

# **FIRE**

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# **RESISTANCE**

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# **OF INDUSTRIAL**

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# **FLUIDS**

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**George E. Totten**  
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EDITORS

 **STP 1284**

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# *Fire Resistance of Industrial Fluids*

*George E. Totten and Jürgen Reichel, Editors*

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The quality of the papers in this publication reflects not only the obvious efforts of the authors and the technical editor(s), but also the work of these peer reviewers. The ASTM Committee on Publications acknowledges with appreciation their dedication and contribution to time and effort on behalf of ASTM.

## Foreword

This publication, *Fire Resistance of Industrial Fluids*, contains papers presented at the symposium of the same name, held in Indianapolis, IN on 20 June 1995. The symposium was sponsored by ASTM Committee D2 on Petroleum Products and Lubricants. George E. Totten of Union Carbide Corporation in Tarrytown, NY and Jürgen Reichel of Deutsche Montan Technologie (DMT) in Essen, Germany presided as symposium chairmen and as the editors of the resulting publication.

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# Overview

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Industrial fires caused by the use of flammable fluids such as mineral oils may lead to devastating loss of human lives and property. Therefore, many industrial processes such as underground mining, steel rolling, die casting, aerospace, and others require the use of fluids that provide substantially greater fire resistance than those attainable with mineral oils. In fluid power applications, this need has led to the development of various classes of fire-resistant hydraulic fluids which include polyol ester, phosphate ester, water-in-oil and oil-in-water emulsions, high-water-based fluids, and water-glycol hydraulic fluids. Although these and other types of fire-resistant hydraulic fluids are now available, the degree and mechanism of fire resistance that each provides is not the same. From the viewpoint of insurance underwriters, labor organizations, government regulation, and the industry itself, it is becoming increasingly critical to be able to determine appropriately the relative fire resistance provided by the use of a particular fluid in a specific industrial process. This typically cannot be done with the use of a single fire resistance test, particularly the various spray flammability tests that have been traditionally used by various organizations in the United States and Europe.

It has been nearly 30 years since a symposium focusing on fire resistance testing of industrial oils in general, and hydraulic fluids in particular, has been held. Since that ASTM symposium, which was held in 1966, there have been considerable developments in testing procedures for modeling fire risks involved with a particular industrial process and for discriminating the fire resistance offered by a particular hydraulic fluid. This is reflected by the institution of a new fire resistance testing procedure used by Factory Mutual Research Corporation and by the different fire resistance testing procedures required by the 7th Luxembourg Report.

This symposium will provide a forum for the discussion of the current and future global status of fire resistance testing of industrial oils, primarily hydraulic fluids and turbine oils. Four specific areas will be covered: fundamental principles, historical and current testing methodologies and limitations, spray flammability tests, and new test methods.

Two fundamental aspects of fluid flammability will be discussed. One is the often ignored issue of the potential toxicity of fluid combustion byproducts that may be formed. The second aspect of fire resistance testing that will be discussed in detail is modeling and characteristics of pool fire burning which is important when the fire risk potential of fluid leaks and spills must be considered.

To provide a thorough treatment of fire resistance testing, an overview and analysis of the various hydraulic fluid testing procedures, including traditional and current testing procedures, have been reported. The objective of these reviews is to identify the limitations and deficiencies of these various tests. All of these tests model only one type of fire risk, for example, spray ignition or pool fire burning. Thus, it is usually necessary to use two or more tests to provide an adequate assessment of the fire risk that may be encountered. However, many of these tests, although they have been used for many years, do not adequately reflect the fire risk involved with the use of a particular fluid. The inability of these tests to discriminate adequately fire risk will be discussed in the various papers presented here.

Fortunately, very significant advances have been made in the testing of the fire risk potential of hydraulic fluids. Two tests that are currently being promoted for this purpose are the Factory Mutual Research Corporation "Spray Ignition Parameter" test, which will be-

come one of the primary fire resistance testing procedures in the United States, and the “Relative Ignitability (RI)-Index” derived from the newly developed Buxton Test, which will become one of the primary testing procedures required in Europe. The testing procedures for both tests and the results obtained for various types of aqueous and nonaqueous hydraulic fluids will be discussed.

Most of the tests require large volumes of fluid and often can only be conducted by relatively few laboratories (often at high cost). With few exceptions, the reproducibility of these tests is relatively poor and many do not adequately model the actual relative fire risk encountered. Therefore, the identification of much smaller scale, lower cost methods for characterizing fire resistance offered by a particular hydraulic fluid is of great interest. The potential use of two calorimetric testing procedures for the evaluation of hydraulic fluid fire resistance will be discussed here.

From these papers, it is clear that significant gains have been made in modeling and quantifying the relative amount of fire resistance exhibited by a hydraulic fluid. Incorporation of the more recently developed testing procedures into harmonized national and international standards will become increasingly important with globalization of safety standards. One of the most significant results of this conference may be the possibility for harmonizing global fire resistance testing standards.

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# Introduction

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Common industrial fluids include: mineral oils, synthetic hydrocarbon blends, and chemical compositions formulated with additives to achieve properties required for specific applications. Potential fire resistance and environmental and toxicological properties of these fluids are composition dependent.

In hydraulic fluid power systems, power is transmitted and controlled through a liquid under pressure within a closed circuit. Petroleum oils are the most commonly used hydraulic fluid. Petroleum oils are also commonly used for turbine governor controls and other hydraulic systems in electrical power stations.

Some applications demand a greater degree of fire resistance than afforded by petroleum oils. In these situations, fire-resistant fluids may be used. Fire resistance is defined by the ability of the fluid to ignite and propagate flame. Fire resistance properties vary widely among the types of fluids. Examples of fluids commonly used for their fire-resistant properties include: phosphate esters, polyol esters, thickened water/glycols, and high water base and invert emulsions.

However, fire-resistant fluids are not completely inflammable. They may present some degree of fire risk. The hazard will be especially serious if those fluids are used either in close or explosion-prone environments such as those present in underground mining applications or in highly safety sensitive areas such as the aerospace industry. Fire-resistant fluids are also commonly used in the steel, aluminum, and die casting industries. Therefore, the use of industrial fluids, such as hydraulic fluids, in fire- or explosion-prone areas are subject to regulations regarding the amount of fire resistance that they must provide.

The benefits of fluid power over electromechanical drives include: smaller size, higher energy efficiency, and ease of adjustment. All of these advantages are lost if an incident occurs in which the hydraulic fluid, under pressure, is sprayed in the presence of an ignition source resulting in a fire.

Three factors required for a fire are:

- an inflammable fluid,
- a source of ignition, and
- oxygen.

If one of these components is lacking, combustion will not occur. Sprays from a hydraulic system may be caused by hose breaks, pinholes, cracks in fittings or measuring connections that failed to resist the load of pulsation, defective sealing elements, and mechanical damage by external influences. Sprays of easily inflammable petroleum oil will ignite in the presence of an ignition source whether the system has an operational pressure of 40 or 400 bar. Even the removal of the source of ignition will not help flame extinction. Fire-resistant fluids, however, may exhibit either fire-inhibiting or even self-extinguishing properties.

This symposium will address the vital question of proper assessment of fire resistance of industrial fluids. Basic principles in fire resistance characterization will be discussed. This will be followed by a discussion of standardization activities and current and recent test methodology development. There will be a comprehensive discussion on spray ignition tests and novel test methods and an assessment of these methods will be provided.

In specification development, it must be assured that potential hazards will not give rise to exaggerated safety requirements that will lead to technically unreliable applications. This would be intolerable not only for economic reasons but would also restrict many applications of fluid power technology. Operational safety and economics are imperative in fluid power technology! Hydraulic fluids represent only one element of the system and cannot be replaced indiscriminantly with no risk.

We are very fortunate that the experience gathered in the United States and Europe during the past 35 years in the development of fire-resistant hydraulic fluids and test methods to determine fire resistance can be presented here in one forum. Hopefully, as a result of this meeting, both national and international standards test methods for the determination of fire resistance for individual applications in the different industrial applications can be harmonized in the future.

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