



AEROSPACE INFORMATION REPORT

AIR1662™**REV. B**

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Superseding AIR1662A

(R) Minimization of Electrostatic Hazards in Aircraft Fuel Systems

RATIONALE

This document has been revised extensively to include the latest understanding, research, and change in regulation relating to electrostatics in aircraft fuel tanks.

FOREWORD

The prevention of fires and explosions resulting from electrostatic discharges in aircraft fuel systems is of special concern to aircraft designers and operators. The purpose of this SAE Aerospace Information Report (AIR) is to give a basic understanding of the hazard caused by electrostatics. It includes a review of the physics of electrostatic phenomena, and an overview of design practices which can reduce the hazard. This document is not intended as a complete design guide - extensive research and testing may be required to produce a successful design.

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1. SCOPE

This SAE Aerospace Information Report (AIR) provides background information, technical data, and related technical references for minimization of electrostatic hazards in aircraft fuel systems.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this document to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this document and references cited herein, the text of this document takes precedence. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

AIR4170 Reticulated Polyurethane Foam Explosion Suppression Material for Fuel Systems and Dry Bays

AIR5128 Electrical Bonding of Aircraft Fuel Systems

AS5751 Design and Operating Requirements of the Onboard Aircraft Refueling System and Associated Ground Refueling Equipment Interface

2.1.2 ASTM Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org.

ASTM D1655 Standard Specification for Aviation Turbine Fuels

ASTM D7566 Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons

ASTM D4865 Generation and Dissipation of Static Electricity in Petroleum Fuel Systems

2.1.3 United Kingdom Ministry of Defence (UK MOD)

DEF STAN 91-091 Turbine Fuel, Aviation Kerosene Type, Jet A-1

2.1.4 Military Specifications

Copies of these documents are available online at <https://quicksearch.dla.mil>.

MIL-DTL-5624U Turbine Fuel, Aviation, Grades JP-4 and JP-5

MIL-DTL-83133J Turbine Fuel, Aviation, Kerosene Type, JP-8 (NATO F-34), NATO F-35, And JP-8+100 (NATO F-37)

2.1.5 FAA Publications

Available from Federal Aviation Administration, 800 Independence Avenue, SW, Washington, DC 20591, Tel: 866-835-5322, www.faa.gov.

AC 25.981-1D Fuel Tank Ignition Source Prevention Guidelines

2.1.6 Coordinating Research Council (CRC)

Available from Coordinating Research Council, 5755 North Point Parkway, Suite 265, Alpharetta, GA 30022, Tel: 678-795-0506, www.crcao.com.

1. CRC Report No. 590, The Effect of Aviation Fuels Containing Low Amounts of Static Dissipater Additive on Electrostatic Charge Generation
2. CRC Report No. 647, CRC Aviation Committee - World Fuel Sampling
3. CRC Report No. 663, Handbook of Aviation Fuel Properties
4. CRC AV-22-15, Charge Generation and Dissipation in Aviation Fuel handling with Filter Monitors

2.1.7 Energy Institute

Available from Energy Institute, 61 New Cavendish Street, London W1G 7AR UK +44 (0)207 467 7100, <https://publishing.energyinst.org>.

1. EI1583, Laboratory Test and Minimum Performance Level for Aviation Fuel Filter Monitors
2. A Test Method for Measuring the Electrostatic Charge Produced by Aviation Filter-Monitor Retrofit Technologies, January 2019
3. EI1588, Laboratory Tests and Minimum Performance Levels for Aviation Fuel Water Barrier Filters
4. EI1599, Laboratory Tests and Minimum Performance Levels for Aviation Fuel Dirt Defence Filter

2.1.8 Other References

1. Leonard, J.T., "Generation of Electrostatic Charge in Fuel Handling Systems: A Literature Survey," Naval Research Laboratory Report 8484, September 1981.
2. "Recommended Practice for Protection Against Ignition Arising Out of Static, Lightning and Stray Currents," American Petroleum Institute RP2003, Washington, DC, Eighth Edition, 2015.
3. Lewis, B. and von Elbe, G., "Combustion, Flames and Explosions of Gases," 3rd Edition, Academic Press, New York, NY, 1987.
4. Lyle, A.R. and Strawson, H., "Estimation of Electrostatic Hazards in Tank Filling Operation," in "Static Electrification, 1971," Institute of Physics, London, 1971. (Available as an article in Physics Bulletin 23(8): 453-456, August 1972).
5. Grenich, A.F. and Tolle, F.F., "Electrostatic Safety with Explosion Suppressant Foam," AFWAL-TR-83-2015, Wright-Patterson Air Force Base, OH.
6. Eggers, D.F. et al., "Physical Chemistry," Wiley and Sons, New York, NY, 1964.
7. Kutcha, J.M. and Clodfelter, R.G., Aircraft Mishap Fire Pattern Investigations, AFWAL-TR-85-2057.
8. Johnston, J.E., Owen, T.E., and Hutzler, S.A., "Investigation Of Electrostatic Charge in Hose Lines," TFLRF No. 384, SWRI, October 2006.
9. Hearn, G.L., "Electrostatic Ignition Hazards arising from Fuel Flow in Plastic Pipelines," Journal of Loss Prevention in the Process Industries 15 (2002) 105-109.
10. NFPA 407 "Standard for Aircraft Fuel Servicing," 2007 Edition.
11. Presentation "Conductivity 101 Why it is a Concern, Recent Work and Next Steps," Rob Midgley, Shell Aviation Aviation Fuels Committee, 2018, available from the Energy Institute - see details above.

12. A Review of the Flammability Hazard of Jet A Fuel vapour in Civil Transport Aircraft Fuel Tanks, DOT/FAA/AR-98/26, June 1998.
13. AFAPL-TR-78-56 - Static Electricity hazards in Aircraft Fuel Systems (December 1978).
14. Britton, L.G., "Avoiding Static Ignition Hazards in Chemical Operations," American Institute of Chemical Engineers, 1999.
15. BS5958-2 "Code of practice for Control of Undesirable Static Electricity Part 2: Recommendations for Particular Industrial Situations," British Standards institute, 1992 (Superseded - Replaced By : PD CLC/TR 50404:2003, which was subsequently superseded by BS PD CLC/TR 60079-32-1 : 2015).
16. BS EN 13463-1:2009, "Non-electrical equipment for use in potentially explosive atmospheres Part 1: Basic method and requirements" (Superseded - Replaced by ISO 80079-36).
17. JSSG-2009 - Joint Services Guide - Air Vehicle Subsystems, Department of Defense, Oct 1998.
18. ISO 80079-36 Non-Electrical Equipment for Explosive Atmospheres - Non-electrical equipment for explosive atmospheres - Basic Method and Requirements.
19. Bustin, W.M., Koszman, I., Tobye, I.T., "A New Theory for Static Relaxation," Hydrocarbon Processing Vol 43, No. 11, Nov-1964, (Esso Research and Engineering Co).

2.1.9 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

- a. Bridges, J.E. et al., "Gap Energy, a More Accurate Criterion for Ignition Threshold of Flammable Mixtures," 1975 IEEE Electromagnetic Compatibility Symposium Record, San Antonio, TX, October 1975.
- b. Desmarais, L.A. and Tolle, F.F., "Integrated Aircraft Fuel Tank Inerting and Compartment Fire Suppression System," Vol. I, AFWAL-TR-83-2021.
- c. UTE C 23-597(equivalent to CLC/TR 50404:2003- ELECTROSTATICS -CODE OF PRACTICE FOR THE AVOIDANCE OF HAZARDS DUE TO STATIC ELECTRICITY)
- d. BS 5958-1:1991 Code of Practice for Control of Undesirable Static Electricity. General Considerations

2.2 Acronyms and Abbreviations

API	American Petroleum Institute
C	Coulombs
CRC	Co-ordinating Research Council
CU	Conductivity Units
m	metres
mJ	milli-Joules
μJ	Micro-Joules
pS	Pico-Siemens
s	Seconds

SDA Static Dissipative Additive

V Volts

3. ELECTROSTATIC HAZARDS

The API (reference 2.1.8-1) has summarized the conditions necessary for an incendiary electrostatic discharge as follows:

- There must be a mechanism to generate electrostatic charge.
- There must be a means to accumulate electrostatic charge in enough quantity to produce an incendiary spark.
- There must be a means of discharging the accumulated electrostatic charge in the form of an incendiary spark, that is, a spark gap.
- There must be a combustible vapor and oxidizer (air) in the spark gap.

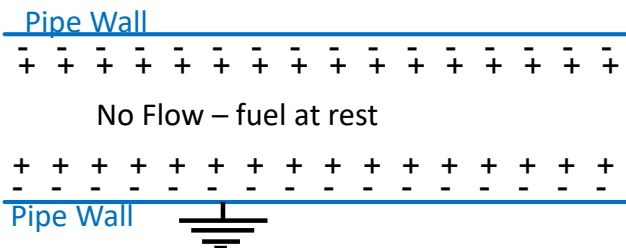
The hazard, then, may be eliminated by designing to prevent one or more of these necessary conditions.

3.1 Physics of Electrostatic Charge Generation and Accumulation In Aircraft Fuel Systems

3.1.1 Charge Generation

Electrostatic charge is generated in a number of ways whenever there is friction between two bodies moving relative to one another. Charge separation occurs in liquid systems on the molecular level at the interface of any two unlike materials, so a static charge will be generated in any moving fluid, with positive or negative charges moving from the fluid onto the bounding surface. When a hydrocarbon liquid such as jet fuel flows past a surface, positive and negative electrostatic charges can be separated along the surface. From ASTM D4865, this charge is attributable to ionic impurities (polar atoms) present in the fuel in parts per million or parts per billion quantities. Figure 1 shows a pipe wall with an affinity for negative charge, resulting in a net positive charge in the body of the fuel. If the fuel is set into motion and charge is separated, the immediate re-association of the separated charges is hindered by the very low electrical conductivity of highly refined hydrocarbon fuels. Charge is, therefore, convected away by the liquid flow, in opposition to the electric field between the liquid and its surroundings, creating a potentially hazardous condition. Whether the fuel becomes positively charged (as shown in Figure 1) or negatively charged depends on the combination of fuel, impurities, and containers involved. This mechanism is known as “tribo-electric charging” and when the charge is carried downstream it is known as a “streaming current.” If the pipe is conductive, the charge on the pipe walls will be conducted to ground (assuming the pipe is bonded), resulting in a zero charge on the pipe.

Impurities adsorbed at interface between fuel and pipe walls



Separation of charge as fuel flows through pipe

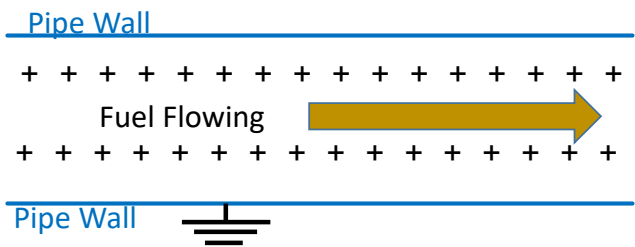


Figure 1 - Charge generation mechanism (tribo-electric charging)