

Ignition of hydrocarbon oil and greases

This document is based on the knowledge and experience of both the oxygen system manufacturer SAFRAN AEROSYSTEMS and the WHA¹ institute specialized in Oxygen Fire Risk Analysis (OFRA).

(...) WHA provides failure analysis services (...) ignition of hydrocarbon oils and greases has frequently been implicated in oxygen fires for the last several decades. Their low AIT² in oxygen, as well as their high heat of combustion combine to make them very undesirable in oxygen systems. WHA test experience and failure analysis experience also indicate that these oils and greases are among the most easily ignited materials in oxygen systems, especially as oxygen pressure/temperature increases and as ignition mechanisms such as compression heating become more severe.

Pressures in the 1 MPa range are low, but, under a sufficient ignition energy, if the hydrocarbon contaminant exists in the right concentrations, then ignition can certainly occur. WHA have been able to ignite hydrocarbon contaminants as test samples in our adiabatic compression test system at pressures as low as 2-3 MPa. WHA failure analysis experience also has indicated that with contaminated hospital systems, operating in US Hospitals at less than 1MPa, fires have developed in oxygen ventilators where hydrocarbon contaminants have been identified by chemical analysis where they shouldn't be in the post-fire residues, both upstream and downstream of the fire's origin location, implicating them in the ignition process.

ASTM standards G 63 and G 93³ address the concerns with hydrocarbon oils/greases, ASTM G63 from an ease of ignition standpoint and ASTM G93 from a cleaning standpoint. It is noteworthy that the guidance from these two standards is generally harmonized with the standard guidance from EIGA, CGA, and other oxygen practitioners worldwide.

The following provides some of the discussion in ASTM G63 pertaining to hydrocarbon contaminants (*underlining is for the purpose of this annex*):

5.2.1 Factors Affecting Ease of Ignition—Generally, when considering a material for a specific oxygen application, one of the most significant factors is its minimum ignition temperature in oxygen. Other factors that will affect its ignition include relative resistance to various ignition energies, geometry, configuration, specific heat, relative porosity, thermal conductivity, preoxidation or passivity, and “heat-sink effect.” Heat-sink effect is the heat-transfer capacity of the material relative to that of the material in intimate contact with it, considering the mass, physical arrangement, and physical properties of each. For instance, a gasket material may have a relatively low ignition temperature but be extremely resistant to ignition when confined between two steel flanges. The presence of a small amount of an easily ignitable contaminant, such as a hydrocarbon oil or a grease film, can promote the ignition of the base material. Accordingly, cleanliness is vital to minimize the risk of ignition.

¹ <https://wha-international.com>

² AIT : Auto Ignition Temperature

³ ASTM G 63, *Standard Guide for Evaluating Nonmetallic Materials for Oxygen Service* and ASTM G 93, *Standard Guide for Cleanliness Levels and Cleaning Methods for Materials and Equipment Used in Oxygen-Enriched Environments*

(It is difficult to find AIT data for hydrocarbon oils/greases because they are universally avoided in oxygen systems. However, ASTM G 63 does publish the following for hydrocarbon oils as a comparison to other classes of oils)

7.8.6.3

Oils in these candidate classes are found to have the following autoignition temperatures in Table X1.2:

CTFE 374 °C to 427 + °C

PFPE 410 °C to 427 + °C

PE 235 °C to 266 °C

Fluorosilicone 232 °C to 249 °C

HC 190 °C to 199 °C

Silicone 216 °C to 241 °C

The following are from ASTM G93 (*underlining is for the purpose of this annex*):

10.1.4

Fluids Versus Solids—Through the years, more attention has been focused on fluid oil films than on solid contaminants. This is due to several reasons. Oil films tend to be more easily ignited. They migrate. They vaporize. They are more likely to be present in greater total amounts. Also, when an oil film is scrupulously removed, it is likely that there will be little if any unacceptable particulate contaminant remaining.

10.1.2.2

Adiabatic compression is the primary ignition mechanism of oils and greases, having produced ignition experimentally at approximately 6 mg/ft² [65 mg/m²]; also, migration and collection of nonviscous oils appears to occur above ~20 mg/ft² [~220 mg/m²]. This suggests 6 mg/ft² [65 mg/m²] may be the highest conservative limit that may be applicable for incompatible oils in severe service. In a system that does not experience rapid compression, this conservative limit might be extended to 20 mg/ft² [220 mg/m²] on small components or regions that are difficult to clean whether they are part of larger systems or not.

In addition to the above, WHA has tested some representative mineral oils and hydrocarbon hydraulic oils for their AIT using ASTM Standard G72 (at 1500 psig) and have obtained the following results:

Mineral Oil 238 °C AIT

Hydraulic Oil 222 °C AIT

These AITs were obtained at elevated pressure; but, the AIT of many hydrocarbons may not change with pressure too substantially.

(...)