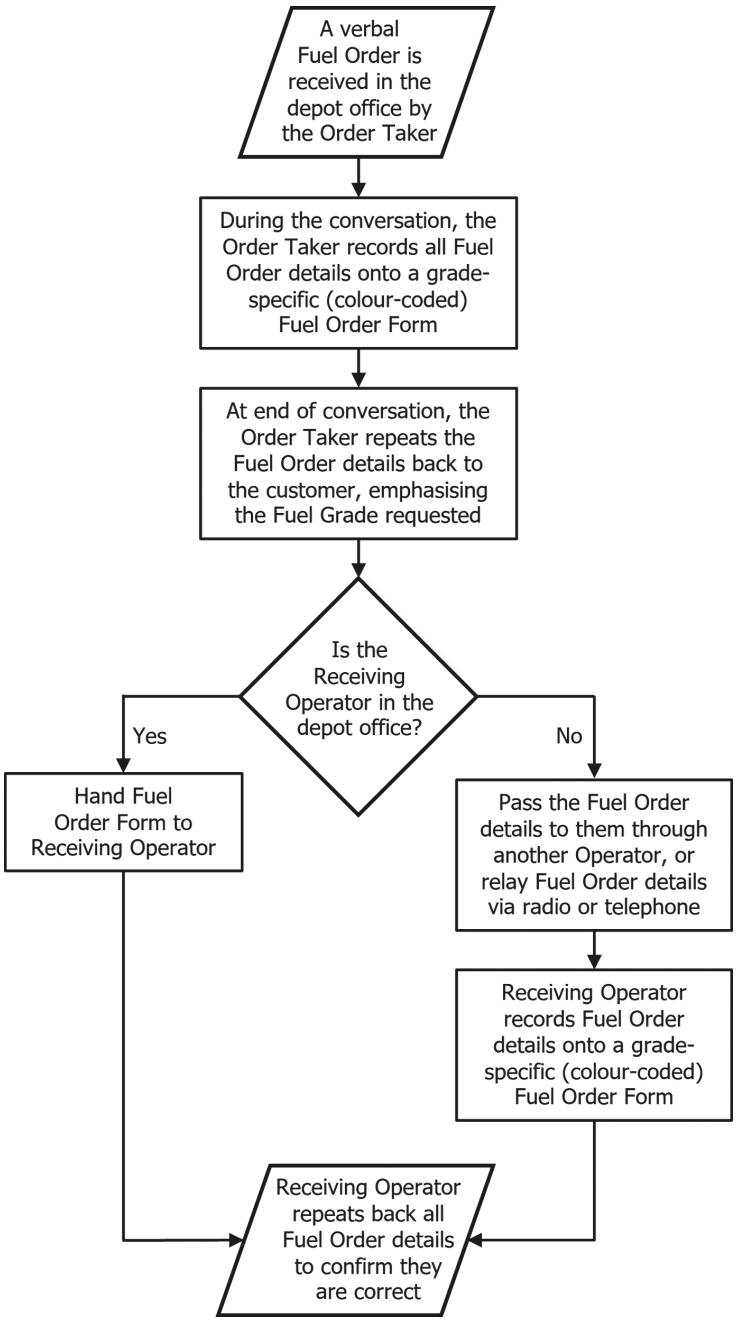


Figure F.1: Example task flow chart for the receipt of a verbal Fuel Order in the depot office

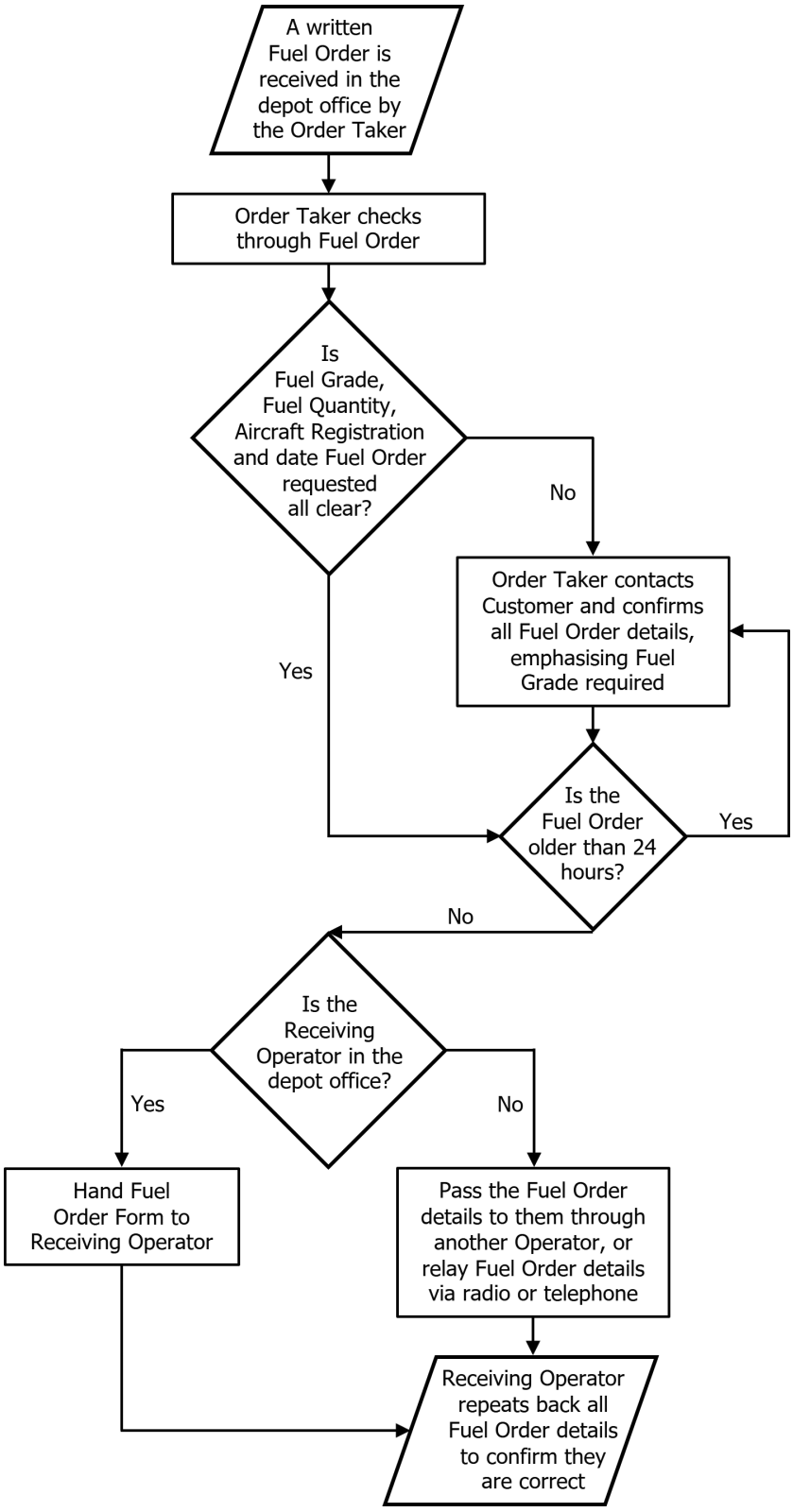


Figure F.2: Example task flow chart for the receipt of a written Fuel Order in the depot office

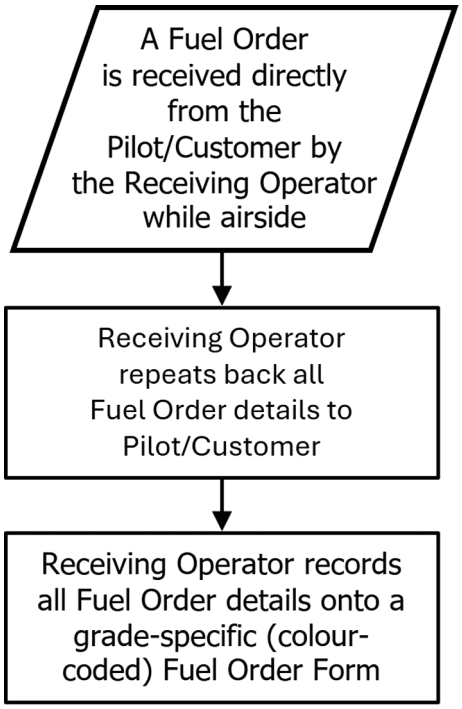


Figure F.3: Example task flow chart for the receipt of a verbal Fuel Order airside

ANNEX G
REFERENCES

The following publications are referenced in this publication:

Airframe Manufacturer[2]

Pilot's Operating Handbook

ASTM (https://www.astm.org)

ASTM D7826 *Standard guide for evaluation of new aviation gasolines and new aviation gasoline additives*

Energy Institute (https://publishing.energyinst.org)

EI 1538 *Handling of fuel system icing inhibitor and aviation fuel containing fuel system icing inhibitor*

EI 1540 *Design, construction, commissioning, maintenance and testing of aviation fuelling facilities*

EI 1542 *Identification markings for dedicated aviation fuel manufacturing and distribution facilities, airport storage and mobile fuelling equipment*

EI/JIG Standard 1530 *Quality assurance requirements for the manufacture, storage and distribution of aviation fuels to airports*

General Aviation Manufacturers Association (https://gama.aero)

Specification #3 *Specification for decal to minimize the misfueling of general aviation aircraft*

Joint Inspection Group (https://www.jig.org)

Health, safety, security and environmental management system (HSSEMS)

National Air Transportation Association (https://www.nata.aero/)

Safety 1st program

Society of Automotive Engineers (https://www.sae.org)

Aerospace Standard AS 1852 *Nozzles and ports – Gravity fuelling interface standard for civil aircraft*

2 Available from each individual airframe manufacturer.

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