

## Executive Summary

### Project Background and Goal

Many NFPA codes and standards, in particular NFPA 400, Hazardous Materials Code, specify separation/clearance distances for hazardous chemical storage and processes from other equipment and occupied buildings. Many of these requirements have historical undocumented origins. Guidance, which may inform a sound technical basis for adjusting these distances, has been requested by NFPA Technical Committees. There are a number of methodologies in the literature, both risk and hazard based, which are used in the chemical safety process safety field that may be relevant to the calculation of these distances.

The purpose of this project is to provide guidance to NFPA technical committees on methodologies to develop technically based separation/clearance distances for hazardous chemical storage/processes and their application to the chemical storage and processes. The specific focus of the project is those hazards within the scope of NFPA 400.

### Program Organization

This report is sectioned to address the major tasks of this program:

1. Task 1, an expanded review of literature relevant to NFPA 400
2. Task 2, a case study of the separation distances between Ammonium Nitrate (AN) solids and both personnel and chemical storage
3. Task 3, a discussion of recommendations for the further development and testing of separation distances as they relate to NFPA codes and standards
4. Supporting information including material safety data sheets for the case study materials and the original Kazarians and Associates literature review

### Literature Review

The purpose of this literature review is twofold. The first purpose is to build upon a literature review performed by Kazarians and Associates in a previous effort focusing on classifying separation distance guidance into three categories: consequence-based, risk-based, and look-up tables. The previous review covered much ground and provided a substantial list of resources from which to begin this review process.

The second purpose of this review is to focus on guidance provided by the project panel to determine topics of interest and importance to stakeholders. The project panel communicated in its initial discussions with the contractor that vapor cloud explosions, and injury to personnel in areas governed by NFPA 400 were of large concern. Given these two broad areas to address, information was sought that defined the risk and hazards posed from vapor clouds and for personnel in chemical storage and processing facilities.

To this end, various industry, regulatory, and academic sources were reviewed to identify the issues of concern. Specifically, information was focused to enhance the previous literature review in areas where there were knowledge gaps as determined by stakeholders.

Specific documents were selected for review based on their overall applicability to NFPA 400. Many documents address separation distances in an indirect manner; those that were found to be only generally, not specifically, applicable are included as Additional References.

### Ammonium Nitrate Solids Case Study

Storage of Ammonium Nitrate (AN) solids is governed by Chapter 11 of NFPA 400, therefore, testing the separation distances for this material was selected as a case study. Both the process-to-process separation distance and process-to-personnel separation distance was tested to determine whether the published guidelines are adequate for protection of personnel and property and prevention of a catastrophic event.

To address separation distances for this material, a central explosive donor charge was used to simulate a catastrophic event occurring at a facility. The process-to-process test was performed by placing three containers of AN at varied standoff distances from the central donor charge to observe any sympathetic detonations. The process-to-personnel test was performed by placing a wall construction typical of a process building at the specified separation distance from the donor charge to observe injurious fragments and airblast.

### Recommendations

It is very important to consider both risk and consequence based methods for the broad array of potential hazardous materials. Focusing on only risk-based methods for vapor cloud explosions, for example, ignores the possibility that a large vapor cloud explosion could occur, whereas only observing the consequence-based methods provide a more burdensome standard which may be difficult to achieve due to cost, even when the possibility of such an event is remote. Therefore, it is the opinion of the authors that, ideally, a technical-based approach consisting of both risk and consequence be instituted. Using this hybrid approach, a base level of risk may be assumed by the facility managers while understanding of and preparations for a worst-case event can be evaluated and methods for mitigating such an event can be handled by methods other than strictly separation distances.