

Application Note 1045: Mitsubishi Electric M&P UL60335-2-40 Ed. 4 A2L Compliance Overview

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1. Introduction

The purpose of this document is to explain the assumptions underlying the calculations in Mitsubishi Electric's manuals and allow the designer of record to understand how they can consider adjusting their calculations and/or assumptions for local code compliance. The guidelines expressed in Mitsubishi Electric's manuals are the only guidelines supported by Mitsubishi Electric and METUS. If electing to deviate from the guidelines expressed in Mitsubishi Electric's manuals then Mitsubishi Electric and METUS are not responsible for any issues that may occur. It is the responsibility of the designer of record to prove compliance with local and federal codes.

With the introduction of A2L, slightly flammable refrigerants, numerous code updates were required to safely design and apply equipment for direct expansion systems given the proximity of these refrigerants to occupied spaces. This included updates to ANSI/ASHRAE Standard 34, ANSI/ASHRAE Standard 15 & 15.2, UL and IMC/UMC. As the equipment manufacturer, Mitsubishi Electric's responsibility is to meet the product safety standard to ensure that the products sold into the market are designed in a manner that is consistent with the guidelines of UL, specifically UL60335-2-40 Ed. 4.

Mitsubishi Electric Corporation (MELCO) performs risk assessment, in addition to complying with the requirements of UL60335-2-40 Ed. 4, which includes modeling scenarios outside of normal operating conditions. In some cases MELCO implemented additional restrictions beyond the minimum requirements of UL60335-2-40 Ed. 4 to minimize risk as much as possible. **For simplicity, these areas are written in red in this document to more easily identify areas where MELCO is more conservative than UL60335-2-40 Ed. 4.**

The primary point of contention among the field is that historically UL has defined how to safely design the equipment and ANSI/ASHRAE 15 has defined how to apply the equipment with IMC/UMC defining elements related to installation of the equipment. IMC/UMC typically adopts a version of ANSI/ASHRAE 15 either verbatim or with modifications. Given the transition to A2L refrigerants because of the EPA's Technology Transition rule, the UL standard has adopted prescriptive guidance for how the systems should be applied which is a departure from how the codes were historically divided. Furthermore, the guidance for application safety standards are not aligned between the codes which causes further frustration in the field.

It's important to note that the guidance found within Mitsubishi Electric installation, service and/or technical manuals was derived to comply with UL60335-2-40 Ed. 4 requirements. The code requirements of either the local jurisdiction or federal jurisdiction may vary and it's the burden of the party responsible to ensure compliance with these standards.

2. Overview of Assumptions

A2L Charge Limits for Mitigation

UL60335-2-40 Ed. 4 Annex GG defines that refrigerant charge and room size must be considered as part of the installation for any case where m_c (system charge) is above m_1 where m_1 is defined as 6 x LFL. This is defined in the following equations:

$$m_c \leq m_1 \rightarrow \text{No room size restriction}$$

$$R454B \text{ LFL} = 0.296 \text{ kg/m}^3$$

$$m_1 = 6 \times \text{LFL} = 6 \times 0.296 \text{ kg} = 1.776 \text{ kg (3.92 lbs)}$$

Theoretically if the system charge (base charge + additional field charge) is below 3.92lbs then there is no room size restriction and the system is compliant without further considerations.

Mitsubishi Electric requires a room size restriction even on systems with less than 3.92lbs to ensure that risk is minimized.

Minimum IDU Installation Heights

Annex GG.2 provides reference installation heights that serve as minimum installation heights for manufacturers' indoor units.

Floor Mounted (MFZ): No higher than 5-7/8in (150mm)

Wall Mounted (MSZ/PKA/PKFY): 5.9ft (1.8m)

One Way Cassette (MLZ): 7.2ft (2.2m)

Four Way Cassette (SLZ/PLFY-NFMU): **8.2ft (2.5m)**

Four Way Cassette (PLA/PLFY-NEMU): **8.2ft (2.5m)**

Ceiling Suspended (PCA/PCFY): **8.2ft (2.5m)**

Ceiling Concealed Ducted (PEAD/PEFY): **8.2ft (2.5m)**

Multi-Position AHU & A-Coil (SVZ/PVA/PAA/PVFY): Varies depending on installation site

These minimums are noted in the installation manuals and labeled on the indoor unit. Mitsubishi Electric does not endorse installations that are below these limits.

Room Volume vs. Refrigerant System Charge Calculations

As noted in the previous section there are minimum installation heights required by UL which act as the primary input in determining minimum room area requirements. While these are installation heights they act as release height in regard to the point at which the refrigerant would enter the room in the event of a leak. **Mitsubishi Electric keeps the release height constant at 5.9ft (1.8m) for all indoor units** where the result is a consistent room area vs. refrigerant charge relationship (releasable charge, or MRel, in the case of MXZ-SM).

$$A_{min} = \frac{m_c}{CF \times LFL \times H_r} = \text{required room area in } m^2$$

m_c = total system refrigerant charge (kg)

CF = concentration factor of 0.50

$R454B \text{ LFL} = 0.296 \text{ kg}/m^3$

H_r = release height in m

$$A_{min} = \frac{m_c}{0.5 \times 0.296 \times 1.8} = \frac{m_c}{0.27}$$

If the actual installation height is higher than 5.9ft (1.8m) then the release height in the equation could theoretically be increased and as a result, the required room area reduced.

Natural Ventilation to Increase Room Area

The room areas listed in the installation manuals don't address whether the space is connected or unconnected to any adjacent space. This point is left vague given that the direction for connecting spaces via natural ventilation will vary based on the local code. In the case of UL60335-2-40 Ed. 4, natural ventilation can be used to connect adjacent rooms as part of the minimum volume assuming the following:

- The rooms are on the same floor
- The rooms are connected by two permanent openings that cannot be closed
- The lower permanent opening is below 11-13/16in (300mm) from the floor
 - **At least 50% of the total A_{nv} is below 7-7/8in (200mm) from the floor**
- Openings that extend to the floor must have a minimum height above the top of the floor or floor covering (e.g. tile surface or carpet pile) of 13/16in (20mm)
- The higher permanent opening should have an area of **at least 50% of the total A_{nv} and be above 4ft-11-1/4in (1.5m)**
 - The requirements of this second opening can be met by drop ceilings, ventilation ducts or other scenarios that allow for an airflow pathway between the spaces
- Example of natural ventilation scenarios include but are not limited to ventilation ducting, passive through-wall ducts, drop ceilings, louvered doors, door undercuts, space between wall and floor, etc.

The size of the opening, A_{nv} , is dictated by whether the system meets Enhanced Tightness Refrigeration Systems (ETRS) requirements of UL60335-2-40 Ed .4. A full list of Mitsubishi Electric outdoor units and their ETRS status are provided in Section 4 of this document.

For ETRS-compliant systems:

$$A_{nv} \geq 22in^2 \text{ or } 114cm^2$$

For Non-ETRS-compliant systems:

$$A_{nv} \geq 0.0317 \times (m_c - 0.337 \times (\sqrt{A})) \times \sqrt{0.563 \times \sqrt{A}}$$

A = area of the room in m^2

m_c = system refrigerant charge in kg

Other Compliance Options (Additional Safety Measures)

Refrigerant Leak Detectors

Refrigerant leak detectors, or a refrigerant detection system (RDS), are used as a tool for UL compliance in certain scenarios but are not required for compliance. The use of RDS in Mitsubishi Electric indoor units varies based on the application. See [App Note 1043](#) for full details on leak detection sensors but there are 3 distinct scenarios where leak detection is required.

1. Ducted Units: Per Annex GG.9 (Charge limits for appliances using A2L refrigerants connected via an air duct system to one or more rooms), the dispersal area of the system charge can be the total conditioned space connected by the ducts so long as the appliance has a RDS that triggers a circulation airflow upon leak.
 - a. Mitsubishi Electric ducted units utilize a RDS with circulation airflow compliance in all applications and as such this allows us to use the total conditioned space in determining the room area vs. system charge
 - b. While using RDS with circulation airflow should allow for a higher room height, up to 7.2ft (2.2m), Mitsubishi Electric still assumes a height of 5.9ft (1.8m) and does not adjust the room area vs. charge relationship
 - c. Furthermore, supply registers must be at 7.2ft (2.2m) or higher for PEAD, SEZ & PEFY units per Mitsubishi Electric policy given that UL requires a specified discharge velocity for low supplies which can't be guaranteed would be met for all installations. SVZ, PVA, PAA & PVFY units don't have this same restriction, given their potential to be installed in spaces other than above the ceiling, and as such have their own compliance instructions outlined in the installation manual
 - d. Plenum returns are not allowed per UL Annex DD unless a RDS is provided in the unit and immediately below the return air plenum duct joint. Mitsubishi Electric indoor units do not have provisions for any additional sensors so plenum return configurations are not allowed
 - e. Common returns, or central returns where a return duct is not directly in the same space as the supply duct, are not expressly disallowed. UL only requires a ducted supply and return to the space
2. Floor Mount Units: Given that the installation height of these units is lower than the assumed 5.9ft (1.8m) assumed discharge height, a RDS and circulation airflow are required
 - a. While using RDS with circulation airflow should allow for a higher room height, up to 7.2ft (2.2m), Mitsubishi Electric still assumes a height of 5.9ft (1.8m) and does not adjust the room area vs. charge relationship

- Indoor Units on MXZ-SM: All indoor units present on MXZ-SM outdoor units utilize RDS which are used in conjunction with refrigerant recovery sequence and the solenoid valves in the ODU so that the system can claim a releasable charge, m_{rel} , which is lower than the system charge, m_c . This lower releasable charge allows for a smaller room area requirement

MXZ-SM Solenoid Shut Off Valves & M_{Rel}

MXZ-SM systems employ solenoid shut off valves, RDS and a refrigerant recovery sequence in order to limit the releasable charge as noted above. The MXZ-SM systems use m_{rel} when determining the minimum room area required.

The MXZ-SM models use different compressor models across the range and as such the releasable charge amount is different based on the compressor's ability to recover charge back to the ODU. This is expressed in the table below:

Applicable Models							
MXZ-SM36NLHZ MXZ-SM42NLHZ MXZ-SM48NLHZ MXZ-SM60NL				MXZ-SM36NL MXZ-SM48NL			
System Charge		Mrel		System Charge		Mrel	
lbs	kg	lbs	kg	lbs	kg	lbs	kg
15.7	7.1	3.5	1.6	15.7	7.1	4.4	2
16.3	7.4	3.7	1.7	16.3	7.4	4.6	2.1
17.4	7.9	3.7	1.7	17.4	7.9	4.9	2.2
18.5	8.4	4	1.8	18.5	8.4	5.1	2.3
19.6	8.9	4.2	1.9	19.6	8.9	5.3	2.4
20.7	9.4	4.4	2	20.7	9.4	5.5	2.5
21.8	9.9	4.4	2	21.8	9.9	5.7	2.6
22.9	10.4	4.6	2.1	22.9	10.4	6	2.7
24	10.9	4.9	2.2	24	10.9	6.2	2.8
25.1	11.4	5.1	2.3	25.1	11.4	6.4	2.9
26.2	11.9	5.1	2.3	26.2	11.9	6.6	3
27.3	12.4	5.3	2.4	27.3	12.4	6.8	3.1
28.4	12.9	5.5	2.5	28.4	12.9	7.1	3.2
29.5	13.4	5.7	2.6	29.5	13.4	7.3	3.3
30.6	13.9	5.7	2.6	30.6	13.9	7.5	3.4
31.7	14.4	6	2.7	31.7	14.4	7.7	3.5

3. Conclusion

The overview of the assumptions used to construct the safety guidelines in Mitsubishi Electric literature are intended to promote clarity around the topic of safety compliance. Local codes will vary in the guidelines and restrictions and it's important to be able to show the difference between local code, UL60335-2-40 Ed. 4 & Mitsubishi Electric's interpretation of the code.

Mitsubishi Electric can't directly endorse nor condemn alternative compliance options as that's at the discretion of the designer of record.

4. Reference Material

Additional Information on RDS

See [App Note 1043](#) for additional information on the refrigerant detection sensors and shut-off valves

Mitsubishi Electric ETRS Compliant Outdoor Units

SKU	ETRS
MUY-GX09NL-U1	No
MUY-GX12NL-U1	No
MUY-GX15NL-U1	No
MUY-GX18NL-U1	No
MUY-GX24NL-U1	No
MUY-GX30NL-U1	No
MUY-GX36NL-U1	No
MUZ-FX06NLHZ-U1	No
MUZ-FX09NLHZ-U1	No
MUZ-FX12NLHZ-U1	No
MUZ-FX15NLHZ-U1	No
MUZ-FX18NLHZ-U1	No
MUZ-FX24NLHZ-U1	No
MUZ-GX09NLHZ-U1	No
MUZ-GX09NL-U1	No
MUZ-GX12NLHZ-U1	No
MUZ-GX12NL-U1	No
MUZ-GX15NLHZ-U1	No
MUZ-GX15NL-U1	No
MUZ-GX18NLHZ-U1	No
MUZ-GX18NL-U1	No
MUZ-GX24NLHZ-U1	No
MUZ-GX24NL-U1	No

MUZ-GX30NL-U1	No
MUZ-GX36NL-U1	No
MUZ-HX09NL-U1	No
MUZ-HX12NL-U1	No
MUZ-HX18NL-U1	No
MUZ-HX24NL-U1	No
MUZ-JX09WL-U1	No
MUZ-JX12WL-U1	No
MUZ-WX09NL-U1	No
MUZ-WX12NL-U1	No
MUZ-WX18NL-U1	No
MUZ-WX24NL-U1	No
MXZ-2D20NLHZ-U1	Yes
MXZ-2D20NL-U1	Yes
MXZ-3D24NLHZ-U1	Yes
MXZ-3D24NL-U1	Yes
MXZ-3D30NLHZ-U1	Yes
MXZ-4D30NL-U1	Yes
MXZ-5D36NL-U1	Yes
MXZ-5D42NL-U1	Yes
MXZ-SM36NLHZ-U1	Yes
MXZ-SM36NL-U1	Yes
MXZ-SM42NLHZ-U1	Yes
MXZ-SM48NLHZ-U1	Yes
MXZ-SM48NL-U1	Yes
MXZ-SM60NL-U1	Yes
PUY-AH24NL-U1	Yes
PUY-AH30NL-U1	Yes
PUY-AK12NL-U1	Yes
PUY-AK18NL-U1	Yes
PUY-AK36NL-U1	Yes
PUY-AK42NL-U1	Yes
PUY-AK48NL-U1	Yes
PUY-AK60NL-U1	Yes
PUZ-AH24NL-U1	Yes
PUZ-AH30NL-U1	Yes
PUZ-AK12NL-U1	Yes
PUZ-AK18NL-U1	Yes
PUZ-AK24NLHZ-U1	Yes
PUZ-AK30NLHZ-U1	Yes
PUZ-AK36NLHZ-U1	Yes

PUZ-AK36NL-U1	Yes
PUZ-AK42NLHZ-U1	Yes
PUZ-AK42NL-U1	Yes
PUZ-AK48NLHZ-U1	Yes
PUZ-AK48NL-U1	Yes
PUZ-AK60NL-U1	Yes
SUZ-AA09NLHZ-U1	No
SUZ-AA09NL-U1	No
SUZ-AA12NLHZ-U1	No
SUZ-AA12NL-U1	No
SUZ-AA15NLHZ-U1	No
SUZ-AA15NL-U1	No
SUZ-AA18NLHZ-U1	No
SUZ-AA18NL-U1	No
SUZ-AA24NL-U1	No
SUZ-AA30NL-U1	No
SUZ-AA36NL-U1	No
SUZ-AK24NLHZ-U1	Yes
SUZ-AK30NLHZ-U1	Yes
SUZ-AK36NLHZ-U1	Yes
SUZ-AK48NLHZ-U1	Yes
SUZ-AK48NL-U1	Yes
SUZ-AK60NL-U1	Yes