IMC 2018 Changes Affecting Parking Garage Exhaust Systems Implementation

Rev 1.0

1 **Introduction** 3

2 **Mechanical Code Expert Authority – *The International Code Council*** 3

3 **Local Code Adoption Process** 4

4 **Variances** 4

5 **Tracking the IMC Evolution** 5
- 5.1 2003 International Mechanical Code 5
- 5.2 2006 International Mechanical Code 5
- 5.3 2009 International Mechanical Code 6
- 5.4 2012 International Mechanical Code 6
- 5.5 2015 International Mechanical Code 7
- 5.6 2018 International Mechanical Code 8

6 **IMC Summary 2003 – 2018** 9

7 **Energy Cost & Greenhouse Savings and Return on Investment** 9

8 **References** 10

1 Introduction

In the 2015 IMC update, carbon monoxide (CO) and nitrogen dioxide (NO_2) sensor-based control of the ventilation equipment in enclosed parking garages officially became the only alternative to running the fans at full speed all the time. The 2018 code continues to move best practices forward with respect to both energy efficiency and human safety. Before looking specifically at the latest code changes, we need to understand who develops the code and why it is important. Once we establish the proper perspective on the IMC authors, we need to look at adoption of these codes locally. Although the code is changing, it does not mean that any individual local authority will adopt it right away or at all. Due to the wide array of mechanical codes nationally, we will take a chronological look at the evolution of the code and its effect on parking garage design and operations.

Although this document will conclude with the IMC 2018 code changes, it should be noted that in Europe, mitigation of CO and NO_2 in parking garages and tunnels is now a life-safety application and the sensors and controls are being held to strict international standards of performance and reliability (EN50545-1). Similarly, since 2013, the California Title 24 Building Efficiency Code has had very specific language requiring energy efficiency and self-monitoring reliability. With the 2018 International Mechanical Code update, the US market is starting to move in that same direction.

2 Mechanical Code Expert Authority – *The International Code Council*

The International Mechanical Code (IMC) is developed by the International Code Council (ICC). "The International Code Council (ICC) was established in 1994 as a non-profit organization dedicated to developing a single set of comprehensive and coordinated national model construction codes. The founders of the ICC are Building Officials and Code Administrators International, Inc. (BOCA), International Conference of Building Officials (ICBO), and Southern Building Code Congress International, Inc. (SBCCI). Since the early part of the last century, these non-profit organizations developed three separate sets of model codes used throughout the United States. Although regional code development has been effective and responsive to our country's needs, the time came for a single set of codes. The nation's three model code groups responded by creating the International Code Council and by developing codes without regional limitations; the International Codes" (ICCsafe.org). Consequently, the International Mechanical Code is widely accepted as the authority defining industry "best practices."

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3 Local Code Adoption Process

While the ICC develops comprehensive construction codes, it is up to each local municipality (Authority Having Jurisdiction or AHJ) to adopt, enact and ultimately administer them locally. The burden of administrating each code is quite a formidable task. Significant resources are expended on inspectors, plan reviewers and support staff. Unfortunately the process of reworking the local codes to incorporate recommended changes set forth by the ICC is a burden added to departments that are typically stretched thin. The proposed changes must be reviewed and their applicability to the local markets must be evaluated. If the proposed changes to the code are deemed warranted by the city managers, the proposed changes are typically brought to the city council for a vote. If approved, the changes will be written into the local code after training is developed and executed to ensure city code enforcers and plan reviewers are aware of the impact of the changes. This is quite a burdensome process and it exhausts significant resources in its execution. The proposed changes must be seen by the local officials as a value added proposition as they weigh the time and effort of implementing these changes. It is no wonder why some cities are using code developed in the year 2000.

4 Variances

The resultant lag in code adoption at the municipality level places the burden of liability on any engineer wishing to incorporate newer code features into their design. While each engineer is required to add his seal of approval on all project drawings, it stands to reason why some would prefer to relent to the status quo vice push for the implementation of new standards due to the risk of liability. A variance can be issued if there is sufficient documentation validating the need for the change but each municipality will hold the project documents on file. If an event occurs that would have been covered by the code circumvented by a variance, the liability for this event falls to the engineer of record.

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5 Tracking the IMC Evolution

The following excerpts are from the 2003-2018 IMC's. Section 404 titled "Enclosed Parking Garages" is the only relevant section to this discussion. The bulleted points are commentary inserted for clarification purposes and are designed to simplify the specific portions of the code applicable to gas detection and ventilation rates.

5.1 2003 International Mechanical Code

*"**404.1 Enclosed Parking Garages**. Mechanical ventilation systems for enclosed parking garages are not required to operate continuously where the system is arranged to operate automatically upon detection of a concentration of carbon monoxide of 25 parts per million by approved automatic detection devices." (IMC, 2003)*

- CO detection with a set point of 25 ppm is specifically called out as a means to modulate fans.

*"**404.2 Minimum ventilation**. Automatic operation of the system shall not reduce the ventilation rate below 0.05 cfm per square foot (0.00025 m3/s × m2) of the floor area and the system shall be capable of producing a ventilation rate of 1.5 cfm per square foot (0.0076 m3/s × m2) of floor area." (IMC, 2003)*

- Minimum ventilation rate of 0.05 cfm per square foot required.
- System must be capable of 1.5 cfm per square foot at full speed.

> **The "net green impact" here is a +5 in a scale of -5 to +5 since it allows us to scale back exhaust fans when toxic gas levels are safe.**

5.2 2006 International Mechanical Code

- This iteration removed the specific provision for Carbon Monoxide.

*"**404.1 Enclosed Parking Garages**. Mechanical ventilation systems for enclosed parking garages shall be permitted to operate intermittently where the system is arranged to operate automatically upon detection of vehicle operation or the presence of occupants by approved automatic detection devices." (IMC, 2006)*

- The insinuation inherent here is that the system would be controlled using motion sensors.
- Some local officials such as the City of Dallas interprets this to mean that if carbon monoxide detection is engineered into the job and the detectors are on the prints that are approved by the city, then this becomes an "approved detection device".
- No guidance is given to determine set-points, it is up to the engineer of record and he is held liable if there is a problem.

> **The "net green impact" here is a -5 in a scale of -5 to +5 since it removed the provision for gas detection as a means to allow us to scale back exhaust fans when toxic gas levels are safe. The "motion sensor" application was never widely accepted nationally as an acceptable means to modulate exhaust fans.**

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5.3 2009 International Mechanical Code

- Did not change section 404.1.

*"**404.2 Minimum ventilation.** Automatic operation of the system shall not reduce the ventilation rate below 0.05 cfm per square foot (0.00025 m3/s × m2) of the floor area and the system shall be capable of producing a ventilation rate of 0.75 cfm per square foot (0.0076 m3/s × m2) of floor area." (IMC, 2009)*

- 2009 reduced the required system capability in half. It went from 1.5 cfm per square foot to 0.75 cfm per square foot. This is substantial since it allows engineers to decrease the size of the exhaust fans and saves cost of ownership to garage owners.

The "net green impact" here is a +2 in a scale of -5 to +5 since it allowed designers to decrease the size of fan systems which ultimately saves energy and decreases costs to building owners in both initial construction and ongoing operations.

5.4 2012/2013 International Mechanical Code

- The Mechanical Code Committee of the International Code Council approved CO/NO_2 detection as an alternative to motion detection for fan control. A code supplement will be published in 2013 with the accepted changes.

*"**404.1 Enclosed parking garages**. Mechanical ventilation systems for enclosed parking garages shall be permitted to operate intermittently in accordance with Item 1, Item 2, or both, where*

1. The system is shall be arranged to operate automatically upon detection of vehicle operation or the presence of occupants by approved automatic detection devices.

2. The system shall be arranged to operate automatically by means of carbon monoxide detectors applied in conjunction with nitrogen dioxide detectors. Such detectors shall be installed in accordance with their manufacturers' recommendations.

***Reason:** Our experience on the last several projects is that the operation of motion sensors in parking garages is very costly and energy inefficient. Initially the code just required carbon monoxide detectors and there was a concern about diesel emissions that could not be detected by the carbon monoxide detectors. Since that time, nitrogen dioxide detectors have been developed which will detect diesel emissions solving the concern about the increase of diesel powered vehicles in parking garages. Using both detectors has been the preferred option as an alternate method of addressing the problem.*

***Cost Impact**: Less overall expenses in power bills." (ICCsafe.org, 2010)*

- This change is significant. For the first time ever, nitrogen dioxide in addition to carbon monoxide detection is called out specifically as a proper means to operate parking garage ventilation systems automatically. The resultant system infrastructure provides superior protection against toxic gas buildup in enclosed parking structures while reducing energy consumption.

The "net green impact" here is a +5 in a scale of -5 to +5 since it couples CO detection with NO_2 detection to allow us to scale back exhaust fans when toxic gas levels are safe.

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5.5 2015 International Mechanical Code

- The following excerpt is listed under M54-12 in the Tentative Order of Discussion for the Mechanical Code Committee of the International Code Council. It was advocated by Don Davies, Salt Lake City Corp/Salt Lake City County representing Utah Chapter of ICC, Brent Ursenbach, Utah Chapter of ICC, and Donald R. Monahan, P.E., Walker Parking Consultants/ Engineers, Inc. Representing the Parking Consultants Council of the National Parking Association.

*"**404.1 Enclosed parking garages**. Where mechanical ventilation systems for enclosed parking garages operate intermittently, such operation shall be automatic by means of carbon monoxide detectors applied in conjunction with nitrogen dioxide detectors. Such detectors shall be installed in accordance with their manufacturers' recommendations.*

Reason: *Enclosed parking garages require mechanical ventilation to safeguard the building occupants from emissions of high levels of carbon monoxide (CO) by cars and/or nitrogen dioxide (NO_2) from diesel engines. In most enclosed parking garages, the operation of the ventilation system consumes the major portion of the total energy use of the facility. Reducing the energy use for ventilation while maintaining adequate indoor air quality can be achieved using demand ventilation control strategies. However, permitting motion detectors to operate the ventilation system does not promote energy efficiency and will not provide optimum life safety protection for the following reasons:*

- *The mechanical ventilation system will run unnecessarily every time a vehicle or person moves even though the CO or NO_2 concentrations are within the safe indoor air quality levels.*
- *Dangerous levels of CO and/or NO_2 from an idling vehicle will go undetected by motion detectors.*

Whereas the mechanical ventilation system will only run when toxic gases present a threat to the safety of people, which is the most important purpose of a ventilation system. The revision to the main section simply gets rid of permissive language.

Cost Impact*: There will be significant savings in energy cost with approval of this proposal as follows: Consider a 100,000 sf underground parking structure for about 350 parking spaces with a combined horsepower of all fans of approximately 75 HP. 75 HP X 746 watts per HP = 55,950 watts or 55.95 kilowatts. Annual fan power consumption without gas detection = 12 hours per day X 365 days per year X 55.95 kW = 245,061 kWh. With gas detection demand control = 2 hours per day X 365 days X 55.95 kilowatts = 40,844 kWh. The annual savings is 204,217 kWh. At a U.S. average electric utility rate of $0.10 per kWh, the annual cost savings is $20,422.*
(Source: "Demand Controlled Ventilation Cuts Energy Bills, Increases Patron Comfort", Parking Magazine by National Parking Association, March 2011.) In the 2000 ASHRAE Transactions, the paper "Evaluation of Design Ventilation Requirements for Enclosed Parking Facilities" by Ayari and Krarti indicated an energy savings of 17 to 46% with demand control ventilation strategies."

The code committee stated the following reason for approval: "Approval is based upon the proponent's published reason. This proposal improves life safety. Such detectors are reliable. Motor vehicles could continue to operate without moving to actuate a motion detector."

- This change makes continuous monitoring of carbon monoxide *and* nitrogen dioxide the only method of implementing demand controlled ventilation.

The "net green impact" here is a +5 in a scale of -5 to +5 since the change eliminates an ineffective means of controlling ventilation systems (motion) leaving only highly energy-efficient and field-proven CO and NO_2 monitoring.

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5.6 2018 International Mechanical Code

*"**404.1 Enclosed Parking Garages**. Mechanical ventilation systems for enclosed parking garages shall operate continuously or shall be automatically operated by means of carbon monoxide detectors applied in conjunction with nitrogen dioxide sensors. Such detectors shall be listed in accordance with UL 2075 and installed in accordance with their listing and the manufacturers' instructions. Automatic operation shall cycle the ventilation system between the following two modes of operation:*

1. Full-on at an airflow rate of not less than 0.75 cfm per square foot of the floor area served.

2. Standby at an airflow rate of not less than 0.05 cfm per square foot pf the floor area served."

In 2015 the code specifically identified CO and NO_2 sensors as the only alternative to running the ventilation equipment at its full design flowrate at all times. The 2018 code includes an energy efficient alternative whereby the equipment runs at a very low baseline flowrate at all times but is increased to 100% design airflow in response to the presence of significant CO or NO_2 gas. Although the code defines the baseline and full airflow rates, it does not define the thresholds (parts per million) at which the airflow must be increased. Typically, those thresholds are set at 25 ppm CO and 2 ppm NO_2 although local codes may require the control points to be higher or lower.

The 2018 code also include for the first time a requirement that the sensors be tested by an independent lab to a relevant UL standard. In many parts of the world, the mitigation of toxic gas in parking garages and tunnels is considered a life safety application and consequently the sensors and controllers deployed are required to be third-party certified to rigorous performance and reliability standards (see European Norm EN50545-1). By requiring UL 2075 listing, the International Mechanical Code has taken a step in that same direction for the US market (UL 2075: Standard for Gas and Vapor Detectors and Sensors).

The "net green impact" of this change is another +5 on a scale of -5 to +5 since the addition of the low airflow baseline and sensor-based switch to full airflow delivers substantial energy savings without compromising human safety.

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6 IMC Summary 2003 – 2018

- **IMC 2003** specifically called out carbon monoxide detection as a valid means to modulate exhaust fans to keep inhabitants safe while conserving energy.
- **IMC 2006** removed the provision identifying CO detection and replaced it with verbiage relating to the use of motion sensors to detect pedestrians or the operation of vehicles.
- **IMC 2009** decreased the required ventilation capacity from 1.5 cfm per square to 0.75 cfm per square foot.
- **IMC 2012** adds CO coupled with NO_2 detection as a viable demand based exhaust ventilation control strategy for enclosed parking structures.
- **IMC 2015** removes motion sensors leaving continuous monitoring of CO and NO_2 as the only valid alternative to 7/24/365 fan operation at full speed.
- **IMC 2018** maintains CO and NO_2 sensing as the only alternative to 7/24/365 full speed fan operation but adds a highly energy efficient baseline airflow rate. In addition, the gas sensors are required to be listed to a specific UL standard.

7 Energy Cost & Greenhouse Savings and Return on Investment

The table below illustrates the carbon impact of demand control exhaust ventilation on a typical 350-space parking garage.

<table>
<tr><td colspan="4">Underground Garage/Parking Structure of an Office Building
- 100,000 sq ft for about 350 parking spaces for automobiles
- Approximately total 75 HP (Horsepower), combined of all fans
- 12 hours/day and 7 days/week garage operation</td></tr>
<tr><td colspan="4">HP (Horsepower) to Watts (Electrical Power) Conversion
(In this example the fan motor efficiency and load factor canceling out each other)
75 HP x 746 Watts/HP = 55,950 Watts divided by 1,000 = <u>55.95 kWatts</u></td></tr>
<tr><td rowspan="2">Annual Fan Power Consumption (kWh)</td><td colspan="3">Without Gas Detection Demand Control
12 hours/day x 365 days x 55.95 kWatts = <u>245,061 kWh</u></td></tr>
<tr><td colspan="3">With Gas Detection Demand Control
2 hours/day x 365 days x 55.95 kWatts = <u>40,844 kWh</u></td></tr>
<tr><td>Annual Savings</td><td colspan="2">kWh Savings per Year:
No Demand Control 245,061 kWh
<u>Demand Control - 40,844 kWh</u>
<u>Savings = 204,217 kWh</u></td><td>Electricity Cost Savings per Year:
204,217 kWh
<u>x $ 0.175 per 1 kWh</u>
<u>Savings = $ 35,738</u></td></tr>
<tr><td rowspan="2">- Installation Cost -
Return of Investment</td><td>With Utility Rebate</td><td colspan="2"><u>Immediate</u> to <u>0.5 Year</u></td></tr>
<tr><td>(No Rebate)</td><td colspan="2"><u>0.8</u> to <u>1.5 Year</u></td></tr>
<tr><td>Greenhouse Savings</td><td colspan="3">273,651 lb CO</td></tr>
</table>

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