Carbon Monoxide Incidents: A Review of the Data Landscape
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New requirements for the installation of CO detection into several types of occupancies (both new and existing occupancies) are being addressed in the latest editions of NFPA 101 Life Safety Code® and NFPA 5000, Building Construction and Safety Code®. This project seeks to collect and summarize data available for non-fire CO incidents, specifically for commercial-type occupancies from a variety of sources. The research sought to identify the characteristics of the data on CO incidents currently collected by organizations. Then, using data from the sources deemed to be the most useful, identify and evaluate the factors that contributed to the non-fire CO incidents.

Data on CO incidents was found in eight databases. Organizations managing these databases included the Center for Disease Control and Prevention (CDC), Consumer Product Safety Commission (CPSC), Institute of Health Metrics and Evaluation (IHME), National Highway Traffic Safety Administration (NHTSA), National Transportation Safety Board (NTSB), Occupational Safety and Health Administration (OSHA), United States Fire Administration (USFA) and Jenkins Foundation. The review of these databases resulted in the observation that those by CPSC, OSHA, USFA and the Jenkins Foundation provided the most comprehensive information (within their noted scope) and their databases were the most accessible.

The CPSC compiles information on incidents involving safety hazards caused by consumer products. The CPSC NEISS On-Line Query System can be used to access incidents that meet particular criteria. This system sorts the database of CPSC incidents, and compile a list of incidents that contain the particular tags in the query.

A total of 2,226 incidents were identified between 2011 and 2020 using the NEISS database. A total of 1,840 incidents in the CPSC database (or approximately 82% of the total evaluated) occurred in “homes”, i.e. apartments or single-family homes. This high proportion is expected given that more consumer product related incidents will occur in residential occupancies where consumer products are routinely utilized. All new residential occupancies are required to have CO detection under both NFPA and ICC requirements. Approximately 3.7% of incidents occurred where CO detectors would not be required (except for New Assembly under NFPA). These incidents include bars, restaurants, sport arenas, garages, pharmacies, water restoration facilities, parking lots, jail, churches, gyms, dinner halls, and hookah bars. The remaining 9.5% occurred in unknown or otherwise unrecorded occupancies.

The CPSC dataset does not comprehensively identify if CO alarms were present and if present where they were located to assess compliance with current code requirements. Additionally, the extent of the injury cannot be surmised from the CPSC data. The database does not allow a comparison of the number and severity of injuries that resulted when an alarm was present versus when an alarm was not present. Unfortunately, the CPSC data set is not detailed enough to determine if current requirements for CO detector placement are sufficient.
The NFIRS data was prepared for analysis by filtering the “basicincident” dataset that is included in NFIRS’ Basic Module. The filtering was done to include only the 424 incident type (the code for non-fire CO incidents) and excluded any incidents where nothing else was entered. The data was also filtered to exclude the 400 and 419 property use codes, corresponding to “Residential, other” and “1 or 2 family dwellings,” respectively, because these property use codes were outside the scope of this analysis.

In total, there were 678,265 Carbon Monoxide incidents from 2011-2020. Of these, 199,473 (29.4%) incidents occurred in commercial occupancies, 468,901 (69.1%) incidents occurred in residential occupancies (i.e. single-family dwellings), and 13,966 (2%) incidents occurred in commercial/residential mixed-use occupancies. Of the commercial occupancies, the three leading property uses were restaurant or cafeteria (3,686 incidents, 0.5%) hotel/motel (3,140 incidents, 0.5%) and mercantile/business/other (3,125 incidents, 0.5%).

In the NFIRS database, the mercantile and business office occupancies included the greatest proportion of incidents with casualties. However, because injury and fatality data is rarely entered into NFIRS for non-fire CO incidents, these values are not reliable indicators of in-the-field experience. In those incidents with casualties in mercantile occupancies, business offices and “manufacturing, processing” occupancies, it is noteworthy that CO detectors are not required in any of these occupancies. The only occupancy type where a death/injury occurred where a CO detector was required was a hotel/motel.

One major limitation of the NFIRS database is that many of the fields that would be helpful to this analysis are not required to be completed by responders for CO incidents. A prime example of this is the “detector alerted occupants” field within the Basic Module, which is allowed to be left blank for non-fire incidents. Thus, only a small fraction of the incidents included in this analysis have this field completed. Additionally, the NFIRS HazMat Module includes fields more relevant to CO incidents than the Basic Module (i.e. equipment involved in release and civilian casualties), but this entire module is optional for responders to complete. Therefore, NFIRS has limited value for the analysis of analyzing CO incidents in commercial occupancies.

A total of 130 non-fire CO incidents were located in the OSHA database between 2011 to 2020. Incidents occurred in a wide variety of occupancies, with 115 incidents occurring in commercial occupancy types. The IBC occupancy type with the greatest proportion of incidents was Factory/Industrial (F-1) at 24%. The second most frequent occupancy was Business (B) at approximately 16%.

The most common contributing factor in non-residential occupancies was limited ventilation of the work area (39%). These cases predominantly involved renovation or construction activities. Maintenance and product misuse were the next two most commonly cited contributing factors (15% and 10% respectively). For the 11 incidents where the injured or deceased occupant was found in a different room, in seven of these incidents, “maintenance” was a contributing factor. In these cases, the source was a boiler, heat exchanger or water heater.

There were 46 deaths and 242 total injuries reported in the OSHA database from exposure to CO in non-fire incidents in non-residential occupancies (i.e. all of the incidents included in the
database minus those in multi-family residences). In 43 of the 115 cases in non-residential occupancies (37% of the incidents), there was at least one reported death. In three cases, there were two deaths. There was at least one reported injury in 69% of the incidents. The maximum number of injuries in any one incident was 37.

The two most common occupancies noted in the OSHA database experiencing a CO incident were Factory/Industrial (24%) and Business (16%). The limitations of the database should be taken into considerations in that more workplace related incidents are likely to occur in Business and Industrial occupancies than Residential occupancies. Under both the IBC and NFPA, CO detectors are not required in Factory/Industrial or Business occupancies. Based upon the OSHA data, it can be concluded that CO incidents occur in commercial occupancies and these occupancy types are not required to have CO detection. The extent of injuries that result from these CO incidents, however, cannot be surmised from the information provided in the database.

The database compiled by the Jenkins Foundation includes 164 incidents that occurred in hotels between January 2011 and March 2022. In 12 of those incidents, there were a total of 23 deaths, and in 96 incidents, there were a total of 671 injuries. Pool heaters, water heaters, and boilers were the leading known sources for CO in the incidents. The Jenkins Foundation dataset clearly shows a high number of occurrences of CO related incidents in hotels and motels. Both new and existing hotels are required to have CO detections per NFPA and ICC requirements. However, it is recognized that a jurisdiction must adopt, in full, the requirements set forth in the newest editions of these code before requirements take affect in new or existing structures.

Overall, it was found that databases hosting CO incident information did not provide a sufficient level of detail to fully understand the CO exposure problem in the U.S. Of the databases that capture information on occupancy type, NFIRS is the only database that includes incidents occurring in a wide range of occupancies. Because it is consumer product centric, CPSC is biased towards residential incidents, and OSHA, because it is workplace-related, is biased towards commercial occupancies. As such, neither of these two databases offer a balanced view.

While all databases show that incidents are occurring in commercial occupancies, and many of these occupancies are not currently required to have detection, these limited databases do not allow for a national-level appreciation of non-fire CO incident occurrences or frequencies. Moreover, the limited datasets do not provide a comprehensive view of injuries and deaths resulting from CO exposure correlated by occupancy type. Therefore, the frequency of injuries occurring in all types of commercial occupancies is unknown; this is a critical piece of information needed to determine if current requirements for CO detection are adequate. Moreover, there is no database which details the location of the victim relative to the CO source. As such, there is no way to determine, using these databases alone, if current CO detection placement criteria, e.g., detector in space with CO source, is adequate.