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REGULATIONS ON AIR CONDITIONING AND HUMIDITY CONTROLS IN EXPLOSIVES AREAS

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CONTENTS

PREFACE

Air-conditioning is now-a-days being extensively employed in explosive manufacturing and storage areas. Since the environment in the explosive areas is of a hazardous nature posing potential risk to the personnel and property, air-conditioning installation for such facilities have to meet very stringent requirements. To fulfill its role effectively, constant endeavors to improve upon air-conditioning system with more versatile equipment, accurate controls and instrumentation are called for.

This pamphlet highlights the various safety aspects in detail and prescribes the guidelines for the selection and location of an appropriate air-conditioning system.

It is hoped that users will find this revised STEC Pamphlet 2025 simpler, easier to understand and implement, thereby promoting the safe storage and transportation of military explosive. This publication supersedes STEC Pamphlet, 2017 on the subject.

REGULATIONS ON AIR-CONDITIONING AND HUMIDITY CONTROL IN EXPLOSIVES AREAS

Introduction

1. In recent years there has been a phenomenal rise in the requirements of controlled atmospheres for manufacturing processes and for prolonging shelf life of costly and sophisticated explosives/ammunition stores. These requirements now-a-days vary widely with temperatures dipping to 20 ^{0}C (68 ^{0}F) and relative humidity ranging from a minimal 20% to values as high as 80%. With the tropical and coastal climates prevalent in India, the need is frequently felt for cooling by air-conditioning during hot and humid seasons. Quite often, humidification and dehumidification, heating in winter and even evaporative cooling are also required individually or in conjunction with air-conditioning. A combination of summer cooling and winter heating will provide round-the year-conditioning.

2. Air-conditioning, strictly speaking, constitutes simultaneous control of temperature, humidity, purity and distribution/motion of air in a confined conditioned space. For modern production and storage practices, control of most or all of the above mentioned factors is absolutely vital and so air-conditioning has become an important backbone of industries.

Fundamental Principles

3. Air-conditioning comprises basic refrigeration system and airhandling equipment for circulation of treated air. The refrigeration portion works on the popular vapor compression system consisting of a refrigerant compressor driven by an electric motor, a refrigerant condenser of the air-cooled or the water-cooled type, a receiver to store liquid refrigerant (which is sometimes incorporated in the condenser itself), an expansion valve, finned cooling (evaporator) coil and interconnecting refrigerant piping (Fig. 1). Clause 2 “Terminology” in IS 660-1963 (reaffirmed 2017) “Safety Code for Mechanical Refrigeration” (revised) gives the brief purpose of these components. The airhandling equipment houses the cooling coil of the refrigerating system, air filter, and the humidification apparatus (if provided). The supply and return air ducts convey the conditioned air to and from the conditioned space. The refrigerant circuit is entirely independent of the treated air circuit.

4. In the simplest form, this system can maintain temperature as low as 18 ^{0}C (64 ^{0}F) and relative humidity around 40%. For obtaining lower conditions than these, special features will have to be incorporated in the air-conditioning system and sometimes in the conditioned building also. Winter heating arrangements (where required) can easily be incorporated into this system.

5. In the arrangements shown in Fig. 1, air from the conditioned space is taken back through the return air duct to the airhandling unit and recycled along with some fresh air drawn in through the air filter. Thus there is re-circulation of air from the conditioned space and for all practical purposes, the weather maker room could be considered to be a part and parcel of the air-conditioned space itself. Allowing for leakages of air from the conditioned space

to outside, it is possible to re-circulate as much as 95% of the air in the conditioned space. Increased re-circulation results in smaller plant and all round economy.

Inherent Dangers

6. In process and laboratory building where explosives are manufactured and processed, explosive vapours/dust are invariably generated. Thus in the arrangement shown in Fig. 1, the explosive vapours or dust generated in the conditioned space will reach the weather maker room through the return air duct. It will also flow through the airhandling unit coming into contact with the airfilter, cooling coil, blower and motor etc. before being blown through the supply air duct into the conditioned space.

7. The inherent danger of fire and/or explosion occurring in any part of the air duct and the weathermaker room, therefore, exists. The explosive dust may settle in the air ducts to form an encrustation, which is difficult and dangerous to deal with. Similar settlement occurs in the weathermaker room and the duct accumulates rapidly in the air filter. The presence of explosive dust in this fashion poses serious danger during inspection and maintenance / repair operations, as an explosion can easily result from surface friction produced by rubbing or a spark struck during the operation. Any fire or explosion in the conditioned space will spread into the weathermaker room through the ducts and vice versa.

8. The design and specifications of the air ducts and the adjuncts, accessories and equipment installed in the weathermaker room, therefore, assume paramount importance. It is equally desirable to pay full attention and care to the design and construction of the weathermaker room and the conditioned space/building. All decisions and provisions should be totally safety oriented. Ad-hoc or temporary arrangements for air conditioning even for a short duration are **NOT** acceptable.

Fresh Air Changes and Re-circulated Air

9. In spite of recirculation of air form the conditioned space, a certain quantity of fresh air from an uncontaminated ambient source has to be inducted into the system to provide for metabolic needs of the occupants, to maintain freshness and to make up for the inevitable loss of conditioned air by leakages through cracks/door openings. The fresh air so admitted replaces continuously the air in circulation and provides a certain number of fresh air changes in the conditioned space every hour which equals:

$$\frac{\text{Volume of fresh air inducted per hour}}{\text{Volume of conditioned space}}$$

The values of fresh air required for occupants are given in IS: 659-1964 (reaffirmed 2017) "Safety Code for Air-conditioning (Revised)". These norms stipulate an insignificant fresh air change rate when the occupants are few or the conditioned space volume is large. Practical considerations dictate the minimum fresh air changes per hour to be one. An increase in fresh air changes per hour reduces the proportion of re-circulated air and diminishes the pollution prospects inside the conditioned space which is a positive step towards safety.

10. To illustrate the point, repetitive calculations with increasing number of fresh air changes per hour have been made assuming certain data and the results are tabulated below:

Data assumed: Conditioned space 12m L x 6m B x 3.5m H
Brick walls, PCC floor, and RCC roof with 25mm insulation.
Inside temperature 76 deg F, RH 50%
Occupancy 8 persons.
Internal electric equipment load 2 KW.

Sr.No.	No. of Fresh air changes per hour	Fresh air qtyinducted cfm	Percentage in total air		Plant Capacity tons	Remarks
			Fresh Air	Re-circulated Air		
1.	1	160	5.5	94.5	5.7	Minimum practical fresh air change entails maximum recirculation of air.
2.	2	320	10.8	89.2	6.4	
3.	3	480	15.9	84.1	7.1	
4.	5	800	25.4	74.6	8.4	75% of air recirculated
5.	6	960	29.8	70.2	9.2	
6.	8	1280	38.2	61.8	10.6	
7.	10	1600	45.9	54.1	12.0	
8.	11	1760	49.5	50.5	12.7	Mid point. 50% fresh & 50% recirculated air.
9.	12	1920	55.5	44.5	13.4	
10.	15	2400	66.0	34.0	15.5	
11.	17	2720	71.5	28.5	16.8	
12.	18	2880	75.0	25.0	17.5	Only 25% of air recirculated.
13.	20	3200	80.6	19.4	18.9	
14.	22	3520	85.8	14.2	20.4	
15.	24	3840	90.8	9.2	21.8	Less than 10% of air recirculated.
16.	26	4160	95.5	4.5	23.2	
17.	27.	4320	97.7	2.3	23.9	
18.	28	4480	Exceeds 100%	Not applicable	24.5	Fresh air more than sufficient. Hence no recirculation.

11. The above matrix frame gives the proportion of fresh air (col. 4) and re-circulated air (col.5) for a given number of fresh air changes per hour (col. 2) and its corresponding plant capacity (col. 6) for this particular case. It shows that one fresh air change (serial I) would entail recirculation of nearly 95% of the air from the conditioned space, and equal proportion of fresh air and re-circulated air occurs at 11 fresh air changes (srl 8). With 28 fresh air changes (srl18) there is no need to resort to recirculation and the system can work on all (or 100%) fresh air itself. The plant capacity leaps from a mere 5.7 tons with one fresh air change per hour (srl 1) to 24.5 tons with 100% fresh air (srl 18), and thereby highlights the importance of judicious appraisal of fresh air requirements (see para 16).

12. It is obvious that change in any value of the data assumed in the above case will influence the calculated values. A simple change in the value of electric power consumed by user equipment alone (assumed as 2KW in the above case) will provide a striking example of the effects on air quantity and plant capacity as shown below:

Sl. No.	Electric power consumed by equipment in conditioned space KW	All fresh air (no recirculation) occurs with following fresh air changes per hour	Plant capacity (tons)
1.	2	28	24.5
2.	4	30	26.6
3.	8	38	33.0
4.	12	45	38.5
5.	15	50	45.0
6.	20	58	58.5

13. It therefore becomes apparent that the above-calculated figures can project only a very generalised picture on which a universal yardstick cannot be formulated. The importance of detailed calculation for every specific situation based on actual ground data can also be realized.

14. The number of fresh air changes per hour to be adopted is governed by several factors, such as the quantum and nature of the pollutant (e.g. vapor or dust, coarse or fine, light or heavy, safe/unsafe, harmful to men/materials etc.) introduced by the process/activity in the conditioned space. Generation of loathsome or nauseating smell or vapours by the process in the conditioned space could also be an important contributing factor. So also, longer the working hours, the greater the chances of progressive accumulation of pollutants. Due to the compensating / cumulative effects of the various factors involved, no hard and fast scale or guidelines for every possible situation can be laid down in case of explosives buildings. The broad guidelines are:

a) The fresh air change rate selected should ensure that the atmosphere in the conditioned space is maintained at a pollution level well below the risk level at all times. The level of pollution concentration in the conditioned space should not be a health hazard to the occupants.

b) In the range of ONE to FIVE fresh air changes per hour, the air under recirculation is considerable (above 75%). Utility of this range for any explosives process/laboratory building is doubtful. This could possibly be considered for buildings used for storage of explosives.

c) Where intake of generous quantity of fresh air becomes essential and the quantum of re-circulated air is to be restricted (to about 10% or less), it may be more advantageous to adopt all fresh air arrangement (see para 15).

15. Where recirculation of air from the conditioned space is dangerous and is not desired, the return air duct is omitted and entire quantity for air required for air-conditioning is drawn in from outside fresh air. The air in the conditioned space is exhausted to atmosphere by deliberate leakage or sometimes forcibly by means of exhaust fans. This results in all fresh air system (and no recirculation) and directly involves a tremendous increase in plant capacity and recurring expenditure. Even in this system, explosive vapours/dust generated in the conditioned space can enter the supply air duct when the plant is shut down or is not in operation and pass along to the weathermaker room. Thus the possibility of danger cannot be ruled out and full attention to all safety aspects has to be paid.

16. As mentioned in Para 11, a careful approach to the selection of fresh air changes is essential because of its impact on plant capacity/recurring cost. At the same time the following factors should also be borne in mind:

(a) Inducting massive fresh air quantities involves an equivalent discharge of polluted air from the conditioned space to the free atmosphere. Any danger posed by the quantum of explosives contained in the discharged air should be carefully appreciated and suitable action taken to ensure safety.

(b) Fresh air change rates of TEN and OVER creates significant positive air pressure inside the conditioned space. The effect of this conditioned but polluted air under pressure on the electrical fitments and other gadgets (which may be of pressurized type) is to be carefully appreciated and suitable steps taken to ensure safety.

17. For category ‘A’ buildings involving flammable/explosive vapours, recirculation of air is NOT recommended from ultimate safety angle and all fresh air system shall only be adopted. In case of Category ‘B’ buildings involving explosive dust and Category ‘C’ buildings, recirculation of air is permitted to the extent that it does not create unsafe levels of explosive dust concentration. Sufficient quantity of fresh air shall be admitted at all times to ensure that the explosive dust concentration everywhere is well below the acceptable risk level. Keeping in view these aspects, it is recommended that for category A, B and C explosive buildings, 100%, 50% and 25% fresh air changes per hour should be followed respectively. Where air recirculation is accepted, the return air duct should not end at the entrance point to the weathermaker room but should extend right upto the air handling unit and be rigidly connected to it.

18. In some cases, air-conditioning is required for cooling during summer/monsoon seasons and it is possible that the plant will be shut down during the winter months. If the airhandling unit is also switched off, induction of fresh air and circulation of air through the conditioned space will cease, which could result in a buildup of pollutant inside the conditioned space. This is dangerous. If the airhandling unit is kept working, then it will create circulation of cold air. This could prove uncomfortable to the occupants who may rightly insist on the stoppage of cold air draughts. Therefore, to maintain air circulation during winter and still ensure comfort, it will be necessary to incorporate winter heating with the air-conditioning system of the building used for process/laboratory work. IS: 659-1964 (Reaffirmed 2017) "Safety Code for Air-Conditioning (Revised)" gives inside design conditions for human comfort during winter months. Operation of the airhandling unit and normal movement of air should never be interrupted during the working hours. Spare blower, motor and controls, etc. should be held in ready stock for emergency use to minimize down time.

Types of Air Conditioning Plants

19. For ready off-the-shelf availability, the air-conditioning manufacturers have brought out the room air-conditioner (also popularly called as window air-conditioner) and the package type air-conditioner. In addition, the central type of air-conditioning plant is also in vogue. These are briefly described in the succeeding paragraphs.

Room (or Window) Air-Conditioner

20. These air-conditioners are factory assembled composite small units, mass produced for instant use for providing human comfort conditions (Fig. 2). The most popular size is the 1 Ton and 1.5 Ton units. Room air-conditioners are covered by IS 1391: Part 1: 2017 Room Air Conditioners - Part 1: Unitary Air Conditioners and IS 1391: Part 2: 1992 Room Air Conditioners: Part 2 Split Air Conditioners (Reaffirmed 2013). The only advantage attributable to this type are the ready availability coupled with instant installation as plant room, ducting, elaborate electric and water services are not required.

21. These air-conditioners have several limitations as given below:

(a) They can lower the room temperature by a maximum of 14 to 17 ^{0}C(57 to 63 ^{0}F) from the ambient, but they cannot control the inside temperature effectively.

(b) They are totally ineffective in controlling relative humidity.

(c) They have to work with maximum recirculation of air and cannot provide more than about 1½ fresh air changes per hour.

(d) They have to be mounted on the periphery of the space to be conditioned. The blower unit is small and hence does not permit provision of air ducts.

(e) Their capacity of filter air is very nominal. They do not give sufficient air circulation in the room also.

(f) The electrical components incorporated are normal and cannot be improved due to space restrictions.

22. In view of the above limitations, these machines are NOT suitable for use in explosive buildings.

Split Type Air Conditioners

23. These are factory assembled units in standard capacity of 1 ton, 1.5 ton, 2 ton and 2.5 ton. In split type air conditioners the compressor & motor as well as condenser and its cooling fan are located at a distance from the air conditioned space. In explosive buildings where no humidity control is required, the split air-conditioner to be used should meet the following stipulations:

(a) The blower motor should comply with the standards specified for the electrical installation in the building in which it is being used.

(b) All the control switches for the blower unit should be located in the compressor room for split air-conditioner and compressor room should be located beyond the traverse wall of the building.

(c) The compressor motors and all the electrical installation/apparatus associated with it in the compressor room should be totally enclosed (TE) type.

(d) The split air-conditioner should be certified from CIMFR, Dhanbad for use in explosive buildings.

Package Type Air-Conditioners

24. These are also factory assembled units in standard capacities of 5 ton, 7.5 ton and sometimes 10 ton. Their shape resembles steel almirahs, the compressor-motor-condenser unit being located in the lowest portion and the middle and top portions containing the air filter-cooling coil and blower-motor unit (Fig. 3). They are invariably water-cooled and need pump-sets with cooling towers. A plant room has to be provided to house them and their accessories. Since the blower unit is somewhat powerful, short lengths of supply and return air ducting can be provided for air distribution in the conditioned space and for installing the units in a separate adjoining room. Also the manufacturers sometimes agree to modify their standard design slightly to suit customer's requirements of temperature, relative humidity, air purity and quantity. These units, being somewhat bigger require adequate external electric/water supply services.

25. Their construction is such that the air handling unit cannot be effectively sealed and separated from the compressor-motor compartment. Hence flammable explosive vapour or dust reaching the blower through the return air duct has easy access to the compressor-motor

unit. This can prove to be very dangerous. Also the explosive vapour / dust can leak out of the unit and spread inside the plant room coming in contact with all electric gadgets provided therein. This enhances the risk of fire and explosion.

26. Since it is possible to adopt central air-conditioning system of equivalent capacities incorporating the requisite safety specifications, the use of package type air-conditioners in explosive process buildings is not desirable. However in explosive storage buildings, the package type air conditioners are permitted with following stipulations:

(a) The blower motor and compressor motor and all the electrical installations in the weather maker/plant room should be totally enclosed type.

(b) The plant room including weather maker room should be sited beyond traverse wall and only ducting should be used to connect the air conditioned space and weather maker room.

(c) Approved type of fire dampers as per specification given in STEC pamphlet No. 22 should be installed in A/C duct so as to ensure that in case of fire emanating from weather maker room plant room, it does not travel to conditioned space & vice versa.

Central Air Conditioning Plant

27. A typical central air-conditioning system is depicted in Fig. 4. In this case the individual components of the system are specially selected, matched and put together at site to provide the specified inside conditions of temperature, relative humidity, air purity and quantity, air flow pattern etc. The system is similar to that shown in Fig. 1 and should NOT be confused with a "centrally located" plant.

28. These installations are tailor made for a specified and predetermined purpose and could be of any capacity to suit the requirements. They need plant room, air ducting, pumpsets and cooling tower, adequate and reliable external electric/water supply services and trained operators. The most important factor in their favour is that adequate and requisite safety can easily be incorporated to make the installations safe for use in explosive buildings.

29. As central type air-conditioning plants can be rendered intrinsically safe and can provide guaranteed performance to comply with specified conditions, their choice is automatic in almost all cases.

30. Central air-conditioning plants could work either on the direct expansion system or the chilled water system which are described below:

(a) **Direct expansion system**: In the system depicted in Fig. 1 and Fig. 4, the air under circulation is cooled directly by the refrigerating plant's cooling (or evaporator) coil. This arrangement is simple and direct in nature. The airhandling unit has perforce to be as near as possible to the rest of the refrigerating machinery and the length of supply/return air ducting is limited by practical consideration which places a certain restriction on the size of space that could be conveniently air-conditioned with one airhandling unit.

(b) **Chilled water or indirect system**: This is shown in Fig. 5. Ordinary clean water is chilled by the cooling (or evaporator) coil of the refrigerating plant and then pumped through the cooling coil of the airhandling unit where it cools and conditions the air passing over it. This system enables one air-conditioning plant of adequate total capacity to condition very large areas with multiple air handling units or several buildings/several floors of the same building with separate and individual air handling units. Also the air-conditioning plant room itself could be located at the center of gravity of the load or at a convenient distance away from explosive buildings. The chilled water pipes are insulated and covered with suitable protective material, and can be run either below or above ground in any fashion that is convenient.

Air HandlingUnits

31. The air handling unit conditions the air and the blower provided in it creates the air flow through the supply and return air ducts. The air handling units (which generally contains air filter, cooling coil, humidifier, blower and motor etc.) is exposed to the effects of the explosive vapour/dust particles that are carried to it via the air ducts. In fact, by and by, the complete weather maker room itself gets polluted by the explosive material and the olfactory senses can easily detect the presence of the same atmosphere here as in the main building. The provisions for the weather maker room should therefore compare with those for the conditioned buildings.

32. Air filters are provided to obtain the desired purity of the circulating air by filtering solid particles. They are not effective against vapours. Air filters provided on the fresh air intake get rid of the atmospheric dust and floating matter. Air filters can also be incorporated in the air handling unit and or in the return air duct to trap dust particles emanating from the conditioned space. However, while the air filters function effectively in trapping the explosive dust, it should be realized that the explosive dust particles keep on collecting at the filter material and may soon reach a high concentration level. The air filter then becomes a very dangerous spot where an explosion or fire can easily occur due to the rubbing effect/friction generated while removing the filter panel for maintenance. Hence indiscriminate use of air filter in the return air duct should be avoided. The design of the air filter unit should be such that no rubbing or sliding effect or friction is involved in the assembly or disassembly operations done during periodical maintenance. Air filter material should inherently be non-combustible. Coir and paper based filter materials should not be used. A wetted type or viscous type of filter is preferable from safety angle. No definite periodicity can be laid down for inspection or maintenance of air filters, but the same should be governed by actual ground conditions.

33. Cooling coils are made of copper or aluminium tubing with fins of copper or aluminium. It is essential that the explosive vapour or dust has no deleterious effect on the cooling coil material. Some examples are given below :

Metal	Compatible	Incompatible
Aluminium	CE, RDX, Hexolite, TNT, Nitrocellulose, propellants both single and double based.	PETN, Pentolite, gun powder.
Copper	CE, TNT, NC propellant, lead styphnate.	RDX, gun powder.

Air Ducts

34. Supply and return air ducts are provided for conveyance of air from and to the conditioned space. Supply and return air grills are provided on the air ducts at appropriate places to control the volume of airflow from and into the duct. IS: 655-1963 (Revised with amendment No. 1) deals with "Metal Air Ducts".

35. Air ducts are a great source of danger arising from accumulation of explosive vapours or dust particles inside them. These are made with airtight joints and generally covered by insulating material and false ceiling, which hampers subsequent strip inspection and maintenance. Fine explosives dust carried along by the motion of air settles inside the ducts to form an encrustation so hard that it cannot be removed even by chipping. Also if the return air duct is terminated at the entrance to the weather maker room (as shown in Fig. 1), then the explosive material will spread in the weather maker room. This fanning out of explosive material could be dangerous. Hence connecting the return air duct to the air handling unit, as shown in Figs.5 & 6, may be more advantageous. It is very important that design, fabrication and installation of ducts are done with utmost care and foresight.

36. The air ducts, once fabricated and installed, are rather difficult to inspect and maintain. Since these are a source of greatest danger, dedicated efforts should NOT be spared towards their regular inspection, maintenance and safety checks. No hard and fast maintenance/inspection periodicity can be specified, but these are to be determined by the actual ground conditions.

Fire Dampers

37. All ducts provide a convenient passage for fire to travel and spread out. Fire dampers are used to block the flow of air and prevent propagation of fire through air ducts. It is mandatory to install fire dampers for all air-conditioned explosives buildings. These could be designed for manual or automatic operation. Automatic fire dampers are generally held open by a fusible link which melts when heated to a predetermined temperature and allows the damper to close shut. However, their operation could also be controlled by electric solenoids triggered by fire alarm systems.

38. Fire dampers are generally required at the following places:

(a) Where the duct passes through a fire partition having a fire resistance rating of not less than two hours.

(b) Where supply or return branch ducts are connected.

(c) Where a branch duct goes through a fire resisting ceiling or floor.

(d) Where the duct passes vertically through an opening.

Air Washers

39. Washing of the return air from the conditioned space by water spray bank could be very effective in extraction of explosive dust particles (see Fig. 7). The water spray bank and spray eliminators (for preventing water droplets from being carried away by air) could be conveniently tucked into the return air duct itself or could be arranged in a separate ante-room beside the weather-maker room. Depending on the pollution level in the return air, water spray washing could be duplicated to ensure maximum settlement of explosive particles thereby rendering the return air to the air handling unit as safe as possible. Care should be taken to employ sufficient number of spray nozzles with correct spacing and the water pressure should be sufficient to result in a fine misty spray. A water filter should be provided to ensure that nozzles do not get clogged with dirt. A toughened glass view window should be provided to enable visual check of the water spray. The water pump and sump could be located in safe area far removed from the explosives contaminated area. Effective make-up water and drain connections should be provided. The periodicity for water change over should be fixed based on actual ground conditions and the disposal of sludge / dirty water should be done following safety procedure. Air washers can be effectively used for cleansing the return air, but they cannot reduce the pollution level inside the conditioned space itself.

40. Water spray washing increases the relative humidity of the return air and imposes additional cooling load on the air-conditioning plant. But this is a small sacrifice to make compared to the important advantages accruing form the use of this cleansing system. Water spray washing is suitable for use in place of air filters in the return ducts.

41. Water spray washing of return air should not be carried out with chilled water from the chiller unit. The water loop of the water spray system should be distinctly separate from the chilled water loop and the condenser cooling water loop of the air-conditioning plant.

Humidification and Dehumidification

42. Humidification involves addition of moisture to the air to increase its relative humidity. This is an important operation and is resorted to for facilitating certain production processes and to reduce generation of static-electricity which is otherwise produced in dry air-conditions. This is mostly used in conjunction with air-conditioning and sometimes by itself.

43. Humidification could be achieved in the following ways:

(a) Steam pan humidifier: Water in a flat pan is heated by electric immersion heaters and evaporated to add moisture to the air. This system is susceptible to danger as the electric heater can develop high temperature in the absence of water.

(b) Steam jet humidifier: Low pressure steam is admitted in a controlled fashion directly into the air stream or into the conditioned space itself to add moisture to the air. This system can give high relative humidity, but has a tendency to increase the inside temperature due to the steam latent heat, or add to the cooling load on the air-conditioning plant. This method is therefore NOT always convenient.

(c) Dry steam diffusion type humidifier: Steam at low pressure is first dried and then throttled through a screen before it is allowed to mix with air stream. Apparently this has the same disadvantage as the steam jet humidifier.

(d) Water spray humidifier : A fine, misty spray of water could be added to the air stream and three ways of achieving the same areas under :

(i) By a pump and spray nozzle combinations located near the cooling coil. The air stream passing through the spray picks up moisture and relative humidity of up to about 60% can be achieved. This method has the added important advantage of cleansing the air of explosive dust particles.

(ii) By compressed air and spray nozzle combination located in the air stream or directly in the conditioned space. Compressed air forces the water through minute orifices and the water converts in the form of a mist. This method is simple and safe, but needs an air compressor and does not assist in removing explosive dust particles.

(iii) By spinning plate atomizer principle: Water is forced by an electric motor driven pump through orifices in a spinning plate. This generates a fine mist of water. Since the motor is of normal specifications, this method is unsafe for use in explosive buildings.

(e) Evaporative cooling of air: Air is drawn through a water spray bank created by pump nozzles arrangement. The air evaporates the minute water particles and thereby picks up moisture. It also sheds the explosive dust particles and becomes cleaner which is an important advantage. By locating the electric motor driven pumpset in a safe place into which the explosive dust laden air has absolutely no access, the whole arrangement could be made safe. This system could be used to great advantage in hot and dry atmospheres as cooling of air is also automatically obtained and hence the inside space gets conditioned somewhat. The smaller units using KhasKhas screens are popularly called as desert coolers and could be used in explosive buildings by incorporating improvements to the electrical system and using a motor of higher specification (flame proof, dust-tight etc.) for driving the pump.

44. Dehumidification involves the withdrawal of moisture from the air to lower its relative humidity. This generally becomes necessary during wet monsoon months to facilitate production processes and prolonging storage life of explosives.

45. Dehumidification is achieved mainly by the following two ways:

(a) By excessive cooling of air by the air-conditioning plant to condense out moisture and then reheating the air to the desired level to reduce its relative humidity. This system can yield relative humidity above 40 to 45%. Subsequent reheating of air is achieved by electric strip heaters, by steam or hot water coils. Several electric strip heaters are installed in the air handling unit or in the supply air duct near to the air handling unit and they are energized in stages by an automatic contractor (Fig. 8). The electric strip heaters have the inherent danger of attaining excessively high temperatures and risk of short circuiting. Also the electric cabling needs constant attention to ensure proper contact and continuity. In view of these factors, electric strip heater is NOT considered suitable for use in explosive buildings. They should not be used except in exceptionally safe cases adopting maximum safety precautions. Heating by hot water coil is safer than heating by steam coil, but the coil size is likely to be bigger. A hot water or steam boiler together with all accessories becomes necessary. However, any one of these heating coils could be used for reheating of air. Reference should be made to IS: 659-1964 (reaffirmed 2017) 'Safety Code for Air Conditioning (Revised)' for information about heating.

(b) By chemical dehumidification using adsorbents: Moisture can be withdrawn from air by passing it over a desiccant that has affinity for water vapour. When moisture is absorbed by the desiccant, latent heat is liberated which elevates the air temperature. Thus the air after the drying process attains a high temperature, in most cases exceeding 40^0C (104 ^{0}F) which would be unacceptable in explosive building. Hence the dried air has to be subsequently cooled before being admitted into the conditioned space. This cooling is best achieved by air-conditioning; alternatively by a cooling water coil through which circulation of ordinary water is kept up by a pump. The desiccant needs frequent reactivation which is achieved by blowing hot air over its surface to evaporate the trapped moisture. By chemical dehumidification relative humidity as low as 10% can be achieved. Chemical dehumidifier models have electric motors, heater, blowers, time switches, relays and contacts electric wiring etc. inbuilt in them. Generally these are of normal specifications quite unsuitable for use in explosive buildings and will have to be replaced by those with higher specification (like flameproof, dust-tight, etc.) before the unit as a whole can be considered safe for use in explosive buildings. Hence before deciding on using any model of chemical dehumidifier, its constructional details and specifications should be critically examined from safety angle and changes effected wherever necessary. Chemical dehumidifiers consume considerable electric power. Wherever very low relative humidity is aimed at, careful note should be taken of the generation of static electricity in dry atmospheres.

Reducing Relative Humidity

46. In the dehumidification processes considered above; lowering or relative humidity is achieved by reducing the moisture content of the air. However, relative humidity can also be lowered by raising the air temperature without extraction of moisture from it. red lamps, The relative merits of electric/steam/water heating have been given in para 45 (a) above. Infra-red rays provide heating by radiation and are NOT safe or convenient for the purpose under consideration. Reducing relative humidity by heating alone appears to be an attractive proposal due to its simplicity and low cost. However, this method could be acceptable during winter months; but during monsoon months, the extent of heating involved to lower the relative humidity will result in a much higher temperature in the conditioned space than the ambient temperature and will create uncomfortable working conditions. Hence this method is NOT acceptable in case of explosive buildings.

Controls used in Air Conditioning

47. The common controls used in air-conditioning are the following:

    (a) Low pressure and high pressure safety controls – used for stopping the compressors in case of very low pressure (vacuum) or excessively high pressures developing in the refrigerating system (see clause 2 “Terminology” in IS: 660-1963 (reaffirmed 2017) Safety Code for Mechanical Refrigeration”)

    (b) Thermostat control – for maintaining desired inside temperature in the conditioned space.

    (c) Humidistat – for maintaining desired humidity in the conditioned space.

    (d) Automatic contactors for pre-heaters – for energizing the heaters in stages to reheat the supply air to the required temperature.

48. All these controls are electrically operated, mostly on 220 volts, and have electric make and break contacts. During operation, sparking at the contacts is inevitable which could prove extremely dangerous in case of explosives buildings. Therefore selection of the location for installing the controls should be done with utmost care.

49. The low pressure and high pressure cut-outs, and the automatic contactors for heaters, are generally located in the compressor room portion of the air conditioning plant room (see Fig.

1 and 4). Explosive vapours and dust do not have access to this region. Therefore the operation of these controls does not pose any danger.

50. The thermostat for temperature control is actuated by a thermostatic bulb and long capillary tube arrangement. Thus the temperature control as such containing the electric contacts could be located in the compressor room portion of the plant room and only the probe portion of the control extended into the weathermaker room. Since the explosive vapour/dust does not have access into the compressor room, the operation of the thermostat control does not pose any danger. In case the thermostatic control operates the refrigerant solenoid valve (where provided), the refrigerant solenoid valve should also be located in the compressor room portion of the plant room. The main point to ensure is that explosive vapour / dust should not have any access to the thermostat control, which therefore will have to be located in an uncontaminated safe place. In chilled water systems, the thermostatic control could be located in the compressor room and will pose no problem.

51. The humidistat used in air-conditioning has been of imported origin. The common type works on the sensitivity of hair elements. The hair element is humidity conscious and actuates the electric contacts through leverages and springs. The whole assembly is a compact unit and for efficient operation, the hair element has perforce to be kept in the air shower whose humidity condition it is to sense. Thus the obvious location for this humidistat unit is in the return air path inside the weather makerroom. When flammable or explosive vapour/dust is present in the return air, the sparking at the electric contacts during make or break operation will prove disastrous. There is no possibility of quenching the spark or isolating the electric contacts from the hair element assembly so that the contact could be located in a safe atmosphere. Therefore, this type of control is definitely NOT safe for use with air-conditioning system of explosives process/laboratory buildings. The utility of this control for air-conditioning systems of explosives storage buildings is also in serious doubt and therefore it is best to avoid use of this control. One particular model of explosion proof humidistat considered safe for use in hazardous buildings is available from M/s Bry Air. Alternatively, the other solution is to omit the humidistat control altogether and operate the plant manually, guided by periodic readings of dry/wet bulb temperatures inside the conditioned space. This calls for skill, experience and dedication on the part of the plant operators. To help matters, the maximum relaxation in relative humidity drift should be permitted by the Users.

52. Some firms are at present engaged in developing and perfecting electronic humidistat control. Until full technical details are available and their performance established, no firm comments could be offered about their suitability for use in air-conditioning systems of explosive buildings.

Refrigerants and Effect of Fires

53. Modern air-conditioning plants work with refrigerants from the Freon family and they are Freon-11, Freon-12 and Freon-22. Ammonia is also sometimes used in cold temperature installations (but rarely in modern air-conditioning plants).

54. The Freon group is neither flammable nor explosive and hence is considered as a safe refrigerant. Ammonia is considered to be moderately flammable and forms an explosives mixture with air when present in the right proportions.

55. When fire occurs nearby, radiant heat reaching the air-conditioning plant can generate high pressures inside the system. This could cause leakage of refrigerant through safety valve or pipe rupture, If Freon is the refrigerant, then it may decompose into toxic gases in contact with fire. In case of ammonia, the fire may increase in violence or an explosion may take place. For these reasons, the area around the plant room should be free of all combustible materials and such materials should not be stored in the plant room. In case of fire, the air-conditioning plant should be shut down following the correct procedure and a vigil maintained to detect refrigerant leakage or other ill effects.

56. As regards fire alarm and fire fighting system, the users shall obtain the recommendations of the Director CFEES.

General Considerations for Air-Conditioned Explosives Buildings

57. Technical requirements for the construction of explosives storages are given in STEC pamphlet No. 3. Explosive building intended to be air-conditioned deserve extreme care and attention during planning/design stages. Reliable and continuous air-conditioning service is extremely vital for the well being of the occupants. Serious consideration is, therefore, necessary for the provision of stand-by units/air-conditioners, spare blower and motor and adequate/ample spares.

Air-Conditioning Plant Room

58. The plant room for housing the central type of air-conditioning plant could be imagined to comprise the compressor room and the weather maker(see Figs. 1 & 4). The preliminary considerations regarding the possible locations of this plant room with respect to the main air-conditioned building would be as follows:

(a) Single building, untraversed.
Plant room attached to the building.

Advantages:

(i) Simple direct expansion system
(ii) Least ducting: Less danger from dust accumulation.Cleaning easy.
(iii) Least cost.

Disadvantages:

(i) Plant operators exposed to danger.
(ii) Loss of plant inevitable in case of accident.
(iii) Fire/accident in plant room is more likely due to equipment in it and this can easily spread to main building.

(b) Single building, untraversed.
Plant room separated by blast wall, but weather makerroom attached to the building.

Advantages:

(i) Plant operators quite safe.
(ii) Plant safe in case of accident.
(iii) Least ducting: Less danger from dust accumulation.

Disadvantages:

(i) Chilled water system costlier.
(ii) Air handling unit performance difficult to monitor.

(c) Single building, traversed.
Plant room outside traverse.

Advantages:

(i) Plant operators relatively safe
(ii) No increase in traverse length
(iii) Simple direct expansion system
(iv) Very suitable for all fresh air system
(v) Plant safe in case of accident

Disadvantages:
(i) Long duct, more initial cost, increased dust collection, difficult to clean.
(ii) If duct runs through traverse, it will weaken it.
(iii) Rather inconvenient for re-circulated air system.
(iv) Separate lightning protection required for plant room.

(d) Single building, traversed.
Plant room attached to the building.

Advantages*:*
(i) Simple direct expansion system.
(ii) Least ducting. Less danger from dust accumulation. Cleaning easy.
(iii) Least cost.
(iv) Lightning protection may NOT be required for plant room.

Disadvantages:

(i) Plant operators exposed to danger.
(ii) Loss of plant inevitable in case of accident.
(iii) Increase in traverse length. Very costly.
(iv) Fire/accident in plant room is more likely due to equipment in it and this can easily spread to the main building.

(b) Single building, traversed.
Plant room beyond traverse, but weather maker room attached to the building and inside the traverse.

Advantages:

(i) Plant operators relatively safe.
(ii) Plant safe in case of accident.
(iii) Least ducting. Less danger from dust accumulation. Cleaning easy.
(iv) Very suitable for re-circulated air system.

Disadvantages:

(i) Chilled water system costlier.
(ii) Marginal increase in traverse length.
(iii) Air handling unit performance difficult to monitor.

59. The above preliminary considerations reveal that, for a small increase in initial cost, the chilled water system is the most suitable arrangement. The important advantages gained are the requirement of least ducting and suitability for both re-circulated and all fresh air systems. It becomes evident that, with the plant room outside the traverse as shown in (c) above, use of direct expansion system will be inconvenient because ducting will be a major problem which becomes worse with recirculated air systems (as the return duct size is very considerable). The arrangement shown at (d) above, being similar, suffers from the same disadvantage. If the plant room is attached to the main building as shown in (a) and (e) above, then the element of risk is somewhat enhanced because of the dangers associated with electric power consuming apparatus machinery and their proximity to the explosive materials in the main building. Sometimes even physical constraints like insufficient space/land influence the location of plant rooms.

Plant Room Location and Type of Air-conditioning System

60. The factors involved in locating the plant room and selecting the type of air-conditioning system are somewhat inter-dependent and demand careful consideration. All decisions should be towards ensuring safety from fire hazard, because the building will contain explosives and the plant room will have electrically operated machinery/controls. Incidence of fire in any one of them, which is very much possible, will pose danger to both of them simultaneously. Use of a simple, reliable air-conditioning plant with minimum ducting is definitely a step towards safety.

61. Locating the air-conditioning plant room or even the weather maker room inside the air-conditioned building is not recommended.

62. In case of Categories ‘A’ and ‘B’ buildings, the air-conditioning system shall be of chilled water type. The plant room shall be located beyond the traverse or SIQD and the weather maker room shall be near to or even attached to the conditioned building. When attached, the wall separating the weather maker room from the building shall be a brick or RCC wall of specified thickness.

63. In the case of small, traversed Category ‘A’ buildings, the air-conditioning system could be of the direct expansion type. The plant room (including the weather maker room) could be located outside the traverse.

64. In the case of small, traversed Category ‘B’ building, the air-conditioning system could be of the direct expansion type. The plant room (including the weather maker room) could be attached to the conditioned building, in which case the wall separating them shall be a brick or RCC wall of specified thickness, or could be located conveniently near to the conditioned building inside the traverse.

65. In the case of Category ‘C’ building, chilled water type of air-conditioning plant is preferred in comparison with the direct expansion system, but is NOT essential. With chilled water system, the plant room could be located beyond the traverse or SIQD and the weather maker room located near to or even attached to the conditioned building. When attached, the wall separating the weather maker room from the building shall be a brick or RCC wall of specified thickness.

66. In the case of small, traversed or untraversedCategory ‘C’ building, the air-conditioning system could be of the direct expansion type. The plant room (including the weather maker room) could be attached to the conditioned building, in which case the wall separating them shall be a brick or RCC wall of specified thickness, or could be located conveniently near to the conditioned building (inside the traverse, if provided).

67. In very exceptional cases, package type air-conditioners housed in a separate room and using air ducts could be provided in case of Category ‘C’ building if the safety aspects are not compromised and always with the prior concurrence of STEC.

68. In case of buildings with several internal bays/rooms to be air-conditioned, safety demands that the individual bays/rooms be separately served by the air-conditioned plant to eliminate the risk of fire spreading from one place to another through the air ducts. Where this is practically not feasible, grouping of bays/rooms could be resorted to with major accent placed on safety. If direct expansion system becomes a cumbersome arrangement, chilled water system with a adequate number of air handling units should be used.

69. When a group of buildings are to be air-conditioned, chilled water system shall be used.The plant room shall be located beyond the SIQD. Each building shall be served by its own

weather-maker unit (s) which shall be housed in weather-maker room (s) attached to the building and separated by a wall of specified thickness or located conveniently near to the buildings.

70. In all cases considered above, the weather maker room shall have the same specifications as the air-conditioned buildings served by them. All electrical items in the weather maker room (s) shall be of same category/specifications as adopted for those in the conditioned buildings.

Summary

71. Air-conditioning and its allied services are finding an important application in the explosives manufacturing and storage activities. Now-a-days the requirements are varied and are becoming increasingly stringent with the advancements in modern technology. The air-conditioning system adopted could be anything from the simplest to the most complicated type supported by several adjuncts to fulfill its roll. In view of the complexity of the equipment involved in this service, each and every equipment should be subjected to a critical examination from safety angle to establish its suitability at the time of incorporation in the works.

72. In order to ensure requisite safety, the following factors should always be borne in mind in respect of air-conditioning service:

(a) Furnishing correct and complete information by the actual users (as given in proforma at Appendix ‘A’)
(b) Correct design, planning and construction of the conditioned building and the plant room.
(c) Correct selection of type and system corresponding to air-conditioning, winter heating or humidification/dehumidification.
(d) Critical examination of each and every equipment used in the installation from safety angle.
(e) Correct selection and incorporation of safety gadgets/aids and fire alarm/fighting system.
(f) Ensuring punctuality in preventive maintenance, repair and replacement schedules.
(g) Ensuring reliable and continuous air-conditioning service.
(h) Training the plant operators to be duty and safety conscious at all times.
(j) Ensuring cleanliness in and around the building and plant room.
(k) Inculcating orderly working habits in the occupants of the building and plant room.

Appendix-'A'

PROFORMA FOR AIR-CONDITIONING OF EXPLOSIVES BUILDINGS

(fill in relevant information and strike out items not applicable)

1. Location
2. Establishment
3. Number of building
4. Purpose of the building
5. Category of explosives handled
6. Building category A/B/C
7. Explosive vapour/dust generated in conditioned space.
   Quantum of generation; slight/moderate/heavy.
8. Building traversed/untravered.
9. Safety distance adopted /NOT adopted.
10. Building isolated/one of a group conditioned
11. Type of roof proposed.
12. Provision of false ceiling proposed/NOT proposed; Material of false ceiling.
13. Thermal insulation type and thickness.
14. Provision of vapour barrier proposed /NOT proposed.
15. Provision of air lock (s) proposed /NOT proposed.
16. Electric fitments and fittings in building:
    Flameproof /Dust-tight /Totally Enclosed.
17. Conditioned space inside parameters:
    (a) Temperature with tolerance.
    (b) Relative humidity with tolerance.
    (c) Internal electric equipment load: Diversity factor (if applicable).
    (d) Heat liberated inside by other equipment.
    (e) Occupancy.
    (f) Air recirculation permitted/NOT permitted.
        (i) If permitted specify maximum quantity to be re-circulated.
        (ii) If NOT permitted, viz. all fresh air system, specify normal exhausting/forced exhausting of air from conditioned space acceptable.
    (g) Air filtration level in microns.
    (h) Number of hours air-conditioning required per day.
    (j) Heating in winter required/NOT required.
        If required, temperature with tolerance:
        Humidification also required/NOT required.
    (k) Standby refrigerating unit required/NOT required.
        If required, give reasons.
    (l) Standby generating set required/NOT required.
        If required, give reasons.

18. Air-conditioning plant details

(a) Type proposed: PACKAGE/CENTRAL direct expansion system/CENTRAL chilled water system.
(b) Number of compressor units.
(c) Humidifier required/NOT required.
Type proposed.
(d) Pre-heater required/NOT required.
Type proposed.
(e) Return air washer (s) required/NOT required.
(f) Air filter (s) in return air proposed/NOT proposed
(g) Return air duct to extend/NOT to extend upto air handling unit.
(h) Fire damper (s) manual and automatic proposed/NOT Proposed.
(i) Provision of modulating motor proposed/NOT proposed.
(j) Cooling coil affected/NOT affected by explosive Material. If affected, specify material for cooling coil.
(k) Electric fittings/fitment/controls/instruments/motors etc. in weather maker room to be flameproof/dust Tight/totally enclosed.
(l) Chemical dehumidifier required/NOT required. If Required, specify electrical category.

19. Air-conditioning plant room.

(a) Compressor room attached or near to main Building/beyond traverse/beyond SIQD.
(b) Weather maker room attached or near to main Building/attached to compressor room.
(c) Weather maker room partitioned off/NOT partitioned off From compressor room.
(d) Lighting protection provided/NOT provided.
(e) Fire alarm provided/NOT provided to actuate/NOT to Actuate fire damper.
(f) Automatic fire-fighting system provided/NOT provided.

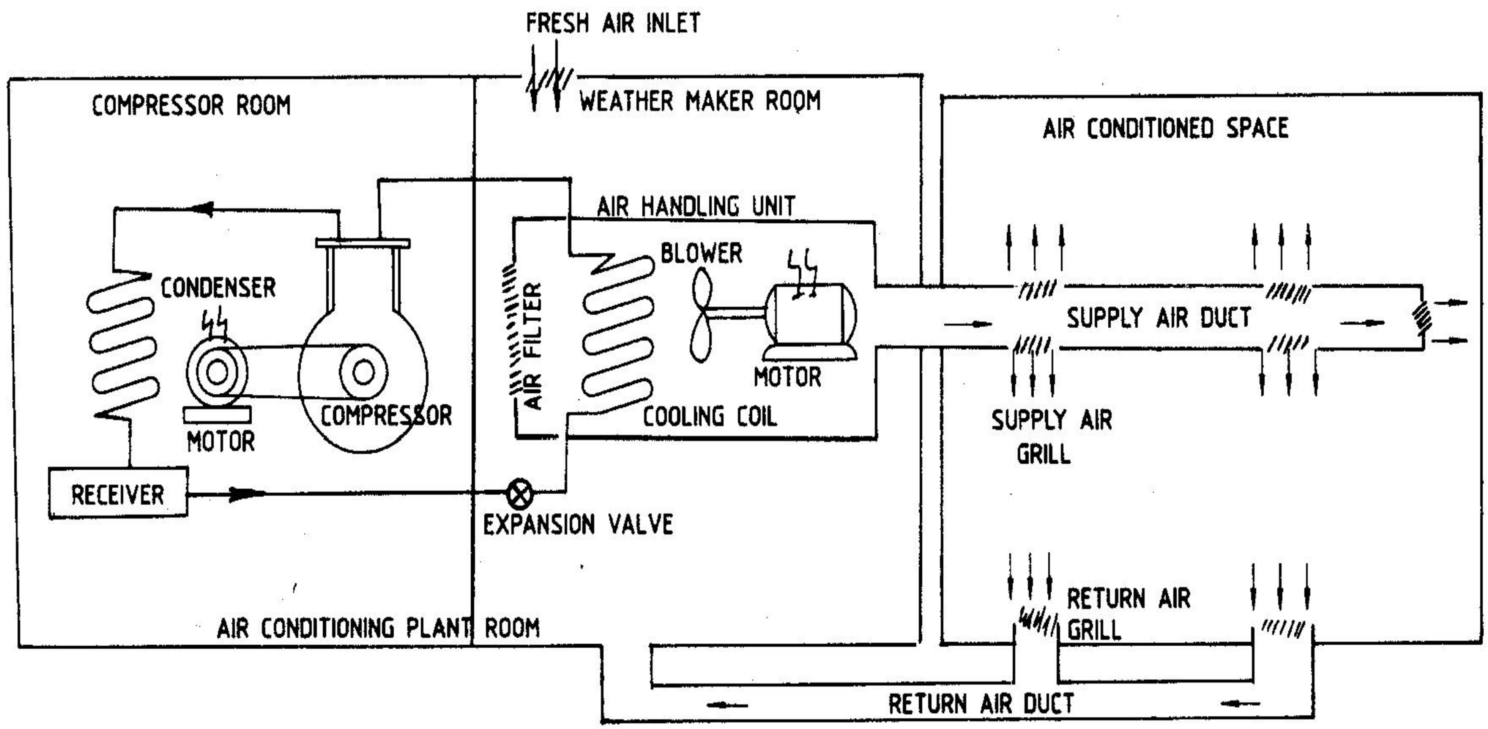


Fig 1: BASIC AIR CONDITIONING SYSTEM

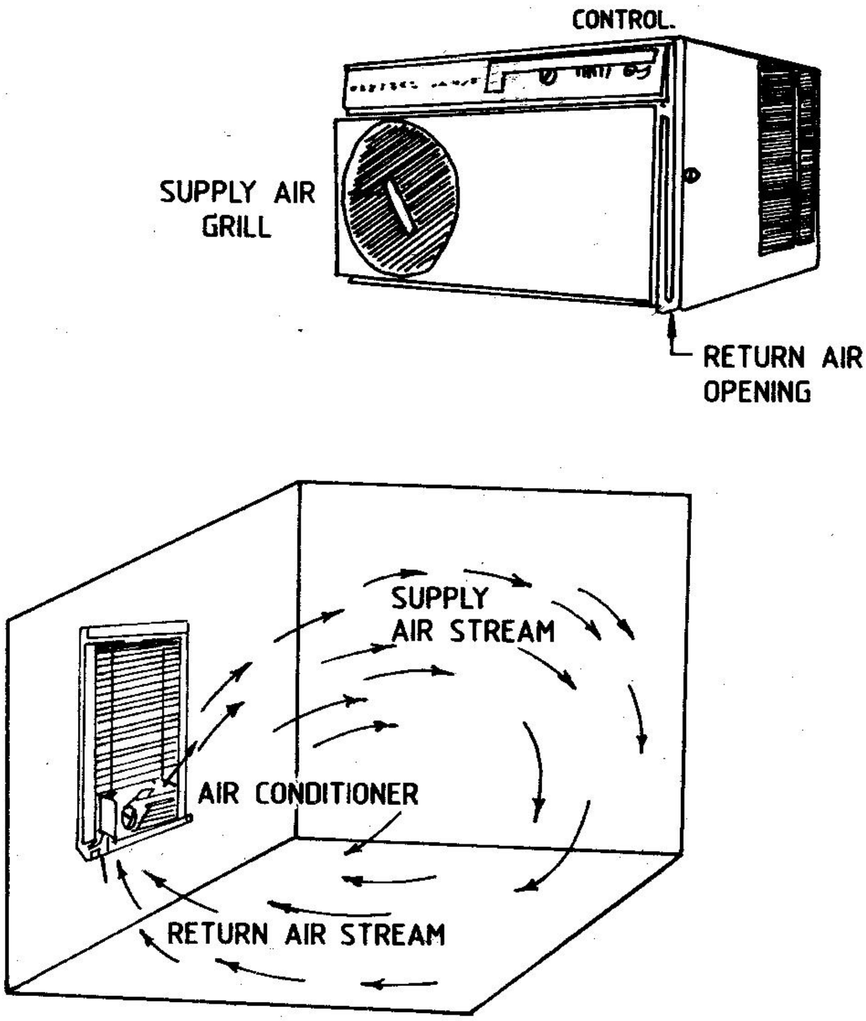


Fig 2 : ROOM (OR WINDOW) AIR CONDITIONER

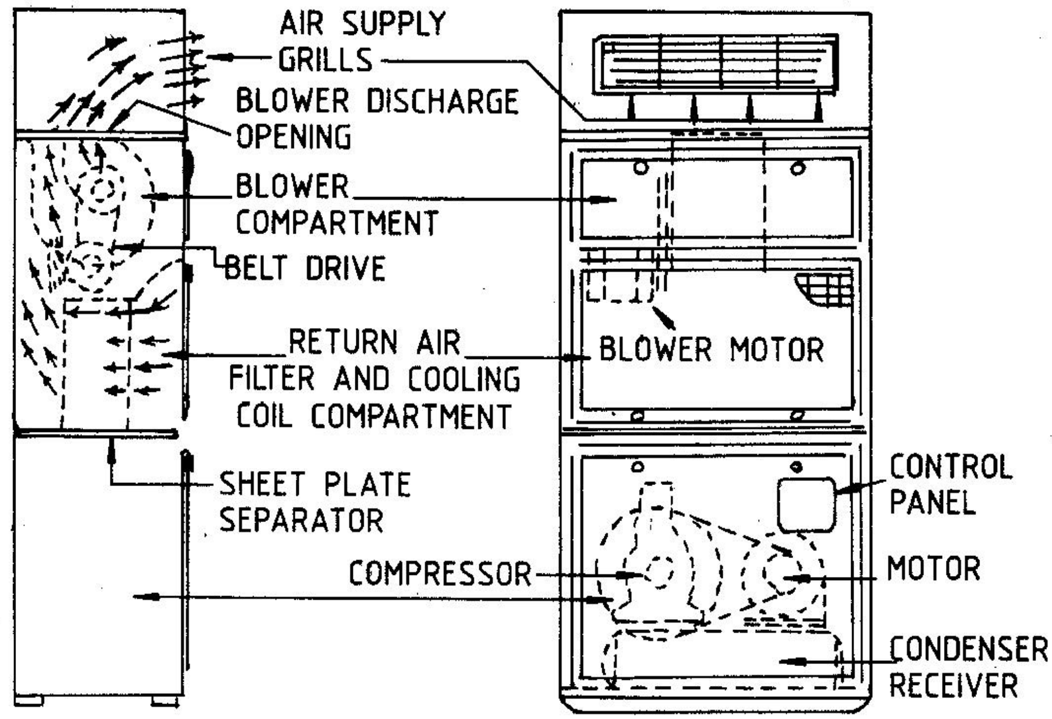


Fig 3 : A PACKAGE TYPE AIR CONDITIONER

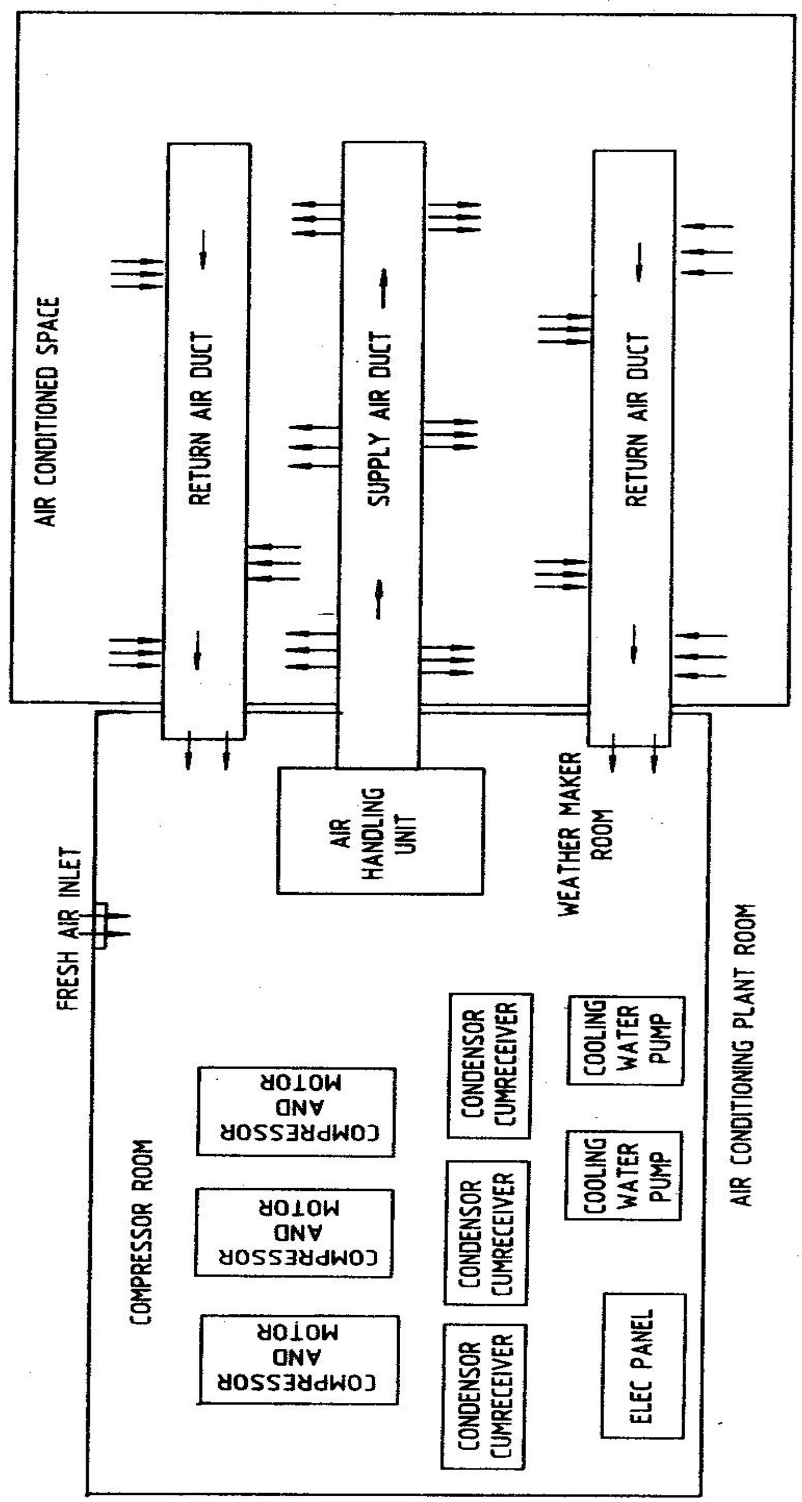


Fig 4 : TYPICAL CENTRAL AIR CONDITIONING PLANT

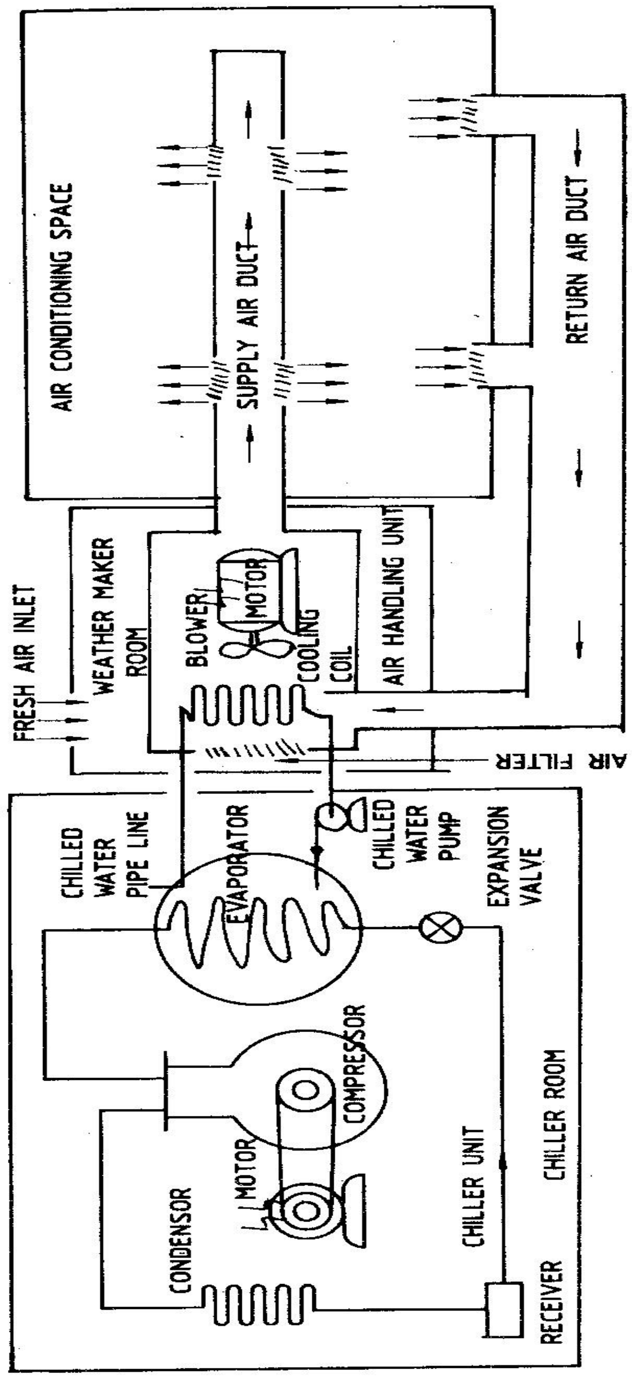


Fig 5 : TYPICAL CHILLED WATER AIR CONDITIONING SYSTEM

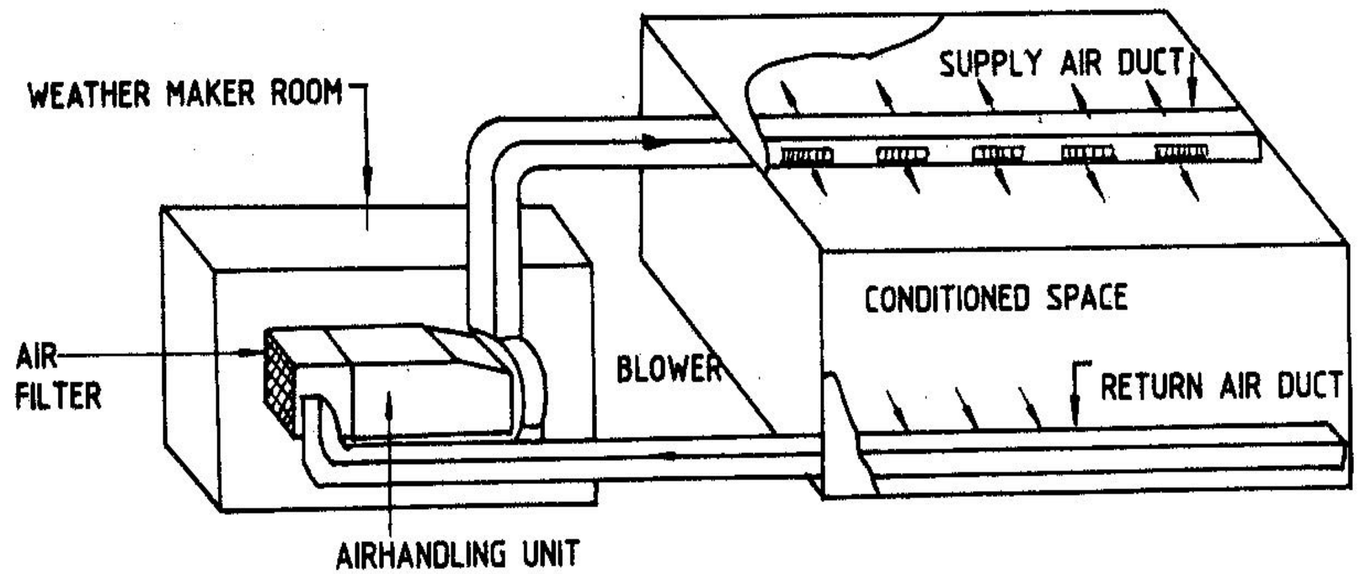
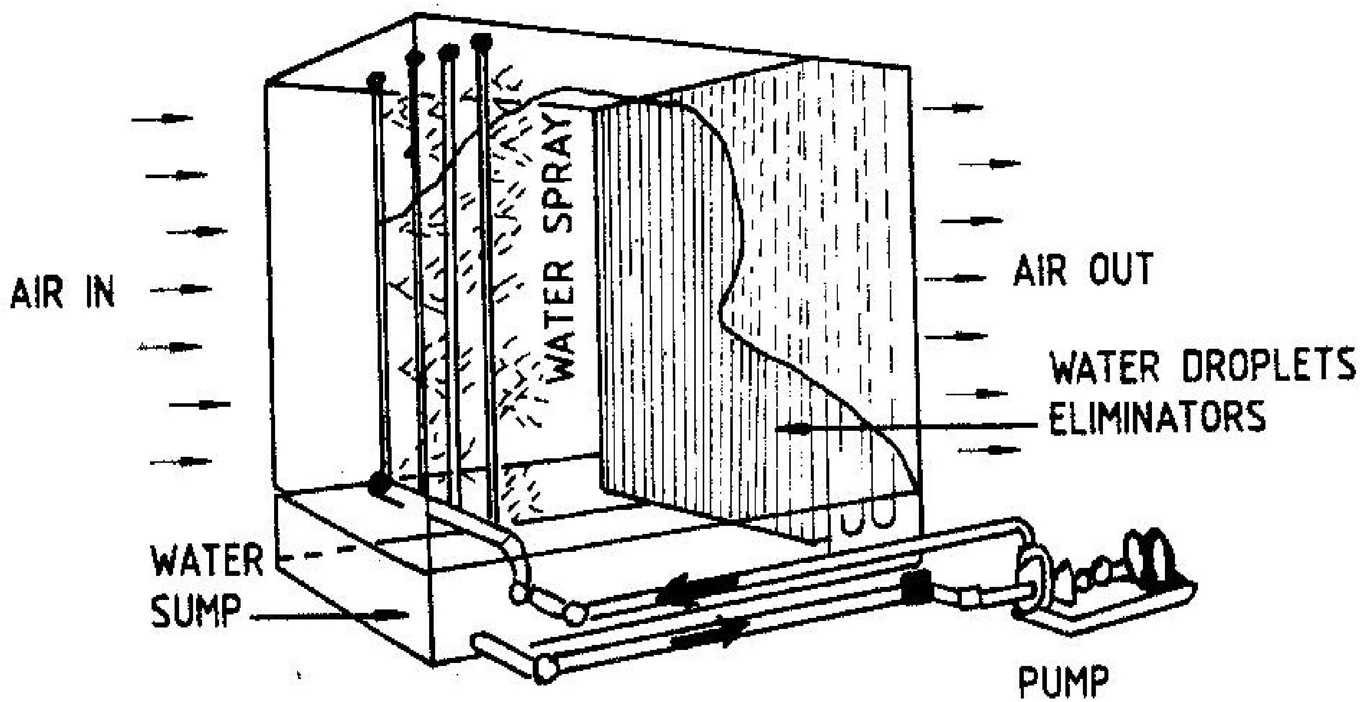


Fig 6 : RETURN AIR DUCT CONNECTED TO AIR HANDLING UNIT



(NOTE : WATER SPRAY MANIFOLD PIPES COULD BE HORIZONTAL ALSO)

Fig 7 : AIR WASHER

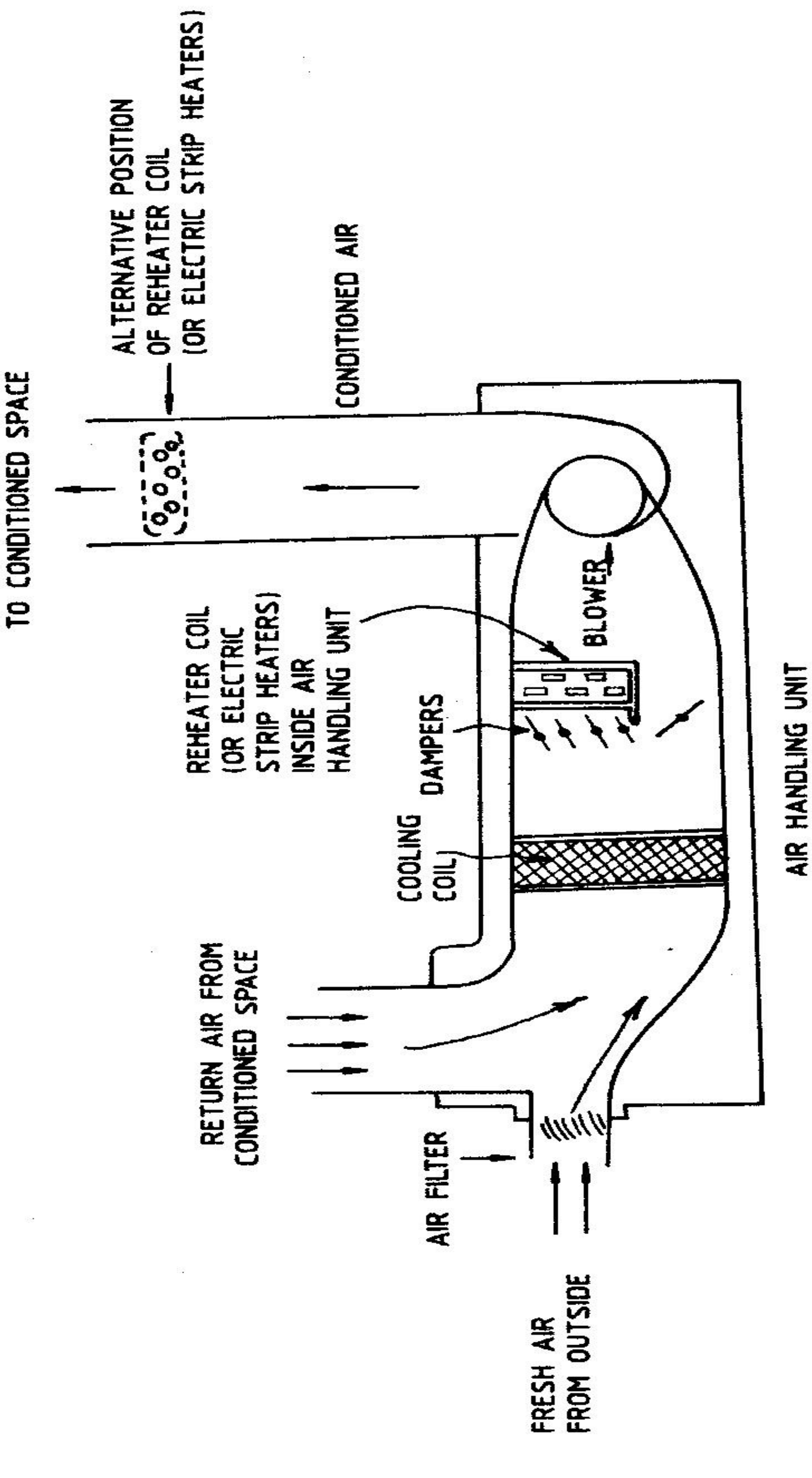


Fig 8 : POSITIONS OF REHEATERS