Fire Prevention in Unitary Air conditioners

Abhinandan Sharma, A.K. De, S.K. Jaiswal and Ram Kishan
Technical Services Division

Abstract
Several incidences of minor fire and a few incidences of major fire in the unitary Air Conditioners (AC) have been observed in BARC in the past. Technical Services Division (TSD), which is responsible for maintaining the ACs, has adopted multipronged approach to prevent recurrence of fire incidences. These approaches consist of using capacitors having highest level of safety protection, i.e., P2 protected as per IEC 60252-1-2001-02 standard with self healing properties, overpressure disconnection device and installing timer control device to avoid continuous running of ACs. Recently we have started installing fire extinguishing aerosol generator with thermo cord/thermal actuating sensor in unitary air conditioners. This article gives an overview of fire occurrences in ACs, their probable causes and technical solution for mitigation.

Introduction
Mechanical Maintenance Section, Technical Services Division is carrying out maintenance of large number of air conditioning, refrigeration and ventilation equipment spread over entire BARC premises. The various equipment such as unitary air conditioners (Window & Split air conditioners) Fan Coil Units, Water coolers, Deep-freezers, Chillers, Cold Rooms and vehicle air conditioners are being maintained on regular basis in order to enhance their reliability, increase their useful lives and reduce downtime & fire incidences.

Equipment Description
The four major components of the unitary AC are a hermetically sealed compressor, a condenser, a capillary tube type throttling device, and an evaporator. Besides, fan motor, capacitors, relay, contactors, and thermostat, etc. also form part of air conditioner. Fig. 1 shows the different components of a unitary AC. The working of unitary equipment is based on Vapor Compression Cycle (VCC) as shown in Fig. 2. The desired degree of cooling is achieved by extracting heat from the space to be airconditioned and expelling the heat into the atmosphere. More than 99% of commercially available air conditioners in the market are based on vapour compression cycle in which refrigerant’s properties are being utilized.

![Fig. 1: Schematic Representation of a Unitary AC](image-url)
Over a period of time spanning more than two decades, we came across maintenance of various makes and models of air conditioners. Earlier ACs were considered as industrial products and they were bulkier. For example, about 25 years back, a typical 1.5TR window air conditioner weighed in the range of 82 to 85 kg. In the recent times however, there is stiff competition in the market which has forced the designers to optimize the designs. Thus, the trend now is to use nonmetallic components wherever possible and to cut down the design margins so as to reduce thickness and size of different components and parts. As a result, the weight of a typical 1.5 TR rating AC is only about 60 Kg.

Fire Incidences

Based upon the statistical record of AC related fire occurrences in BARC in 8 to 10 years in the recent past, numerous cases of burning smell, electrical spark or smoke coming out from air conditioners get reported to TSD during each year. Such cases are more frequent during monsoon as the air is generally wet and there could be moisture ingress into the unit. In majority of the cases, as a corrective measure, the occupant(s) of the room themselves switched the power supply off and reported the incident to TSD for further corrective action. Because of the prompt action of the occupant, there were no significant loss of user’s documents and assets. However, six major fire incidences occurred due to unitary air conditioners and four incidents of these caused significant loss of user’s documents and assets besides destruction of office stationery, furniture and room interior. These places are:
   a) Old Training School.
   b) VIP canteen dining hall at 14th floor Training School Hostel.
   c) Training School Hostel, Room no. 808.
   d) RCnD building, Room no. 109.
   e) Purnima building, Room no. 11-S.

As already mentioned, all the reported events are thoroughly documented. Subsequently, the events are thoroughly discussed and analyzed at various levels including local safety committee and unit level safety committee of respective groups and finally at Conventional and Fire Safety Review Committee (CFSRC). An important aspect of investigation is to arrive at the root cause of the incident and to work out technical solution for prevention of fire incidents in future. The solutions also aim at minimizing damage and loss, if fire were to actually occur.
Causes of AC Fire Incidents

Based on the analysed results and feedback of various safety committees and experience of TSD engineers, it can be stated that the initiation of fire in window and split air conditioners was due to one or more of the following factors:

**Poor Workmanship of Electrical Wiring and Loose Connection:** Owing to stiff competition in the Indian consumer market, it is suspected though difficult to establish that the measures enforced by manufacturers to reduce manufacturing cost might affect the quality of components and materials including wire, clips and joints. Also, sometimes the workmanship could be poor, i.e., soldering/crimping of lugs may not be properly done, screws might not be fitted properly leaving loose connection, etc.

**Thermostat malfunctioning:** Sometimes the thermostat does not work properly and fails to cut-off the machine which results in continuous running of compressor and finally may lead to fire.

**Failure of capacitors:** Most of the commercially available air conditioners are provided with non-metallic or metallic capacitor without explosion proof features. It is observed that over a period of time, the dielectric material of the capacitor deteriorates whereby dielectric loss might increase. This would cause overheating and chances of bursting increases which ultimately may lead to fire.

**Continuous running of air conditioners:** Unitary ACs are generally designed to work intermittently, typically with duty cycle of 12 hours, unless specifically ordered. However, due to under estimation of heat load, too low temperature setting of thermostat of the machine, and bad usage practices e.g. operating ACs with doors/windows kept open, continuous running of ACs might happen. As these ACs are not designed for continuous operation beyond 12 hours, the components may get overheated leading to bursting and ultimately leading to initiation of fire.

**Failure of transformer in control circuit (PCB):** Overheating of transformer provided in the control circuit of air conditioner may lead to its burning, resulting in initiation of fire.

**Addition/alteration in air conditioners:** The various components in commercially available air conditioners are designed for their optimum operation and utilization. Any addition/alteration in original design might affect the performance of the unit drastically, if proper fitting is either not ensured or replacements recommended by the original manufactures are not done. Sometimes due to increase in system resistance the condenser cooling gets affected and may lead to high pressure built up in the system which may lead to failure of components and sometimes may lead to fire.

**Corrective Measures taken by TSD**

Based on our experience over a period of time the following corrective actions have been taken by TSD to reduce fire incidences in unitary air conditioners:

a) TSD is carrying out bi-monthly maintenance for window and split air conditioners to keep the equipment in healthy condition.

b) During maintenance, healthiness of each component is checked and if found faulty, it is replaced with new one.

c) Since last six to seven years, TSD is replacing old non-metallic capacitors with metallic bellows type explosion-proof capacitors, only of a reputed make. In case of overheating, bellows expand as a result of which the power supply is automatically disconnected.

d) More recently, capacitors having highest level of safety features as per IEC 60252-1-2001-02 standard, i.e. P2 protected with self healing properties and overpressure disconnection device, are being installed in the AC units. This will further increase reliability of capacitor and in turn reduces chances of failure and resulting fire.

e) As it is widely known, unitary air conditioners are not designed for continuous operation for more than 12 hours and their extended operation should
be avoided. Hence, TSD has conceived a timer controlled device, comprising of MCB (Miniature Circuit Breaker), contactor, timer, plug and socket, as shown in Fig. 3. These components are assembled in a metallic box and power supply is given to air conditioner through this device. In case of round the clock occupancy of laboratories where operation beyond 12 hours might occur, each machine is fitted with timer so that the machine is automatically started and stopped as per pre-set duty cycle.

f) Aerosol based fire extinguishing device is also being installed on trial basis in AC units. In a number of tests carried out at TSD workshop, the capability of the device in initiation of fire extinguishing has been established. The aerosol extinguishes fire by inhibiting the chain reaction in combustion on molecular level. It removes the flame free radicals and extinguishes fire without depleting oxygen. The temperature set-point for initiation of aerosol extinguisher is verified to be typically 172°C with thermocord and 300°C without thermocord. The aerosol extinguisher is environment friendly and it does not cause any harm to living beings or humans.

Fig. 4 shows a collection of photographs taken during simulated testing of the aerosol based fire extinguisher.

Concluding Remarks

Based upon the analyses of reports of incidences of fire related to unitary air conditioners and the corrective actions taken by TSD, measures such as use of timer for automatic disconnection of power supply to AC, use of aerosol based fire extinguisher for critical areas, and use of P2 protected capacitors having highest level of safety features with self healing properties and overpressure disconnection can be taken. Also, while servicing it must be ensured that no alteration or addition is done so as to affect the performance in an adverse manner. Users should avoid unattended operation of air conditioning equipment and the fire load such as curtain and combustible stationery should not be kept in the vicinity of unitary air conditioners. The practice of wooden paneling, which is often done to improve aesthetics, should be discouraged. Instead, aluminium compressed panels, which are available in wooden textures, are recommended to be used.