EI Research report

Process hazard analysis of an aviation fuel hydrant system

EI RESEARCH REPORT:
PROCESS HAZARD ANALYSIS OF AN AVIATION FUEL HYDRANT SYSTEM

February 2020

Published by
Energy Institute, London
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Registered charity number 1097899

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The EI gratefully acknowledges the financial contributions towards the scientific and technical programme from the following companies

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Uniper
Valero
Vattenfall
Vitol Energy
Woodside
World Fuel Services

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ISBN 978 1 78725 163 2

Published by the Energy Institute

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FOREWORD

This Energy Institute (EI) Research Report has been prepared by Roger Stokes and Robert Magraw of BakerRisk Europe Ltd[1] under the direction of the EI's Aviation Committee.

It reports the findings of a PHA of a European airport that uses a hydrant system to supply aviation fuel (Jet A-1) to aircraft. The present study was undertaken as a follow-up to work contracted by the EI on aviation fuel hydrant emergency shutdown systems. For further details see EI *Research Report: Review of aviation fuel hydrant emergency shutdown systems*.

The intention of this work was to provide for stakeholder consideration information on a topic that may impact several different entities at an airport, given that hydrant owners (or leaseholders) may not be the hydrant operator and that the into-plane refuelling service and/or fuel storage and pumping operation may be undertaken by one or more other entities.

This EI Research Report is intended to assist all those involved in the design, construction, operation, inspection and maintenance of aviation fuel hydrant emergency shutdown systems and all companies involved in the fuelling of commercial aircraft with jet fuel.

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1 Thornton Science Park, Pool Lane, Ince, Chester, CH2 4NU, UK. Tel: +44(0)1244 405960, website www.BakerRisk.com

ACKNOWLEDGEMENTS

This EI Research Report was prepared by Roger Stokes and Robert Magraw of BakerRisk Europe Ltd who also led the process hazard analysis at the airport location. They are thanked for their significant contributions on this topic.

Considerable technical input to the study was provided by Nic Mason (Kuwait Petroleum International Aviation Company Ltd.)

The EI is particularly grateful to the stakeholders at the anonymous airport location that agreed to participate in this study, including the hydrant operator, the into-plane supplier and the fire and rescue service. The success of this work was in no small part due to their expertise and engagement with the process.

A draft version of this report was made available for review by representatives of the following EI Aviation Committee member companies and organisations, who are thanked for their participation and contributions to the preparation of this publication:

Air BP Limited
Air TOTAL
Airlines for America
Chevron
Civil Aviation Administration of China
Compañía Logística de Hidrocarburos (CLH)
ExxonMobil
ExxonMobil Research & Engineering
International Air Transport Association
Joint Inspection Group
Kuwait Petroleum International Aviation Company Ltd.
Phillips 66
Saudi Aramco
Service des essences des armées
Shell Aviation Ltd.
US Department of Defense
Vitol Aviation
World Fuel Services

Project co-ordination and editing was undertaken by Martin Hunnybun (EI).

1 INTRODUCTION

1.1 BACKGROUND

In 2017, BakerRisk was commissioned by the EI to conduct a review of airport fuel hydrant emergency shutdown systems. The report on that project was published by the EI in April 2018[4] and one of its recommendations was to consider conducting a HAZOP on airport hydrant systems that would be useful in systematically identifying various issues, including:

– potential causes and consequences of loss of containment;
– required action of protection systems and their ability to fulfil their required function;
– the required failure modes of protection systems and components, and
– human actions required.

This latest project satisfies that recommendation and comprises a PHA, including a HAZID and HAZOP, of an airport hydrant fuelling system at a European airport.

1.2 OBJECTIVES

The objective of the study was to produce a PHA report for the airport that was visited, including any findings and recommendations that arose. The report was to be suitable for publication as an EI research report for future citation/use by industry. In addition, a standalone guide (to be submitted separately to the EI) would outline the methodology used and steps taken to provide guidance for airport hydrant operating companies who may be considering a similar undertaking at other locations; the guide would also be suitable for inclusion in the next edition of EI 1560.[1]

1.3 SCOPE

As with most European airport locations that have fuel hydrant systems, the fuel farm area falls under the Seveso III Directive, effective 1 June 2015, which has been subsequently implemented within the various EU nation states under their respective national legislation. The Directive applies where dangerous substances are used or stored in large quantities, and requires consideration of potential major accident scenarios at the fuel farm location.

This PHA study does not address fuel supplies to the tanks, or incidents involving the tanks themselves, both of which would fall under the Seveso Directive.

The scope of this study commences at the inlet of the floating suction line within the storage tank, and ends at the filling point on the aircraft.

4 EI 1560 *Recommended practice for the operation, inspection, maintenance and commissioning of aviation fuel hydrant systems and hydrant system extensions*

1.4 METHODOLOGY

The PHA techniques used for this study were developed primarily for the oil, gas, chemical and pharmaceutical industries but are equally applicable to airport locations, and in particular those that use hydrant refuelling systems.

The PHA/HAZOP process is a qualitative risk assessment technique that involves a systematic process of structured 'brainstorming'. It requires the involvement of as many relevant stakeholders as possible to be effective. BakerRisk was able to involve operators and managers of the fuel farm, the 'into-plane' company (who are responsible for connecting to the hydrants and filling the aircraft), and the airport emergency response leader. BakerRisk did not request representation from the airline companies, although some of the scenarios identified may benefit from further discussion with the airline industry.

The PHA process typically commences with a HAZID review, followed by a HAZOP. A further, more rigorous analysis of the protection layers that are identified, often termed a Layer of Protection Analysis (LOPA), can also be conducted. A full LOPA was not included within the scope of this study, although some aspects of the LOPA methodology were applied to the examination of safeguards.

The details of the study and associated findings were documented throughout the process using the BakerRisk PHA-Tool© software.

1.4.1 HAZID

A HAZID comprises a structured analysis of the specific hazards (safety, health and environmental) that are present due to the nature of the materials, the operating conditions, the equipment that is processing them and any external factors. A standard checklist is used as an aid to ensure that all relevant issues are considered by the team, and all potential hazards have been identified. The checklist was edited prior to this study to remove issues that were not relevant (such as chemical reaction hazards, etc.).

1.4.2 Risk matrix

A key early step in a HAZOP involves defining a 'risk matrix', which establishes the degree of risk tolerance within an organisation, i.e. what is an acceptable frequency for the occurrence of any one incident type of a particular severity/consequence. For a large oil or chemical company, this would typically be established at a corporate level. Ultimately, it defines an acceptable frequency for a major event.

For this project, there was no equivalent risk matrix provided, so BakerRisk adapted one that had been established mainly for the risk management of personal safety at the fuel farm. This was not extended to include a tolerable frequency for incidents that involve multiple fatalities (such as loss of an aircraft), since defining such a frequency was outside the scope of the remit. However, based on the matrix that was developed (see Figure 2), certain potential events were identified where further risk reduction may need to be considered. These are outlined in the report.

The utilisation of the risk matrix is described in 1.4.3.

1.4.3 HAZOP

A HAZOP study is a qualitative technique to identify potential variations or hazards created as a result of deviations from the design intent of the system. The piping and instrumentation diagrams (P&IDs), or equivalent drawings for the areas of the facility included in the study were subdivided into workable sections called 'nodes'.

For the continuous and semi-continuous operations comprising the fuel farm, hydrant system, and fueller loading, a detailed team review was conducted using prescribed HAZOP criteria, such as flow and pressure deviations. Each node was examined by applying certain 'guide words' (no, less, more, etc.), which are used to qualify specific physical 'parameters' (flow, pressure, level, etc.) that describe the process. The combination of a guide word and a parameter describe a situation that may result in a 'deviation from design intent'. Each deviation from design intent is a hypothetical situation in which either the equipment is not operating as intended, or personnel are not performing duties as per the operating manual.

For aircraft fueling operations, a 'What-If' technique was applied to the documented procedures associated with those operations. This is another team brainstorming technique where questions are raised such as 'What-If this step is missed?' or 'What-If this is done in a different order?' etc.

In both cases (HAZOP and What-If), for each deviation, the team brainstorms a list of credible causes and makes a qualitative judgement on their expected likelihood. For each cause, the team considers what the maximum credible consequences might be if the accident sequence were allowed to develop. Using the risk matrix this likelihood/consequence relationship provides a qualitative 'unmitigated risk'. Where the unmitigated risk is significant, i.e. not 'low', the team identifies safeguards which would prevent and/or mitigate the consequences. By then considering the action and independence of the safeguards that are in place, an 'order of magnitude' assessment of the effectiveness of the safeguards at reducing the frequency, or if appropriate the magnitude, of the consequence can be made. For a full LOPA, this assessment of each Independent Protection Layer (IPL) is conducted using company or industry data, based on corporate experience or the measured reliability of various types of safeguard. For this assessment, such data were not available and the experience and judgement of the team members were used to estimate the effectiveness of the barriers. In cases where safeguards were not deemed to be independent, they were noted but not given any risk reduction credit. After application of the risk reduction credit agreed for each barrier/IPL, the 'mitigated risk' category was then determined by comparison with the risk matrix.

Where required, i.e. mitigated risk is not 'low', recommendations are made to reduce the likelihood and extent of damage (both to assets and the environment), injury or performance/ quality reduction, in the event the equipment does not operate as designed or if human error were to occur. In some cases, further studies are recommended for scenarios outside the defined scope of the HAZOP/What-If study or when the team does not have the resources to make a definite recommendation to address an issue.

1.5 INFORMATION PROVIDED

To be effective, the HAZOP process requires process safety information including P&IDs, operating procedures and equipment details to be up-to-date.

P&IDs typically show all of the equipment, piping, and instrumentation, and can include useful features such as:

- how the instrumentation operates;
- normal position of valves (closed/open);
- failure position of valves on loss of signal or loss of power (open, close or stay-put), and
- location of blinds (spades) between flanges.

Whilst the majority of the fuel farm was covered by a very basic P&ID, the provided drawings were not fully up-to-date and did not include some of the useful features described here. One key recommendation from this study is to ensure that P&IDs are fully updated and show the instrumentation logic and fail safe position of key valves, etc. This is an important requirement for conducting a HAZOP effectively.