Reducing the Potential Scope of Chemical Catastrophes in the U.S. Chemical Industry: Evidence from the EPA's Risk Management Planning Program

Compiled by Paul Orum * Revised May 18, 2022

Key Issues

- Available information suggests that some chemical facilities are reducing the potential for catastrophic chemical releases to nearby communities.
- The actual extent and nature of any technological changes are not well documented, and the pace of change is slow at best.
- Major Federal programs do not routinely investigate industry practices and communicate lessons learned, thereby missing important opportunities to generate knowledge of solutions that reduce populations at risk.

Background

Federal law requires the owners or operators of some 12,000 U.S. industrial and commercial sites that hold large amounts of certain toxic or flammable extremely hazardous substances to provide Risk Management Plans (RMP) to the U.S. Environmental Protection Agency (EPA). These plans are intended to help the facilities prevent, manage, and respond to chemical emergencies. RMP sites may include chemical manufacturers, petroleum refineries, power plants, paper mills, refrigerated warehouses, storage and distribution terminals, water and wastewater utilities, and other facilities that produce, use, or store RMP-regulated chemicals.

Congress enacted the RMP safety requirements after a series of major chemical accidents starkly demonstrated the potential for serious harm. At one notorious release, in Bhopal, India, leaking toxic gases from a pesticide factory killed several thousand people.

An important feature of each RMP is the evaluation of potential off-site consequences of a worst-case chemical release, which includes the residential population at risk within an off-site "vulnerability zone." These vulnerability zone population figures are estimates of the residential population within the entire vulnerable area of a chemical release, but they are not predictions of potential casualties during any specific release scenario.[a] The

populations residing within these zones varies widely, from none to more than a million, and are disproportionately characterized by environmental justice burdens.[1]

Such vulnerabilities are not inevitable. Technological change can often reduce or remove the potential consequences of a chemical release to workers, emergency responders, and communities.[b] Three key questions are therefore: the degree to which RMP facilities have made changes that reduce the scope of their vulnerability zones since the program began in 1999; whether other facilities could reduce hazards through similar transitions; and how facilities have done so. Unfortunately, the RMP program does not routinely generate and develop information about available solutions that reduce populations at risk.

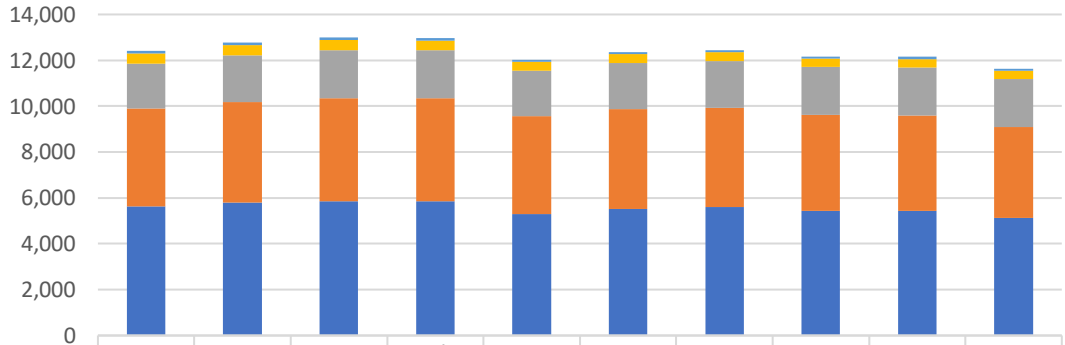
It should be noted that the worst-case scenarios found in RMPs represent the potential scope of rare catastrophic chemical releases. The scenarios do not address the cumulative impacts of facility clusters, the frequency of lesser spills,[c] and chronic non-emergency emissions that may routinely pollute nearby communities or excessively expose workers. Nor do they reflect the presence or lack of effective process safety management and culture, program staffing, funding, and inspections, or add-on safety and security devices and procedures (all of which are fallible). Rather, the scenarios can be viewed as defining a broad measure of incentives and opportunities to reduce underlying catastrophic hazards. RMP facilities may take into account certain passive mitigation measures (e.g., berms, dikes, sumps) but not active mitigation measures (e.g., systems for safe shutdown, emergency isolation, water deluge) in the analysis of the worst-case scenario for toxic gases. Active mitigation systems are assumed – correctly - to fail in a worst-case release.

Any progress?

In the absence of better information, one measure of progress is to track the number of RMP facilities by vulnerability zone population at risk interval (e.g., areas encompassing up to 1,000, 10,000, 100,000, or 1,000,000 or more people at risk). Such analyses have been prepared over the years by the Congressional Research Service (CRS) in response to requests from members of Congress.[d] The CRS analyses are snapshots in time that provide the total number of facilities in each population interval, but do not address whether actual safety measures are in place at any facility. As of January 2021, ten such nationwide analyses by CRS were available between May 2005 and December 2019.[e] Figure 1 compares these analyses.

In general, a comparison of the CRS analyses suggests a gradual decline in RMP facilities in most intervals (excluding facilities with overdue RMPs).[2-11] However, apparent declines in populations at risk may not reflect actual safety changes, as discussed below. Facilities with more than 1 million people living within their vulnerability zones dropped from 106 to 83, or 22 percent. Facilities that endanger any of 100,000 to 999,999 residents also showed an encouraging decline from 453 to 360, or 21 percent. However, facilities in the next interval, with vulnerability zone populations from 10,000 to 99,999, increased from 1,952 to 2,098, or seven percent. Facilities in the next interval, with populations from 1,000 to 9,999, declined from 4,260 to 3,956, or seven percent. Facilities in the lowest interval, with populations from 0 to 999, declined from 5,631 to 5,121, or nine percent. The overall total number of RMP facilities dropped from 12,402 to 11,618, or six percent.

Figure 1. RMP Facilities by Vulnerability Zone Population Interval
Up-to-Date RMPs Only

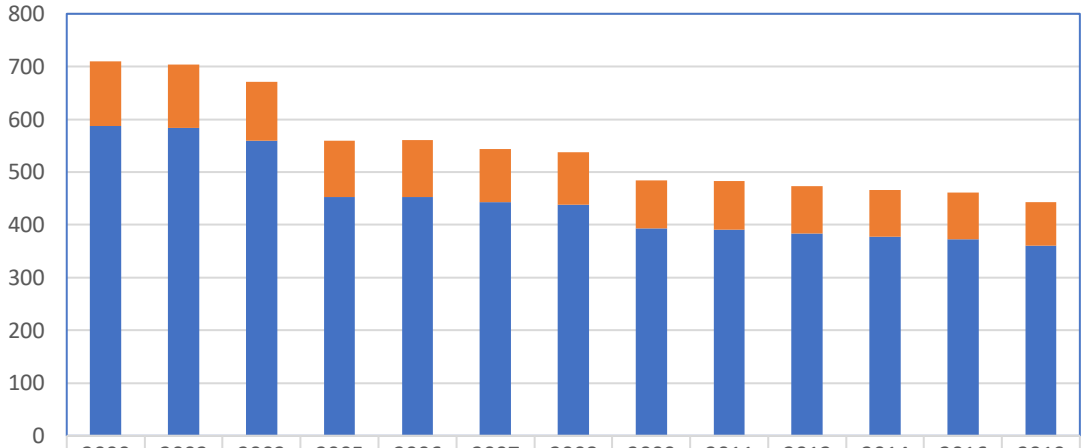


	May 2005	Mar 2006	Sep 2007	Feb 2008	Dec 2009	Apr 2011	Nov 2012	Dec 2014	Oct 2016	Dec 2019
1,000,000+	106	108	101	99	91	92	89	88	89	83
100,000-999,999	453	453	443	438	393	391	384	378	372	360
10,000-99,999	1,952	2,036	2,090	2,072	1,991	2,015	2,043	2,074	2,105	2,098
1,000-9,999	4,260	4,384	4,494	4,508	4,259	4,353	4,311	4,186	4,156	3,956
0-999	5,631	5,803	5,863	5,852	5,295	5,510	5,613	5,445	5,426	5,121

While covered facilities began submitting RMPs in 1999, the CRS analyses cited above date from 2005 or later.[2-11] Earlier analyses are available from the years 2000,[f] 2002,[12] and 2003;[13] however the underlying data differ slightly in format from the subsequent datasets.[g] Nonetheless, reasonable comparison is possible for the top two intervals. Using best available information, Figure 2 shows the number of facilities reporting 100,000 or more people at risk from the years 2000 to 2019. Over this longer period, facilities

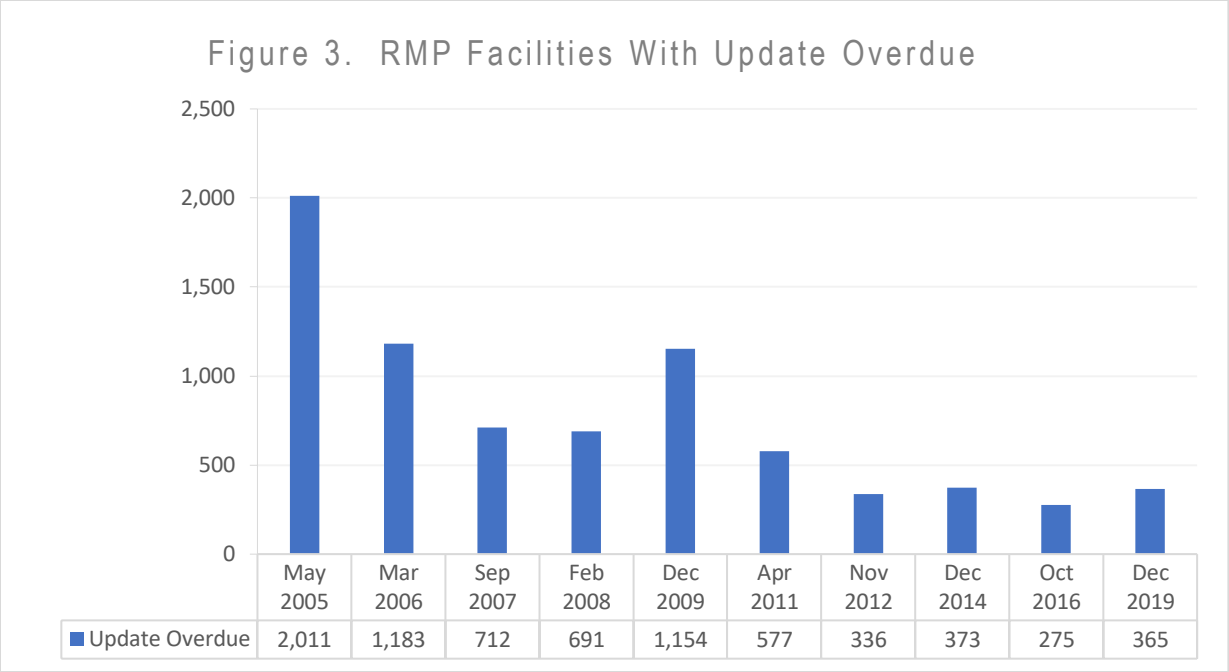
reporting more than 1 million residents at risk declined from 123 to 83, or 33 percent, and facilities reporting from 100,000 to 1,000,000 people declined from 587 to 360, or 39 percent.[2-13]

Figure 2. RMP Facilities With 100,000+ People in Vulnerability Zone
Up-to-Date RMPs Only



	2000	2002	2003	2005	2006	2007	2008	2009	2011	2012	2014	2016	2019
1,000,000+	123	120	111	106	108	101	99	91	92	89	88	89	83
100,000+	587	584	560	453	453	443	438	393	391	384	378	372	360

Covered facilities must update their RMPs at least every five years, or more frequently upon significant changes to processes on site. The RMP dataset therefore evolves over time as facilities are added, make changes, or drop out. Inevitably some facilities have overdue submissions. Figures 1 and 2 above include only facilities with RMPs that are up to date, not overdue. Figure 3 below presents the number of additional facilities with overdue RMP submissions.[h]



Safety changes or recalculations?

The figures discussed above suggest an apparent slow downward trend in the number of facilities in most intervals, especially the top populations at risk. However, the CRS analyses are not intended to ascertain whether actual safety changes occurred at any facility. Reductions in reported vulnerability zone populations may include facilities that recalculate scenarios, reduce inventories below reporting thresholds, or close, as discussed below. Anecdotal evidence suggests that some facilities dropped into the 10,000 to 99,999 interval by recalculating scenarios, but the broad CRS analyses do not by themselves permit such a determination.

Even at the rate of the most significant declines discussed above in just the top two intervals – 33 to 39 percent – it would take more than 50 years for the number of facilities to reach zero. When combining the top three intervals there is even a slight *increase* in the number of facilities. For all RMP facilities to remove potential off-site consequences would take more than 200 years - with no assurance that the numbers would not revert or even increase.

While some facilities are reducing or removing dangers through technological or operational changes (see below), other apparent reductions in vulnerability zone populations are recalculations. Much of RMP data is self-generated by facilities and EPA does not specify that facilities use any particular model to conduct the off-site

consequences analysis. A facility may change its analytical model or use different model input assumptions. For example, one commonly used method is an EPA analytical model called RMP*Comp. Simply changing the surrounding terrain assumption in RMP*Comp from rural to urban will reduce the vulnerability zone distance for 180,000 pounds of liquified chlorine gas (approximately a railcar amount) from 25 miles to 14 miles. The CRS analyses are not designed to account for such recalculations, nor do they document specific operational changes. EPA also does not substantiate and evaluate reported reductions. Without follow-up verification and analysis, apparent reductions may not reflect actual safety changes.

Missed opportunities

Unfortunately, EPA has not developed systems to routinely track hazard reduction and communicate lessons learned from chemical industry practices. The RMP program could better investigate and report adaptive solutions used by facilities, particularly when changes prevent hazards. Since 2004, EPA has required facilities that drop out of the program – or "deregister" – to indicate the reason for doing so. As of October 2016, some 1,998 deregistered RMP facilities reported no longer using any regulated substance, 1,888 had terminated operations, 1,215 reduced inventories below threshold quantities, 934 reported "other," and 1,470 left the query blank.[14] But EPA does not require and enable facilities to report that they have reduced hazards through the most effective strategies of safer design – minimization, substitution, moderation, or simplification – as a routine and integral part of the RMP deregistration form.

EPA's broad categories do not generally explain *how* the facility was able to deregister. In other words, the program does not generate and communicate essential information about the technological changes that some facilities may successfully use to reduce potential consequences of a chemical release. EPA has chosen not to include such reporting in its revisions to the program over the years. As a result, the program does not generate important public data on beneficial risk reduction practices.[i] While EPA could evaluate progress in reducing vulnerability zones under the RMP program, using the CRS method or additional measures, the agency has apparently not done so. Nor does EPA investigate what factors lead some facilities but not others to reduce hazards. As such, the RMP program is missing important opportunities to share knowledge and encourage transitions that protect workers and communities.

A similar situation exists under the Chemical Facilities Anti-Terrorism Standards (CFATS), a program of the Department of Homeland Security (DHS) that addresses intentional chemical releases and other acts of terrorism. About 4,000 CFATS facilities have dropped out of high-risk status by changing processes or chemical holdings.[15] However, DHS does not systematically derive and apply lessons learned from successful practices used when facilities reduce or remove chemicals that otherwise could become terrorist targets.

Generating solutions

Independent surveys of deregistered RMP facilities show a variety of resourceful strategies that some companies are already using to reduce dangers.[16, 17] Unlike add-on safety or security measures, which always add costs, hazard reduction strategies can sometimes improve facility operations and save money. Listed below are sample existing alternatives that remove catastrophic chemical release dangers across some 20 types of industry. Each option is understood to have other advantages and disadvantages that are identifiable through alternatives assessment.

- **Bleach manufacturers** eliminate bulk chlorine gas by generating chlorine as needed "just in time" on-site, eliminating transportation and storage vulnerabilities.
- **Petroleum refineries** avoid dangerous hydrofluoric acid alkylation by using less hazardous sulfuric acid; others are moving to ionic liquid or solid acid catalysts.
- **Water/wastewater utilities** eliminate bulk chlorine gas by using liquid chlorine bleach, ozone without storage, and ultraviolet light as appropriate.
- **Paper mills** eliminate bulk chlorine gas by using hydrogen peroxide, ozone, or chlorine dioxide without bulk storage.
- **Pool service companies** eliminate chlorine gas by using chlorine tabs or liquid bleach.
- **Manufacturers of polyurethane foams** eliminate bulk ethylene oxide by substituting vegetable-based polyols.
- **Soap and detergent manufacturers** eliminate bulk oleum and sulfur trioxide by using sulfur-burning equipment on-site.
- **Manufacturers of non-ionic surfactants** used in diverse consumer products avoid incoming bulk shipments of ethylene oxide through on-site production from bio-based ethanol.

- **Manufacturers of ferric chloride** eliminate bulk chlorine gas by processing scrap steel with less concentrated liquid hydrochloric acid (<37%) and oxygen.
- **Titanium dioxide producers** eliminate bulk chlorine gas by generating chlorine on-site as needed without storage, or by using the sulfate process.
- **Secondary aluminum smelters** eliminate bulk chlorine gas by removing impurities with nitrogen gas injected with magnesium salts.
- **Manufacturers of semiconductors, silicon wafers, and metal products** eliminate concentrated hydrofluoric acid by using less concentrated forms (<50%).
- **Power plants** eliminate bulk anhydrous ammonia gas by using cleaner combustion or by using aqueous ammonia or urea in pollution control equipment; they also remove chlorine gas by using liquid bleach to treat cooling water.
- **Refrigerated warehouses** reduce anhydrous ammonia gas through low charge ammonia refrigeration systems.
- **Wholesale chemical distributors** eliminate most bulk chlorine gas and sulfur dioxide gas by distributing alternatives such as liquid bleach and sodium bisulfite.
- **Pulp mills, food processors, wastewater plants, and hazardous waste recovery operations** eliminate bulk sulfur dioxide gas by, as appropriate, generating sulfur compounds on-site or purchasing sodium bisulfite, metabisulfite, hydrosulfite, or other alternatives.
- **Diverse manufacturers** eliminate bulk chlorine gas by generating chlorine on-site as needed without storage, such as for fuel additives, water treatment chemicals, and aramid polymers used to make bulletproof vests.

Where applicable, similar changes at other facilities could remove substantial hazards. For example, under the RMP program some 63 million Americans live within the vulnerability zone of one or more bleach manufacturers. Likewise, vulnerability zones around RMP petroleum refineries encompass 18 million residents; drinking water treatment 33 million; wastewater treatment 21 million; pulp and paper five million; electric power generation four million; and chemical manufacturing at least 79 million.[1p33]

Conclusion and recommendations

Given the scope of danger, evaluating progress in reducing the potential consequences of worst-case chemical releases is important to public health, safety, and security. Analyses from CRS suggest that some facilities may be reducing hazards and independent surveys identify methods companies sometimes use. However, while safety

changes are certain in several respects, the extent of overall improvement is unverified. EPA does not document progress in reducing populations at risk, derive lessons learned from industry practices, share proven hazard reduction measures, or obligate facilities to assess and utilize practical alternatives.

Solutions data could make a meaningful contribution to the reduction in catastrophic chemical release potentials. EPA should collect hazard reduction information as RMP facilities deregister, compile these adaptive strategies over time into an ever more thorough data source, and incorporate the findings into RMP plans and programs. By routinely collecting and disseminating information on beneficial risk reduction practices the RMP program could generate practical opportunities to protect workers, emergency responders, and communities.

Notes

a. Not all residents within the vulnerability zone would ordinarily be affected by any specific chemical release. At the same time, the figures do not include employees or additional people who may be in schools, hospitals, parks, playgrounds, or commercial, office, or industrial areas.
b. Communities of interest broadly include residents, employees, contractors, labor representatives, emergency planners, first responders, state and local officials, technology vendors, insurers, lenders, investors, owners and operators, educators, chemical safety researchers, professional engineers, news media, public interest organizations concerned with social justice, health, and environment, and other parties with a stake in preventing chemical spills and emergencies.
c. While RMP hazard assessments include 5-year histories for serious incidents involving RMP-regulated chemicals, these histories cannot be used to reliably predict rare catastrophic releases, whether intentional or unintentional.
d. Congressional requestors include Edward Markey (2005, 2006, 2007, 2008, 2009, 2014), Frank Lautenberg (2011, 2012), and the House Committee on Homeland Security (2016, 2019).
e. The underlying data are not published as a national data set under the terms of the Chemical Safety Information, Site Security and Fuels Regulatory Relief Act.
f. Figures from the year 2000 are population interval totals accompanying "Chemical accident risks in U.S. industry – A preliminary analysis of accident risk data from U.S. hazardous chemical facilities" by James C. Belke, U.S. Environmental Protection Agency, September 25, 2000 (population interval totals requested from EPA in 2001).
g. The earlier data separate vulnerability zones involving toxic and flammable chemicals, while the later analyses combine them to remove any double counting of facilities. The earlier data also use slightly different intervals, for example 1,001 to 10,000 vs. 1,000 to 9,999. Nonetheless, very few facilities report vulnerability zones with 100,000 or more people at risk for flammable chemicals, which enables reasonable comparison of the top two intervals.
h. Figures from earlier years reflect a greater number of facilities that had filed RMPs for flammable fuels before being exempted by the Chemical Safety Information, Site Security and Fuels Regulatory Relief Act. Over time such facilities have largely deregistered or been marked as administratively closed by EPA.
i It should be noted that existing RMP criteria protect confidential business information (CBI). Only a tiny percentage of RMP submittals have asserted CBI.

References

1. Orum P, Moore R, Roberts M, et al. Who's in Danger? Race, Poverty, and Chemical Disasters. *Environmental Justice and Health Alliance for Chemical Policy Reform*, May 2014.
2. Congressional Research Service. *RMP Facilities in the United States as of May 2005.* Memorandum to the Honorable Edward Markey. 2005.
3. Congressional Research Service. *RMP Facilities in the United States as of March 2006 – Update.* Memorandum to the Honorable Edward Markey. 2006.
4. Congressional Research Service. *RMP Facilities in the United States as of September 2007.* Memorandum to the Honorable Edward Markey. 2007.
5. Congressional Research Service. *RMP Facilities in the United States as of February 2008.* Memorandum to the Honorable Edward Markey. 2008.
6. Congressional Research Service. *RMP Facilities in the United States as of December 2009.* Memorandum to the Honorable Edward Markey. 2009.
7. Congressional Research Service. *RMP Facilities in the United States as of April 2011.* Memorandum to Senator Frank R. Lautenberg. 2011.
8. Congressional Research Service. *RMP Facilities in the United States as of November 2012.* Memorandum to Senator Frank R. Lautenberg. 2012.
9. Congressional Research Service. *RMP Facilities in the United States as of December 2014.* Memorandum to Senator Edward J. Markey. 2014.
10. Congressional Research Service. *RMP Facilities in the United States as of October 2016.* Memorandum to the House Committee on Homeland Security, Subcommittee on Cybersecurity, Infrastructure Protection, and Security Technologies. 2016.
11. Congressional Research Service. *RMP Facilities in the United States as of December 2019.* Memorandum to the House Committee on Homeland Security. 2020.
12. Congressional Research Service. *RMP facilities with toxic WCS residential populations in indicated ranges.* Unspecified Congressional requestor. 2002.
13. Congressional Research Service. *Facilities with RMP toxic WCS residential populations in indicated ranges.* Unspecified Congressional requestor. 2003.
14. Congressional Research Service. *Distribution of Reasons for Deregistered RMP Facilities.* Memorandum to House Committee on Homeland Security, Subcommittee on Cybersecurity, Infrastructure Protection, and Security Technologies. 2016.
15. The Chemical Facility Anti-Terrorism Standards Program (CFATS). *A Progress Report: Hearing Before the Subcomm. on Environment of the House Comm. on Energy and Commerce*. Testimony of David Wulf, Department of Homeland Security. 115th Cong., 2nd Session, June 14, 2018.
16. Orum P. Preventing Toxic Terrorism, April 2006; Toxic Trains and the Terrorist Threat, April 2007; Chemical Security 101, November 2008. Center for American Progress.
17. Orum P. Leading Water Utilities Reduce Their Hazards, Center for American Progress, March 2010.