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# Chemical facility vulnerability assessment project

Calvin D. Jaeger*

*Security Systems and Technology Center, Sandia National Laboratories, P.O. Box 5800, MS 0759, Albuquerque, NM 87185, USA*

**Abstract**

Sandia National Laboratories, under the direction of the Office of Science and Technology, National Institute of Justice, conducted the chemical facility vulnerability assessment (CFVA) project. The primary objective of this project was to develop, test and validate a vulnerability assessment methodology (VAM) for determining the security of chemical facilities against terrorist or criminal attacks (VAM-CF$^{TM}$). The project also included a report to the Department of Justice for Congress that in addition to describing the VAM-CF$^{TM}$ also addressed general observations related to security practices, threats and risks at chemical facilities and chemical transport.

In the development of the VAM-CF$^{TM}$ Sandia leveraged the experience gained from the use and development of VAs in other areas and the input from the chemical industry and Federal agencies. The VAM-CF$^{TM}$ is a systematic, risk-based approach where risk is a function of the severity of consequences of an undesired event, the attack potential, and the likelihood of adversary success in causing the undesired event. For the purpose of the VAM-CF$^{TM}$ analyses *Risk* is a function of $S$, $L_A$, and $L_{AS}$, where $S$ is the severity of consequence of an event, $L_A$ is the attack potential and $L_{AS}$ likelihood of adversary success in causing a catastrophic event. The VAM-CF$^{TM}$ consists of 13 basic steps. It involves an initial screening step, which helps to identify and prioritize facilities for further analysis. This step is similar to the prioritization approach developed by the American Chemistry Council (ACC). Other steps help to determine the components of the risk equation and ultimately the risk. The VAM-CF$^{TM}$ process involves identifying the hazardous chemicals and processes at a chemical facility. It helps chemical facilities to focus their attention on the most critical areas. The VAM-CF$^{TM}$ is not a quantitative analysis but, rather, compares relative security risks. If the risks are deemed too high, recommendations are developed for measures to reduce the risk. This paper will briefly discuss the CFVA project and VAM-CF$^{TM}$ process.


*Keywords:* Chemical facility vulnerability assessment; Vulnerability assessment methodology; VAM-CF$^{TM}$

* Tel.: +1-505-844-4986.
*E-mail address:* cdjaege@sandia.gov (C.D. Jaeger).

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## 1. Background

The chemical facility vulnerability assessment (CFVA) Project was undertaken by Sandia National Laboratories (SNL) under the direction of the Department of Justice's National Institute of Justice (NIJ). The purpose of this effort was to advise the Attorney General of the United States as to a practical method by which the security of chemical facilities within the United States might be assessed. The report provided the Attorney General with a model assessment tool (vulnerability assessment methodology (VAM)-CF$^{TM}$) that can be used to identify and assess the threats, risks, and vulnerabilities of particular chemical facilities, as well as explains the process by which the assessment methodology was developed, validated, and tested. Additionally the report provided the Attorney General with general observations regarding the overall risks, threats, and vulnerabilities that may exist at chemical facilities based on several limited site visits to chemical facilities made during the methodology development process. The report also discussed potential remedies that might be adopted to address these risks, threats, and vulnerabilities, as well as advises the Attorney General on the issues surrounding the public disclosure of the specific information that will result from the assessment of any given chemical facility. Observations for the report were collected through visits to chemical facilities within the United States prior to and after the 11 September 2001 terrorist attacks on the United States.

During the development, testing, and validation of the VAM-CF$^{TM}$, Sandia staff:

- Collected and reviewed extensive information relevant to the threats, risks, and vulnerabilities associated with chemical facilities, including current security practices in the chemical industry.
- Conducted extensive outreach with the field including meetings and discussions with industry, government, and public citizen representatives, as well as private individuals, all of whose observations were considered in developing the methodology and preparing the report.
- Created an Internet web site to describe the development effort and solicit comments.
- Visited chemical facilities to develop the VAM-CF$^{TM}$ approach.

## 2. Overview of the VAM-CF$^{TM}$ process

In the development of the VAM-CF$^{TM}$ considerable effort was expended to leverage existing requirements such as the facility risk management plans and off-site consequence analysis (RMPs and OCAs), as well as, process safety management (PSM). A useful VAM-CF$^{TM}$ must provide CFs with a means to readily judge the adequacy of their current security systems and practices, and a means to identify potential remedies that can be incorporated into the facility's operations to counter identifiable risks, threats, and vulnerabilities. The following figure illustrates areas leveraged by the VAM-CF$^{TM}$. Both the RMP (Fig. 1) and PSM require facilities to conduct process hazard analysis (PHAs). Information collected in the PHAs is particularly important information for use in the VAM-CF$^{TM}$ approach because it describes the chemical processes including potential abnormal reactive chemical incidents.

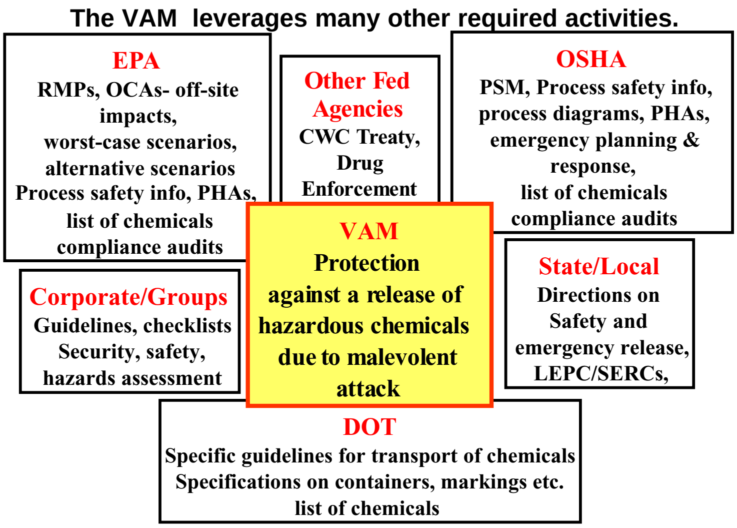


Fig. 1. Interactions with other activities.

The structure of the VAM-CF$^{TM}$ provides for considerable flexibility in the consideration of different CFs, potential undesired events, and possible adversary threats. The worksheets within the VAM-CF$^{TM}$ workbook have been tailored to support the vulnerability assessment VA for an undesirable event of a release of hazardous chemicals with off-site consequences caused by either an outsider adversary (e.g. terrorist) or an insider adversary. If a different undesired event were selected (e.g. loss of production, theft, economic or environmental impact) then different criteria and worksheets would be needed to support that assessment.

In developing the CFVA methodology Sandia focused primarily on physical security at chemical facilities with a secondary consideration on security issues associated with the transportation of hazardous chemicals related to the site and electronic access to chemical facility process control systems. The VAM-CF$^{TM}$ methodology was envisioned to be a tool intended to provide a systematic, risk-based approach to assessing security at chemical facilities based upon potential threats and vulnerabilities, the probability of a successful attack occurring, and the severity of consequences resulting from a successful attack. The VAM-CF$^{TM}$ considers first the physical security system (PPS) and then appropriate safety and emergency response measures that could help mitigate the consequences of a successful adversary attack.

The objective of the VAM-CF$^{TM}$ is to provide a security assessment tool with the following characteristics:

- Systematic, risk-based approach where risk is a function of the following:
  - Threat (type and likelihood of an attack).
  - Severity of consequences of a successful attack.
  - Likelihood of an adversary causing a successful attack.
- Incorporate appropriate safety and emergency response measures that could mitigate the consequences of a successful attack.

- Readily useable by chemical facilities (there is now an automated version of the VAM-CF$^{TM}$).
- Provide meaningful vulnerability information so additional protection measures can be implemented which effectively reduce risk.

From the outset it was also recognized that for a chemical facility's PPS to offer a high likelihood of defeating an attack, three elements must be present and be working properly. These are:

- *Detection*. The ability to detect and identify when an attack occurs. Adversaries must be detected in time to prevent them from accomplishing their goal.
- *Delay*. Adversaries must be delayed long enough for a mechanism or response force to intercept them before they accomplish their goal.
- *Response*. The response mechanism or force must be able to neutralize the adversaries and preserve the integrity of the facility.

Even so, simply including these elements in a security system does not guarantee the effectiveness of the system (if the system is poorly designed, or the technologies, personnel, or procedures in the elements do not perform adequately). While numerous safety systems do exist at CFs that are designed to mitigate the effects of an accidental release (e.g. neutralizing spray systems), the effectiveness of such systems needs to be analyzed for their security effectiveness, with special consideration given the possibility of an attacker attempting to defeat such systems.

The VAM-CF$^{TM}$ is comprised of thirteen steps. These are:

1. *Screening*. This is a determination of which chemical facilities need or desire a security vulnerability assessment (SVA). To determine whether a chemical facility requires a SVA two principal questions must be answered. One is whether loss of the facility would result in a significant national impact. The other is whether a compromise of the facility would result in unacceptable losses in terms of injury and/or death to adjacent populations. If the answer to either is "yes", a SVA should be undertaken. The screening step is very similar to the ACC's prioritization method.
2. *Vulnerability assessment project definition*. Once a determination is made to undertake an SVA, the project should be defined, a team assembled, and the necessary steps taken to proceed with the assessment. Determination of the scope is a very important part of this step.
3. *Characterization of facility*. This entails defining the type, nature, physical parameters and boundaries, operational practices, security systems, and physical characteristics of the facility and the chemicals on site. This is where the hazardous chemicals and processes are identified and the first major step in identifying critical areas for the facility.
4. *Derivation of consequence severity levels*. This entails identifying potential incidents and the severity of resulting consequences ($S$). For current version of the VAM-CF$^{TM}$ this involves off-site impact although other undesired events can be considered.
5. *Threat assessment*. Involves the identification and characteristics of potential threats to the facility ($L_A$). Characterization of the threat is particularly important because this is needed during the development of possible adversary scenarios.

6. *Identification of priority cases for analyses*. This involves an analysis of the likelihood of various attack scenarios against the facility (LS). This step links the asset to a specific threat.
7. *Preparation for analyses*. This entails a compilation of all relevant materials relative to the physical plant, operations, and security systems of a facility.
8. *Site survey*. Physical look at the facility with the focus on the critical areas. Worksheets have been developed for the site, process areas, safety/mitigation and security forces.
9. *System effectiveness analyses*. This includes an analysis of existing on-site security systems and specific analysis of the detection, delay, response and system integration of the physical protection systems. The system effectiveness linked to likelihood of adversary success ($L_{AS}$).
10. *Risk determination*. This involves consideration of the components of risk-based on the facility's characteristics, potential threats, potential consequences, and existing security systems ($R$).
11. *Recommendations for reduction of risk*. Based on the analysis of risks, this step provides an analysis of actual vulnerabilities and helps the user develop measures to reduce risk. Risk reduction measures could be related to threat, consequence or protection system effectiveness.
12. *Consideration of impacts*. This involves consideration of possible upgrades and their costs and potential impacts to facility operations/schedule, safety/health and other factors.

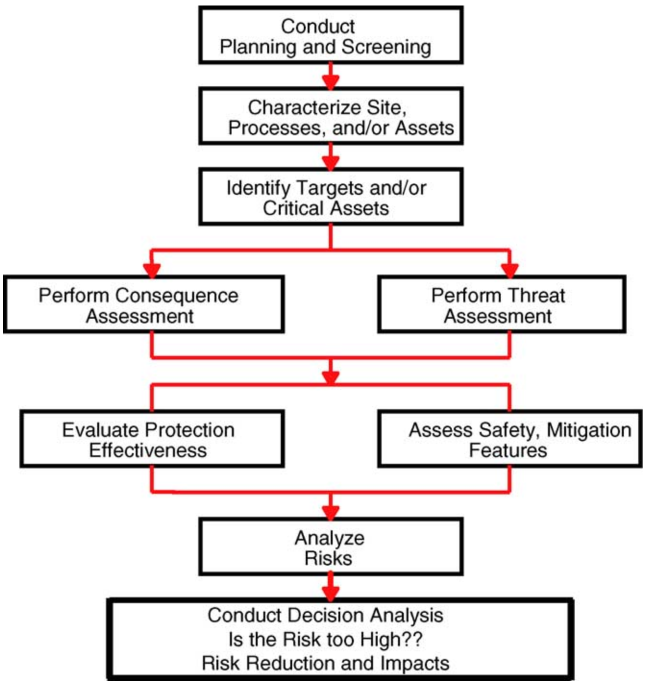


Fig. 2. VAM-CF$^{TM}$ flow chart.

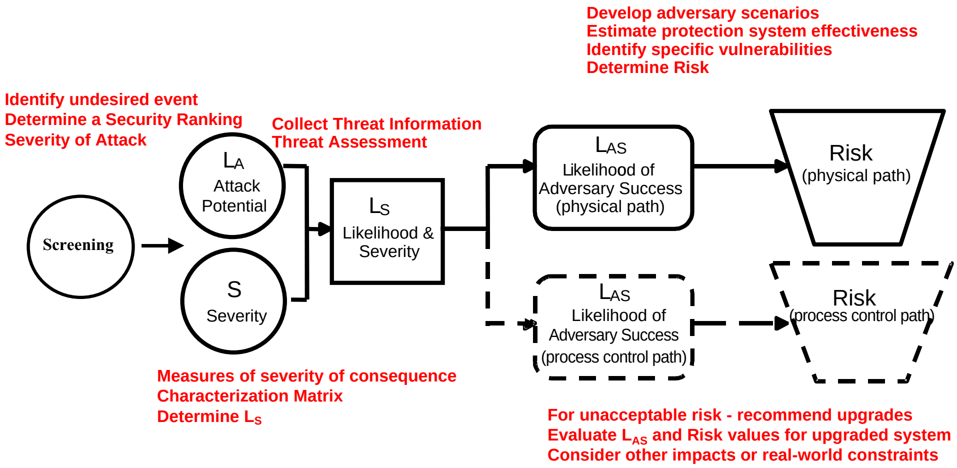


Fig. 3. Risk analysis/VAM-CF$^{TM}$ process.

13. *Final report preparation*. Summary of the findings from the SVA and brief to decision makers.

Worksheets have been developed for each of the above steps. The current version of the VAM-CF$^{TM}$ is a paper-based system but an automated the VAM-CF$^{TM}$ has just been completed. Two figures summarize the VAM-CF$^{TM}$ process and risk analysis approach (Figs. 2 and 3).

## 3. Capabilities/advantages of the VAM-CF$^{TM}$ process

The benefits expected from the use of a chemical facility SVA methodology include the following:

- Uses a systematic procedure to help make consistent risk-based analyses and document the decision process.
- Uses a standardized methodology that will allow for comparison of security risks across a number of chemical facilities and help identify priority CFs and priority operating units within CFs for security upgrades.
- Leverages other requirements (e.g. PSM, RMP) placed on CFs.
- Identifies and prioritizes security vulnerabilities at chemical facilities and the attack scenarios associated with those vulnerabilities so appropriate recommendations can be developed to address those vulnerabilities. Otherwise, security upgrades may be undertaken which do not effectively address the vulnerabilities.
- Provides the capability to address different undesired events and threats.
- Provides a mechanism to decide how to use security funding and other resources at chemical facilities to address priority vulnerabilities.

- Provides ability to screen and focus on critical areas and a framework to identify and prioritize security vulnerabilities.
- Identifies CFs where the consequences of an attack would potentially outweigh the consequences of a accidental release of a hazardous chemical.
- Provides a methodology to help increase protection against the consequences of malevolent attacks on CFs and to make the best use of security funding and other resources.
- Encourages expanded interactions between local law enforcement and emergency response agencies and CFs to evaluate and understand security at chemical facilities.
- Promotes increasing confidence in neighboring communities that chemical facilities have appropriate security.
- Provides a continuous approach to evaluating risk.
- Ultimately, helps to improve protection against the consequences of attacks on CFs.

## 4. Summary

The VAM-CF$^{TM}$ is continuing to be developed. It provides the chemical industry with an easy, usable and effective method for assessing the risk against potential malevolent threats. The systematic approach provides for the ability to focus on the most critical areas first and to be able to trace and justify decisions. If vulnerabilities and weaknesses are identified, the process of developing enhancements and countermeasures to either prevent and/or mitigate the consequences of an undesired event can be initiated. The VAM-CF$^{TM}$ is closely linked to other existing hazard and safety analysis and thus helps to provide for an overall protection strategy that makes CFs more safe and secure. Since the presentation of this paper a number of different SVAs have been developed many of which are similar to VAM-CF$^{TM}$ and have used the principles found in the VAM-CF$^{TM}$ approach. The development of a VAM-CF$^{TM}$ and other SVA methodologies is an important step toward improvements in CFs and chemical industry security against terrorist and criminal acts.

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