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Trending Analysis and Machine Learning (ML) Part 1: DOE Fire Protection Trends

Introduction

This Operating Experience Summary (OES) is the first of a four-part series designed to share outcomes and lessons from the use of Machine Learning (ML) in support of the most recent U.S. Department of Energy (DOE) fire protection trend analysis report. This first part of the OES series provides an overview and general results and conclusions of the fire protection trend analysis report, issued in July 2022. The full report can be found at this link.

Background

The DOE Office of Environment, Safety, and Health (ES&H) Reporting and Analysis, within the Office of the Environment, Health, Safety and Security (EHSS), manages the Fire Protection Reporting System (FPRS) and annual reporting process. The Office then analyzes the fire protection data to identify insights to help DOE elements improve performance.

The report, *U.S. Department of Energy Annual Fire Protection Data Trends for Calendar Years (CY) 2015-2019*, presents the results of the observed trends of fire protection data at DOE operations during the 5-calendar year period of 2015-2019. This report analyzes information from over 59 DOE organizations that submit data to the DOE's Fire Protection Reporting System as well as those that submit fire protection information to the Occurrence Reporting and Processing System (ORPS). The information is reported to DOE in accordance with DOE Order 231.1B, Environment, Safety, and Health Reporting, and has been analyzed to provide a measure of DOE's fire protection safety performance.

Results and Methodology

The trend analysis utilized fire protection loss reports from the FPRS and fire protection occurrence reports from ORPS. The analysis evaluated trends related to fire losses and non-fire losses (i.e., damage sustained as a consequence of non-fire incidents involving fire protection systems) as well as trends related to the types of fire (e.g., building, vehicles, brush, leaks/spills) and the causes (e.g., design, material, weather, electrical, procedure and employee).

The analysis evaluates the trends for frequency as well as the trends of the cost of the reported incidents. Where applicable, the analysis also normalized data by work hours (i.e., per 200K work hours) and by cents per $100 valuation. The normalized trends did not affect the observations of the analysis. Overall, the data indicated that the frequency of incidents is flat, as shown in Figure 1, while the losses per year are increasing, as shown in Figure 2.
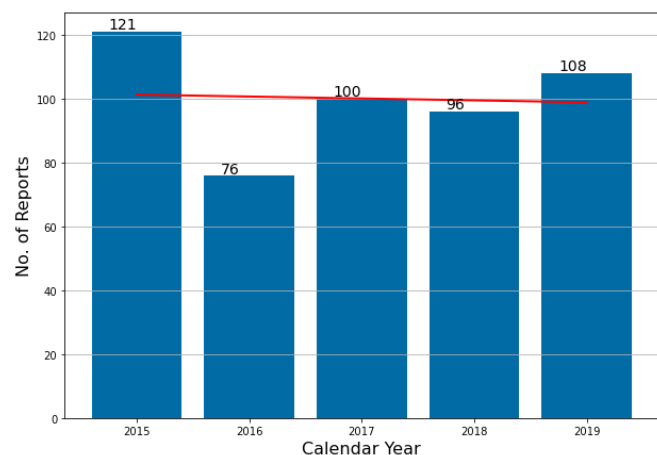

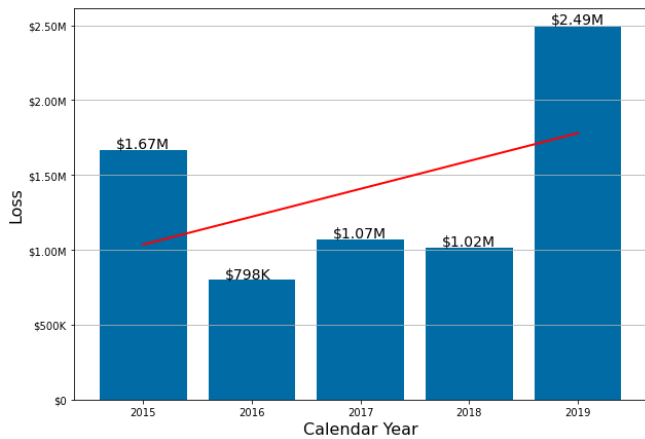**Figure 1: Number of Fire Protection Loss Reports**

Figure 2: Fire Protection Losses per Calendar Year

The evaluation was supplemented with natural language processing and machine learning text clustering methods to analyze the text data of the fire protection loss reports (see Part 2 of this OES series for more on this methodology). The results identified that the most common fire protection incidents resulting in losses greater than $10K were related to the following:

- Vegetation related fires caused by lightning strikes, downed power lines, cigarettes, equipment failures (e.g., electrical arcing)
- Cold weather-related incidents resulting in building flooding damage due to frozen fire protection system pipes
- Equipment failures (e.g., transformers, fans, capacitors, modulators and heating, ventilation, and air conditioning)
- Chemical reactions within fume hoods
- Vehicle accidents
- Kitchen and analytical microwave smoke/fire incidents due to equipment failure or operator error

The analysis also evaluated FPRS fire department response data at four sites but yielded no insights

due to limitations of the data. EHSS is working to improve data collection and data quality to enhance the ability to identify trends, areas of improvement, and potential leading indicators to enhance learning and safety across DOE.

Summary

Analysis of the collected fire protection data between CY2015-2019 indicates that, overall, the number of fire protection incidents is flat, and the trends normalized by work hours are decreasing. However, the analysis found that the trends for total monetary losses are increasing. This may indicate that incidents are becoming less frequent but resulting in higher monetary losses.

When categorizing the causes of the incidents, vegetation or brush fire/smoke incidents and design/material related causes were found to have the highest increasing trends.

Lessons learned and additional opportunities for the application of trending analysis and ML to the DOE fire protection data and other trending and analysis reports are included in the subsequent OESs of this series. See text box below.

OES Series: Trending Analysis and ML

This OES is part of a series of articles focused on the application of trending analysis and machine learning to DOE fire protection data and other ES&H trending analysis reports. The series includes the following four parts:

Part 1: *DOE Fire Protection Trends* **(this OES document)**
Part 2: *DOE Fire Protection ML Text Clustering*
Part 3: *Lessons Learned on ML Tools Design, Development and Use*
Part 4: *References on Artificial Intelligence Best Practices and Principles*