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Causalities due to Fire in Air Conditioners

A study on Electrical Parameters

Introduction

The hot climate in India has made the air conditioner industry very prosperous; nearly six to seven million units are sold last year. To gain a larger market share, manufacturers strive to make their products as affordable as possible. One method for making the product competitive is to meet only the bare minimum of required safety parameters while improving visible features; as a result, the improvement in safety features is minimal.

This study will examine, analyze, and compare the electrical safety requirements specified in Indian standards for air conditioners IS 1391 parts 1 and 2, IS/IEC 60335-2-40 and IS 302 part 1.

Table of standards and its subjects:

SN	Standard	Subject
1	IS 1319-part 1:2017	Room Air Conditioners—Specification—Part 1 Unitary Air Conditioners
2	IS 1319-part 2:2018	Room Air Conditioners—Specification—Part 2 Split Air Conditioners
3	IS 302-part 1:2008	Safety of household and similar electrical appliances—Part 1 General Requirements

4	IS/IEC 60335-2-40:2018	Household and similar electrical appliances – Safety – Part 2-40: Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers
5	IEC 60335—1:2020	Household and similar electrical appliances – Safety – Part 1: General requirements

This study also finds out the effectiveness of the Government Order, called the Air Conditioner and its related Parts, Hermetic Compressor and Temperature Sensing Controls (Quality Control) Order, 2019 (and its amendments) by The Ministry of Commerce and Industry. Govt of India made ISI mark mandatory for air conditioners with effect from 01 January 2023.

Electrical accidents in air conditioners



There are many fire accidents from air conditioners reported in India during the last few years. The major ones which resulted in fatalities are reported by the media, however, the minor ones are not reported.

Fire in an electrical appliance is due to thermal reasons. The appliance is exposed to a higher temperature either due to internal or external reasons. In comparison to external causes, the internal ones are focused in this report, as these can be solved only by the manufacturer.

Internal causes are overcurrent due to defective internal components or continuous running of equipment for longer durations which it is not designed for or a short circuit in the equipment or an earth fault.

Every piece of electrical equipment must have its own protective devices as a fundamental safety requirement, if not the manufacturer should recommend the external protective devices in their manual. In the case of an air conditioner, either such a recommendation does not exist, or availability of internal fuses are not mentioned in the manufacture's documents in most cases.

The purpose of the protective devices placed in the distribution boxes is to safeguard the wiring during overcurrent and disconnect the circuit in case of any leakage/faults. If the protective device in the distribution board is correctly rated, it can safeguard the wiring from overloads, short circuits, and earth faults. In most cases, improper protective devices are used, hence the internal protective mechanism in the air conditioner should be highly reliable.

It is a habit to use voltage stabilizers along with air conditioners to handle the challenges associated with supply voltage. Adding a stabilizer in the circuit increases the impedance of the circuit and reduces the instantaneous short circuit /fault current (for a fault of negligible impedance). The overcurrent protective device with a correct rating can instantaneously trip only if the impedance of the circuit is negligible. Hence using voltage stabilizers in the circuit also increases the chance of fire due to non-disconnection of the protective device (OCPD either internal or external to the air conditioners).



The initial sparks from the air conditioner in the above photo grew into a fire within two to three minutes. Molten plastic from the product's outer shell fell to the floor and continued to burn, resulting in an incident. According to an air conditioner technician, if the fire in the indoor unit had not been extinguished immediately, the refrigerant pipe would have ruptured, resulting in an explosion. This suggests that if this episode is unnoticed, it could have resulted in a massive disaster.

Government Order

MINISTRY OF COMMERCE AND INDUSTRY, Department for Promotion of Industry and Internal Trade

"S.O. 4354(E).—In exercise of the powers conferred by sub-sections (1) and (2) of section 16 read with sub-section (3) of section 25 of the Bureau of Indian Standards Act, 2016 (11 of 2016), the Central Government, after consulting the Bureau of Indian Standards, is of the opinion that it is necessary so to do in the public interest, hereby makes the following order, namely:-

1. Short title and commencement.— (1) This Order may be called the Air Conditioner and its related Parts, Hermetic Compressor and Temperature Sensing Controls (Quality Control) Order, 2019.

(2) It shall come into force with effect from 01.06.2020."

In the revised order, 2021, the enforcement date is modified to "1 January 2023." This order may be titled "The Air Conditioner and Its Related Parts, Hermetic Compressors, and Temperature Sensing Controls (Quality Control) Amendment Order, 2021."

The 2019 order also mandates the use of the standard mark, stating that all the products under the specified standards of table 1 (including air conditioners) must bear the Standard Mark under license from the Bureau of Indian Standards.

The Bureau of Indian Standards has been designated as the certifying and enforcement authority for air conditioner products.

Table 1

Goods or article	Indian Standard	Title of Indian Standard
(1)	(2)	(3)
Room air conditioners unitary air conditioners.	IS 1391 (Part 1): 2017	Room Air Conditioners-Specification Part 1 Unitary Air Conditioners
Room air conditioners split air conditioners.	IS 1391 (Part 2): 2018	Room Air Conditioners-Specification Part 2 Split Air Conditioners
Ducted and package air conditioners.	IS 8148: 2018	Ducted and Package Air Conditioners-Specification
Finned type heat exchanger for room air conditioners.	IS 11329:2018	Finned type Heat Exchanger for Room Air Conditioner
Hermetic compressor.	IS 10617:2018	Hermetic Compressors-Specification
Temperature sensing control devices.	IS/IEC 60730 (Part 2) Section 9: 2011	Automatic Electrical Controls for Household and Similar Use Part 2 Particular Requirements Section 9 Temperature Sensing Controls

The standards mentioned in the above table are the standards applicable for the government order.

This directive is issued due to the high number of fires caused by air conditioners and to ensure that all air conditioners supplied in India are BIS-certified. This directive is anticipated to lower the number of accidents involving air conditioners.

In this study, we will examine the electrical safety parameters of IS 1391 (Part 1): 2017 and IS 1391 (Part 2): 2018, as these two standards apply to split/unitary air conditioners, which are prevalent in every home, commercial, and medical environment. IS 302 (Safety for Household and Similar Electrical Appliances) and IS/IEC 60335-2-40 (safety-particular requirements for air conditioners) will be used to compare the electrical safety parameters of IS 1391.

Based on this study report’s comparison, we will conclude if the GOVERNMENT ORDER help in saving lives or not.

Standards applicable for Air conditioners in India and their safety requirements

The contents for electrical safety related tests are the same for both standards but their clause numbers are different, clause 16.2 for IS 1391-1 and clause 15.2 for IS 1391-2.

The electrical safety tests recommended in IS 1391 are:

- Insulation resistance test: The insulation resistance between all electric circuits and the metal parts when measured at normal room temperature with a voltage of not less than 500 V dc shall not be less than 1 mega ohm.
- High voltage test: The electrical insulation of all circuits shall be such as to withstand a test pressure of 1 000 Vrms applied for not less than 2 seconds between circuits and accessible metal parts at normal room temperature.
- Leakage current test: The leakage shall not exceed 3.5mA when tested as per IS 302 -1.
- Earthing Resistance test: The earthing resistance of an air conditioner shall not exceed 0.1 ohms when tested as per IS 302-1
- [Note: Permissible variations from the type tested and unit Performance test is not included as both the tests are basic parameter testing rather than safety parameter testing]

Safety requirements in IS 302-1 & IS/IEC 60335-2-40

IS 302 part 1 is the standard specifically for safety for household and similar electrical appliances - general requirements. This standard is adopted form IEC 60335-1, part 2-40 explains the mandatory safety requirements for air conditioners. These standards are made in such a way that they should be read in conjunction.

The electrical parameters of IS 1391 part 1 and 2 must meet the requirements of IS 302 part 1 and IS/IEC 60335-2-40 as a mandatory electrical safety requirement.

Clause number 13 and 14 of both standards (IS 302 part 1 and IS/IEC 60335-2-40) explains some of the electrical safety requirements which is mentioned in the table for comparison.

- Leakage current test for stationary class I motor-operated appliances: The leakage current shall not exceed 3.5 mA, or 2 mA per kilowatt rated power input, whichever is higher. The maximum value shall not exceed 10 mA for appliances accessible to the general public and 30 mA for appliances not accessible to the general public.

- Electric strength test: The appliance is disconnected from the supply and the insulation is immediately subjected to 1000V (for a 230/240V equipment) for a period of 1 min.
- Transient over voltage: The device is subjected to an impulse voltage of 1.2/50 μ s, applied three times for each polarity with intervals of at least 1s.
- The equipment should be classified by the supplier to the overvoltage category of II or III (refer IS 302-part 1 annex K). The rated impulse voltage for overvoltage class II is 2500V and for class III is 4000V (the actual impulse test voltages are 2920V and 4920V respectively).
- Earth continuity Resistance test: The voltage drop between the earthing terminal of the appliance or the earthing contact of the appliance inlet and the accessible metal part is measured. The resistance shall not exceed 0.1 Ω as per clause 27.5.
- Glow wire test: Parts of insulating material supporting current carrying connections, and parts of insulating material within a distance of 3 mm of such connections, are subjected to the glow-wire test.

Analysis and comparison of the above points

SN	Test	IS 1319 part 1 and part 2	IS 302 part 1 and IS/IEC 60335-2-40
1	Insulation Resistance test	In this standard, it is mentioned that a 500 V DC current should be supplied and a minimum of 1 megaohm resistance should be present at room temperature.	Not required.
Comment: The insulation resistance test is not necessary if the equipment can pass the leakage current test and Electric strength test of IS 302 part 1.			
2	Leakage current test	The leakage shall not exceed 3.5mA.	The leakage current shall not exceed 3.5 mA, or 2 mA per kW rated power input.
Comment: The minimum leakage current of 2mA is applicable for smaller devices, which is not considered in IS 1391.			
3	High voltage test/ electric strength test	The insulation should withstand 1000Vrms for a duration of not less than 2s.	The test should be for a voltage of 1000V of 50 Hz for 1min.
Comment: The duration of electric strength recommended in IS 302 is not followed for air conditioners. This test is having an influence on the insulation of the equipment.			
4	Transient over voltage	Not provided	The manufacturer should classify the equipment as a pluggable or fixed installation which is overvoltage category II and III respectively. For overvoltage category II: Impulse voltage 2500V For overvoltage category III: Impulse voltage 4000V.
Comment: The basic classification of equipment based on the type of installation is not specified in IS 1391 parts 1 and 2, making the product susceptible to impulse voltage.			
5	Earth continuity resistance test	Earth resistance test: The earthing resistance of an air conditioner shall not exceed 0.1 ohms.	The voltage drop between the earthing terminal of the appliance and the accessible metal part is measured. The resistance calculated from the current and this voltage drop shall not exceed 0.1 Ω .
Comment: The test is primarily used to ensure continuity resistance from the earth terminal to other metal parts accessible within the equipment, thus the content of the test should be the same as IS 302 part 1.			
5	Glow wire test	Not provided	Part of the insulation, depending on the distance of current-carrying conductors, is subjected to high temperatures.
Comment: The most basic fire extinguishing test is not included in IS 1391 part 1 and part 2. This test shows the fire behaviour of plastics used in the products. The plastic in the image of a burnt air conditioner was still burning after it fell to the ground, and the main reason is that the glow wire test was not done.			

(Note: This article only covers a portion of the basic parameters; the rest of the tests mentioned in the standards are also important)

Conclusion

The electrical parameter tests in IS 1391 are insufficient to fulfil the basic safety requirements as per IS 302 part 1 and IS/IEC 60335-2-40. Only by improving the electrical safety requirements can the essence of the GOI (the Air Conditioner and its related Parts, Hermetic Compressor and Temperature Sensing Controls (Quality Control) Order, 2019) be made useful to improve the quality of the product and protect the interests of the consumer. Hence, the standard IS 1391 requires an immediate update in the following parameters:

- Complete adoption of IS 302 part 1 and IS/IEC 60335-2-40, particularly
 - a) High voltage electric test parameter shall be changed from 2s to 1 min.
 - b) Impulse voltage test shall be included in the standard.
 - c) Glow wire test shall be included.
 - d) Earth continuity resistance test method shall be improved.
 - e) Provision of inbuilt fuse in the air conditioner as a complete unit or provision of fuse for units such as compressor, blower etc.
- All air conditioners shall be classified as overvoltage category III
- A temporary overvoltage test of 1200V + rated voltage shall be carried out for 5s in order to satisfy the requirement of IS 732 clause 4.5.2.2.3 (table 5).
- The manufacturers of air conditioners shall train their technicians to test the fault loop impedance at the location while installing the air conditioner and find out the requirement of RCCB for earth leakage/fault protection. Type A/ Type F RCCB



- may be required for inverter-type air conditioners.
- For inverter-type air conditioners the harmonic current emission shall be limited to the values prescribed in IEC 61000-3-2/61000-3-4.
- IS/IEC 60335-2-40 does not provide any cross-references to IS 302 part 1. It does not explain the applicability of IEC 60335-1 as well. As a result, the IS/IEC 60335-2-40 could confuse readers. Hence this standard require proper guidance to read
- IS 302 part 1:2008 should be immediately updated to IEC 60335-1:2022.
- Air conditioner manufacturers shall also include the recommended rating and type of OCPD and supply conductor as per IS 732 in their manual.

Both IS 302 and IS/IEC 60335-2-40 standards recommend several electrical safety parameters, whereas IS 1391 does not consider electrical safety measures other than those mentioned above or has not provided any reference to IS 302 and IS/IEC 60335-2-40.

The above improvements will help increase the quality and reliability of the product, and as a result, failures and fires due to short circuits in air conditioners can be reduced. Thereby 100's of lives and 1000's of crores worth property can be saved. ■

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