

INSTALLATION - OPERATING & MAINTENANCE MANUAL



PROVIDING **INDOOR CLIMATE COMFORT**

Air Handling units



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1. INSTALLATION, OPERATION AND MAINTENANCE MANUAL

1.1. SHIPPING

Units are normally shipped Ex-Works. They are inspected prior to despatch for goods condition and carefully loaded in containers with no crating/boxing. Hence, in case of transit damage, the forwarder must be informed immediately. All claims must be directed to the forwarding/insurance agents and LENNOX take no responsibility.

When units are shipped FOB port, they are either containerised or crated and delivered FOB to forwarders. Immediately upon receipt on site, inspection should be made and any damages must be reported by telex to LENNOX as well as to the forwarding/insuring agents within 24 hrs of receipt.

1.2. OFF LOADING

Special care must be taken to ensure that units are off-loaded from the containers. Rough handling can result in damage to aluminium frame work and double skin panels. It is possible to lift the sections by slings or by forklift.

Slings, preferable nylon, must be placed around the structural base frame as shown in fig 1.2-1.



fig 1.2-1

Before lifting the section, It must be ensured that the slings are properly located so they don't slide from their slot (see fig 1.2-2 and fig 1.2-3).



fig 1.2-2



fig 1.2-3

If everything is all right, then the section can be elevated and taken away (see fig 1.2-4).



fig 1.2-4

In the case in which is utilised a lifting tube, it must be inserted into the specific hole as shown in fig 1.2-5.



fig 1.2-5

Then the sling, which is equipped with a particular loop, must be connected to the tube as shown in fig 1.2-6 and fig 1.2-7.



fig 1.2-6



fig 1.2-7

After that, the section can be lifted (see fig 1.2-8 and fig 1.2-9).

to utilise slings sized on the section weight.

The larger and should be lifted with sufficiently forks to prevent underside of the



fig 1.2-8



fig 1.2-9

It is necessary opportunistically ground of the

heavier units using a forklift long extended damaging the unit.

It is strongly recommended that offloading and installation operation are carried out by specialists with necessary equipment and proper tools. LENNOX cannot accept responsibility for any damage sustained during off-loading and installation.

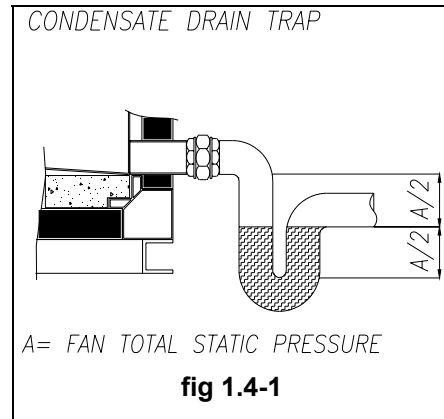
1.3. SHORT DELIVERY/DEFECTS

All items must be checked against purchase order, LENNOX drawing and the packing list for correctness and any claims for non compliance or short supply or any manufacturing defects must be reported to LENNOX by telex within three days of receipt.

1.4. INSTALLATION

Prior to installation, it must be ensured that adequate access exists for connecting all supplies, disposal of condensate/overflows, inspection, maintenance and for replacement of renewal parts such as filters, belts, bearings etc.
 Installation of units must be in accordance with good engineering practise. Structural base for the units must be level and rigid.

Further it must be ensured that the base is high enough from the floor to allow the installation of condensate drain with necessary trap for easy flow as show in fig 1.4-1. It is suggested to take advice for locating the suspension points for ceiling hung units.



1.5. ASSEMBLY

Units are normally designed to make best use of containers (shipping) volume in two or more sections depending on the design of units. However all the sections are externally marked and their sequence of assembly can be easily identified from the enclosed drawings.
 Once all the sections are located, they can be easily aligned and locked together.



First of all, between the sides of the sections that shall be connected, it must be inserted a continuous foam gasket for airtight seal as illustrated in fig 1.5-1.

Push the sections towards one another, making sure that they are lined up with one another.

Consequently the sections are locked together by bolts located in factory pre-drilled assembly holes (see fig 1.5-2 and fig 1.5-3) into the corner brackets on the inside of the frame. Make sure that they are firmly in position.

Necessary stainless steel bolts and foam gaskets are supplied in a bag, normally located within the respective section.

fig 1.5-1



fig 1.5-2



fig 1.5-3

It must be noted that, during installation and assembly, there is a possibility of misalignment if individual sections are not carefully handled. Do not use excessive force to align because it may deform the aluminium structural framework.

In the case it is not possible to access the inside of the casing, the connection can be made either by opening an inspection door or by removing a wall panel.

While LENNOX take no responsibility for consequences due to mishandling etc, will try to assist to ensure that units are properly installed. In case services of factory personnel are required for assembly the same can be provided at extra cost.

1.6. SETTING UP OF COMPONENTS

Duct connection: when duct flanges are connected to damper frames, it must be ensured that the fixing bolts are of correct length and do not obstruct the movement of damper lever/linkages.

1.6..1. DAMPERS

All dampers must be checked for free movement prior to proceeding further.

- 1) *Manually operated dampers* can be adjusted to obtain the required airflow, by loosening the bakelite knob and then turning the control lever. Bakelite knob must be tightened after setting up at the desired location on locking quadrant.
- 2) *Motorised dampers* are supplied with the linkage rod for connection to the actuator. It must be ensured that the actuator motors (not supplied by LENNOX) are rigidly fixed to the structural framework of the unit and not to the double skinned panels. Care must be taken to ensure that the actuator does not attempt to push the damper beyond fully open or fully closed positions.

1.6..2. FILTERS

Check the type and quality of filters is in accordance with the drawing.

- 1) *Panel Filters*: with flat or corrugated media are normally fitted within the unit prior to shipping.
- 2) *Bag Filters*: along with *pre-Filters* (if any) are normally shipped in closed carton boxes, as supplied by filter manufacturer, to avoid any collection of dust and loss of efficiency prior to commissioning. Each Bag Filter is housed within a special holding frame with necessary locking spring to ensure proper sealing. A bank of such special frames (quantity depends on the type and air flow) is assembled within the peripheral aluminium framework of each Bag Filter Section. Entire assembly along with Pre-Filter must be locked with four springs to ensure no leakage of air.
- 3) *Automating roll Filters* have two headers, one houses the clean spool, while the other dirty spool, which is driven by a geared motor and chain drive actuated by differential pressure (D.P.) switch. Normally filter media and D.P. switch are supplied loose for site installation. For assembly, filter media roll is mounted on the clean spool header, taken along the guide channel through working section and locked to the dirty (driving) spool. D.P. switch must be installed and connected to the control panel as shown in the circuit diagram.
- 4) *Absolute Filters* are shipped in sealed carton boxes, as supplied by filter manufacturer. They are housed in a special purpose made of aluminium frame with corner brackets and locking devices for each cell. While assembly special care must be taken to ensure that each filter cell is properly seated within the assembly frame and perfectly sealed against the neoprene foam gasket with no possibility of air leakage.
- 5) *Other type of Filters* such as Actuated Carbon, inertial (sand) Filters, if installed, will be supplied with manufacturer's instructions along with the units.

1.6..3. HEAT EXCHANGER COILS

All coils are leak tested and checked prior to assembly. Fins are checked for proper condition prior to shipping. However during handling and installation they might be slightly bent and hence they must be checked and combed out if necessary. Do not remove plastic protective covers from the header connections until the system is ready for hook up. System layout should take into consideration of possible coil withdrawal. All connecting pipework must be properly insulated.

- 1) *Water Coils*: system design, pipe connections and valve arrangement must be in accordance with good engineering practice. Flow and return connections are clearly identified on the unit panels and pipe work must be connected accordingly, preferably through flexible couplings to avoid transmission of any vibration from the piping to coil. Excessive tightening torque might damage the coils. Pipework must be supported independently to the coil and/or the unit.

Use a pipe wrench to restrain the pipe connections of the heat exchanger when tightening the external pipe connections (see fig 1.6-1).

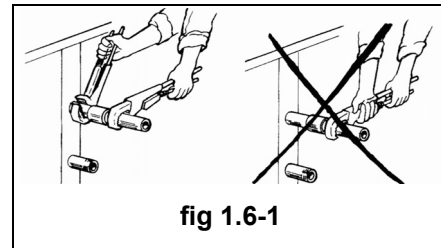


fig 1.6-1

Plugged drain and vents are provided for each coil and their use must be limited to the respective coil. They must not be used for draining or venting the other part of the system. Sufficient antifreeze chemicals must be added to the circulating water in cooling coils, when there is a possibility of them being exposed to temperatures below 2°C.

It is recommended that the water flow is shut off when the fan is switched off.

Normally, each heating coil should be provided with its own circulation pump. This ensures an even circulation of the water in the air heater, regardless of the position of the control valve; and provides the following important benefit:

appreciably less risk of freezing, due to the fact that the water velocity in the coil is always sufficiently high.

- 2) *Direct Expansion Coils*: all direct expansion coils will be supplied with a refrigerant distributor suitable for brazed connections. No expansion valves are supplied by LENNOX. The refrigerant pipe work must be design and installed in accordance with good engineering practise and include necessary shut-off devices, dehydrators, solenoid valves, oil traps etc. Selection, sizing, installation and setting of thermostatic expansion valve should be in accordance with the recommendation of Condensing Unit manufacturer. Flow of nitrogen gas must be maintained through the coil while brazing to avoid formation of oxide film inside, which might clog the suction strainers affecting on the system operation adversely.
- 3) *Steam Coils*: these are similar to that of water coils, but in addition special care in take for collection and disposal of condensate within the coils. Condensate connections to the steam trap must be of same size as the coil outlet. Care must be taken to prevent entry of condensate in the main into the coil by trapping it independently on a coil bypass. The steam trap is normally sized 3 times the design flow.
- 4) *Condensate Drains*: All chilled water coils must be individually trapped and connected to drain with adequate pitch for easy flow. It is recommended to install a trap as shown in fig 1.4-1. Depending on the ambient temperature and plant location, it is recommended to insulate the condensate drain pipework.
- 5) *Electric Heater Batteries*: If not properly wired and controlled electric Heater Batteries can be dangerous by causing serious injury or fires or even DEATH.

Electric Heater Batteries are supplied in the form of sheathed elements assemble in aluminium framework.

Double skinned panels are normally drilled for cable entry. Prior to connecting, heater battery assembly must be checked for conformity to local regulations. All wiring must be in accordance with local standards. In order to protect the elements from overheating and possible START OF FIRE, an airflow switch with necessary control must be installed to cut the power supply OFF to the heater elements.

Heater Battery must be interlocked with fan motor. Power supply must be SWITCHED OFF prior to removal of access door and not be switched ON until the access cover is replaced.

1.6..4. HUMIDIFIERS

Check the type of humidifier and ensure that the necessary Water/Steam/Electric power supplies are available for connection.

- 1) *Electric Pan Humidifier* contains an electric resistance or a bank of resistance in the form of sheathed elements, normally suitable for 3 phase power supply. All wiring must be carried out in accordance with local standards with necessary controls. Connect water supply with shut-off valves. Ensure that overflow is connected to the drainage with a necessary trap.

Important

Check and clean if necessary the terminal screws etc, to ensure that there is no short circuiting between the resistance and the cover plate or the humidifier body.

- 2) *Steam (Pan) Humidifier* must be connected to the steam supply with shut-off valves, inlet strainer, solenoid valve etc. Condensate drain must be complete with a trap.
- 3) *Steam (Injection) Humidifier* is normally supplied with inlet strainer, modulating valve, condensate trap, steam injection manifold with condensate collector and discharge pipe. Ensure that the supply steam pressure is maintained within the limits marked on the modulating valve assembly and connected with a shut-off valve.
- 4) *Air Washer* is a closed circuit humidification system complete with water sump, inlet strainer, centrifugal pump assembly, isolating valves, water distribution system made of nylon tubes and self cleaning adjustable nozzles. Feed/Make-up water supply must be connected to the float valve with a shut-off valve. Overflow and drain connection must be complete with a trap. A common drain line may be used for overflow and drain connections, provided a shut-off valve is installed to isolate the drain connection. Connect power supply to the pump motor in accordance with local standards with necessary controls. Check the pump impeller for free rotation.
- 5) *Electronic Steam Humidifiers* are packaged type and manufactured by others. Please refer to manufacturer instructions for details on installation and maintenance.
- 6) *Eliminators*: There is a remote possibility of eliminator blades being displaced from their position during the transit/installation. In case of such occurrence, they must be set in position, which is a simple operation. Further it must be ensured that no foreign matter obstruct the airflow through the eliminator.

1.6..5. SUPPLY AND RETURN FAN ASSEMBLIES

Anti-vibration mounts, on which fan & motor assembly is suspended, are locked prior to shipping to avoid damage during transit (see fig 1.6-1). Once the unit is in position and fan outlet is connected to ductwork, A.V. Mounts must be released.

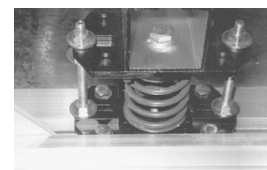


fig 1.6-2

Check the type and voltage of motor. If information is made available, cable entry holes through the double skinned panels can be factory drilled. However it is a simple operation to carry out the same on site, but ensure that no holes drilled and no connections are made through access door. It is recommended to use flexible armoured conduit between the panel and motor terminal box. All conduiting/wiring must be carried out in accordance with local standards. Check the type of start (direct on line/star delta) meets with the local electrical regulations. Provide starter/controls/overload protecting devices/interlocks as required. Manufacturer instruction, which are supplied along with the motor, must be carefully studied and followed. Duct work must be connected and insulated in accordance with good engineering practise. Depending on specified noise levels, attenuators are to be selected and installed as per the recommendations of acoustic specialists. It is recommended to protect all lining and attenuation materials with smooth perforated metallic sheets to avoid migration of fibres into occupied areas/blockage and subsequent replacement of filters frequently.

Belt driven fans must be checked as illustrated in **Chapter 3.4**.

1.6..6. ROOF CANOPY

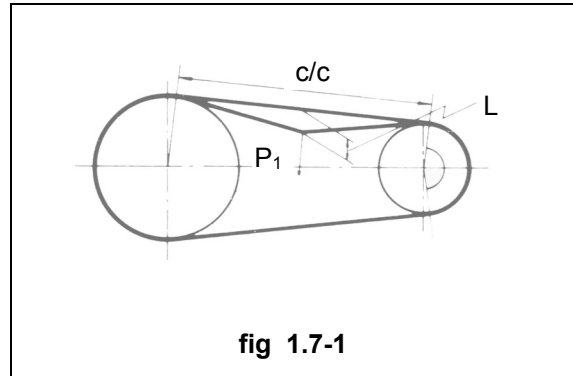
Normally roof canopy is supplied loose to avoid damage during transit for assembly and installation on site. When units are supplied with bottom inlet and/or discharge, it must be ensured that proper flashing is carried out around base frame to avoid possible ingress of water.

1.7. DRIVE

1.7..1. BELT TENSION

The belts must be correctly tensioned to ensure good contact with the pulley. If insufficiently tensioned, the belts may slip, and if excessively tensioned, the motor and fan bearings may be overloaded.

When correctly tensioned (see fig 1.7-1), the belt deflection L will be 15 mm per metre of distance between centres c/c when a force P₁ (N) is applied and $P < P_1 < 1.5 P$, where the force P is dependent on the belt type as shown in Table A.



The deflection should be measured preferably by means of tensiometer.

Table A

Belt section	diameter of smaller pulley (mm)	Force P		
		0 ÷ 10 m/s (N)	10 ÷ 20 m/s (N)	20 ÷ 30 m/s (N)
SPZ	67 ÷ 95	12 ÷ 18	10 ÷ 16	8 ÷ 14
	> 96	19 ÷ 26	17 ÷ 24	15 ÷ 22
SPA	100 ÷ 140	22 ÷ 32	18 ÷ 26	15 ÷ 22
	> 141	33 ÷ 48	27 ÷ 40	23 ÷ 34
SPB	160 ÷ 265	38 ÷ 56	32 ÷ 50	28 ÷ 42
	> 266	57 ÷ 72	51 ÷ 64	43 ÷ 58
SPC	224 ÷ 355	72 ÷ 102	60 ÷ 90	50 ÷ 80
	> 356	103 ÷ 132	91 ÷ 120	81 ÷ 110

1.7..2. CHANGE OF PULLEYS

LENNOX take no responsibility for the consequences, if the pulleys are changed without their written consent.

1.8. MAINTENANCE

In general air handling unit do not require special attention other then routine cleaning and maintenance work. Following is the recommended schedule of maintenance, when units operate at normal conditions. However actual conditions of use/operation will dictate the interval of checking/replacement of the filters, belts etc.

1.8..1. ONCE IN A WEEK

- Check filter condition at weekly intervals. Clean, wash or renew/replace if necessary.

1.8..2. ONCE IN A MONTH

- Check fan belt tension and adjust if necessary.
- Check the condition of spray nozzles and float valve in air washer.
- Check the condition of drain for free flow.
- Check the condition of resistance in electric Pan Humidifier.
- Check the condition of access door hinges and lubricate if necessary.

1.8..3. ONCE IN SIX MONTHS

- Check the fan motor running current.
- Check function controls and their effect on A.H. Unit components.
- Check fan and motor bearings.
- Check electric heater battery elements.
- Add water and flush condensate drain pan, trap and drain line.
- Check circulating pump and motor in air washer.
- Check the condition of inlet strainers.
- Check the condition of chilled/hot water.
- Add chemicals if necessary.

1.8..4. ONCE IN A YEAR (PREFERABLY AT THE START OF SEASON)

- Check the operation of dampers.
- Check the filter frame for proper sealing.
- Replace synthetic media in panel filters.
- Check the access doors for easy operation and proper locking.
- Check the controls and operation of Roll Filters.
- Check the coils and fin condition. Wash with water spray, if necessary.
- Check the condition of all insulating, regulating valves etc in the system.
- Vent the water coils.
- Check motor and fan bearing lubrication.
- Replace belts.
- Check all wiring, controls, isolating devices, terminal connections etc.

While attending to the above maintenance schedules, following must be noted.

1.8..5. FILTERS

It is important to check the condition of filters once a week. When the pressure drop across the filter exceed the maximum pressure drop given in LENNOX drawing, the filter must be attended immediately. Dirty filters reduces the air flow and hence the capacity. *Do not operate the system without filters.* In case the media is synthetic or metallic, they can be cleaned or washed. However it is recommended to replace synthetic media once in every year and metallic media once in every two years. Other filters such as Throw Away Panels, Bag, Absolute, Roll Filters must be replaced with new cells of identical media and efficiency.

1.8..6. HEAT EXCHANGER COILS

It is recommended to drain the water when the system is shut down. In case required coils can be withdrawn as follows:

- Disconnect the coil from the water connection.
- Remove the side (Doubled Skin) panel.
- Remove the bolts by which coil frame is fixed to the unit frame.
- Withdraw the coils. coil can be reinstalled by the following the above procedure in reverse.

1.8..7. SUPPLY AND RETURN FAN SECTIONS

Bearing lubrication

Normally fans are fitted with grease packed ball bearings Series: SY and type: UCP with minimum anticipated running life of (see Table B):

Table B

Fan with speed up to 1000 RPM	25000 hrs
Fan with speed between 1500 ÷ 2000 RPM	20000 hrs
Fan with speed between 2000 ÷ 3000 RPM	15000 hrs

Fans normally installed for high pressure /heavy duty application will have Series: 2300 ball bearings housed in plummer block type: SNA. The recommended intervals are as follow (see Table C)

Table C

BEARING HOUSING	FAN SPEED (RPM)					
	500	1000	1500	2000	2500	3000
SNA 607	25	25	18	17	13	10
SNA 608	25	25	18	15	12	9
SNA 609	25	25	18	14	11	8
SNA 610	25	21	16	12	8	5
SNA 611	25	18	15	11	7	3
SNA 612	25	17	13	9	4	-
SNA 613	25	17	12	8	2	-
SNA 615	25	15	10	5	1	-
SNA 616	25	13	8	2	-	-
SNA 617	25	12	6	1	-	-

(hrs x 1000)

Impeller removal

For some reason, if it is required to take the impeller out for cleaning, following procedure is recommended:

Forward Curved Fan

- Loosen motor mounting bolts and remove the motor.
- Remove belts and bearings.
- Loosen the fan fixing screw and withdraw the shaft.
- Unbolt the flexible connection on fan discharge.
- Turn the fan assembly by 90.
- Take out the impeller from the fan discharge opening. Handle carefully while cleaning, to avoid any damage to blades.

Backward Curved Fan

- Loosen motor mounting bolts and remove the motor.
- Remove belts and bearings.
- Unbolt and remove the flange of bearing supporting ring frame.
- Remove the aluminium inlet cone.
- Withdraw the impeller along with the shaft.
- Inlet cones and impellers are made of aluminium. They must be handled carefully.

1.8..8. CLEANING OF DOUBLED SKIN PANELS

All panels are double skinned and they can be easily detached from the framework by removing screw with simple hand tools. They can be cleaned or washed. However it must be ensured that they are completely dry prior to refixing. Do not drop any heavy weights or sharp edge tools etc. It might damage the plasticised finish or puncture the aluminium panels.

NOTE

If any further information is required, please contact LENNOX, who will be very pleased to assist.

2. SAFETY

The LENNOX air handling units can be considered a safe machinery.

By means of the compliance statement of the EEC and of the symbol “CE” on the unit, it is guaranteed that the LENNOX air handling units fulfil the provisions for the essential health and safety requirements laid down in Annex I of Machinery Directive 98/37/CE .

The “CE” mark appears on every identification label of the unit (see fig 2.1-1).

In spite of all that, the unit could represent a danger, if it is utilised or serviced not properly by staff not sufficiently trained.

We, like manufacturer of the unit, intend to explain to the user, by an exhaustive chapter, the concept of safety referring to air handling unit and to inform him of possible dangers and consequent measures. Observe also the general standards for the safety and the accidents’ prevention coming from the following indications!

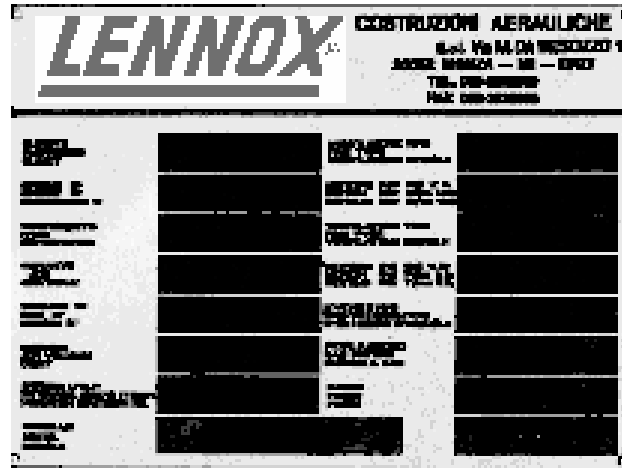


fig. 1.8-2

2.1. TERMINOLOGY

It is considered “danger zone” internal area of the unit close to the movement parts and the electrical parts. In order to be able to access to these areas, it is necessary to provide oneself with the proper key tool to deactivate the safety devices.

The operators are responsible for transport, installation, start up, service and maintenance, including cleaning and troubles repair.

2.2. OPERATION SAFETY

LENNOX air handling units are safe because they are built in accordance with good engineering practise. Nevertheless, the units could represent a hazard if they are used, by an untrained staff, improperly or not in conformity with general provisions. The more common hazards are:

- danger to operator’s safety.
- damages to the unit.
- possibility to compromise the efficiency of unit work.

2.3. USE OF THE UNIT IN CONFORMITY TO GENERAL PROVISIONS

LENNOX air handling units are able to fan, to heat, to cool, to filter, to humidify. Any other use is considered not in conformity with general provisions. The manufacturer is not responsible for damages resulting; the user will be the only responsible.

In order to use the unit according to general provisions proper instructions of installation, exercise and transport must be observed.

Installation and start up of the unit must satisfy the national standards having legal course in the country of the user. **The user is responsible for compliance with standards.**

Besides, it must be avoided any type of work that may compromise safety.

Arbitrary transformations of the unit by user or operator are not allowed and exclude the warranty of the manufacturer for the damages to things and persons. MEASURES OF THE USER/OPERATOR, OBSERVATION OF THE SIGNPOSTS (WARNINGS)

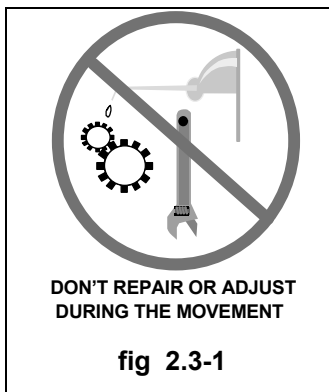
Signposts are placed on the unit, showing:

- 1) prohibition to repair or adjust during motion (fig 2.4-1)
- 2) obligation to turn off the power before opening the access door (fig 2.4-2)
- 3) warning of coming into contact with electrical parts (fig 2.4-3)

This signpost and the other warnings regarding the unit must be absolutely observed.

2.4. STAFF TRAINING

The unit can be started up and serviced (routine maintenance + corrective maintenance) only by authorised and trained staff. This staff must be informed about

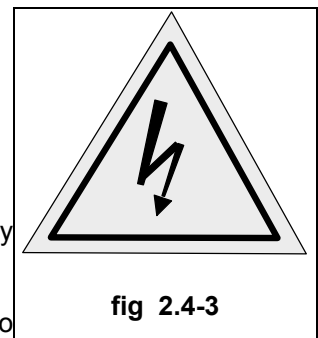
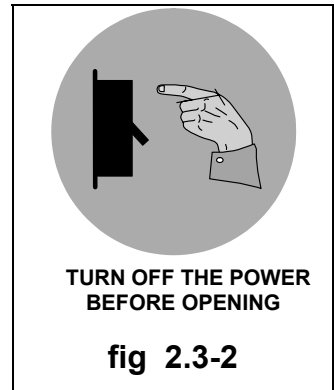


possible hazards regarding:

- electrical connections
- piping connections
- ducting connections
- start up

These operations can be executed only by trained persons.

People who, on behalf of the user, attend to control and to the extraordinary/ordinary maintenance of the unit.



It is necessary to establish and to respect the responsibilities for control and maintenance to guaranty safety, without confusing competencies.

2.5. STAFF TRAINING

The unit can be started up only by means of proper safety devices.

The installer is obliged to install the unit according to installation plans and conditions.

Only authorised persons must operate on the unit.

The staff in charge is obliged to signal immediately to the user any changes that may compromise safety. For this reason it is necessary to inspect for eventual anomalies or damages at least once a week.

The user or operator never must dismount and deactivate safety devices; if these would be removed for extra maintenance, at the end of operations they must be reinstalled.

For all operations of extra maintenance, the power source must be locked out.

2.6. BEHAVIOUR IN CASE OF DAMAGES

If it is necessary to make maintenance, the fan must be switch off, isolated and allowed to rundown.

2.7. MEASURES TAKEN BY MANUFACTURER:

Essential Health & Safety requirements laid down in annexe I of EEC MACHINERY DIRECTIVE 98/37/EC		
Applicable points of EEC MACHINERY DIRECTIVE	Measures taken:	Ref. to harmonised procedure
1.1.4 Lighting	Inspection zone in order to provide maintenance and start-up provided with lighting	UNI EN 292
1.1.5 Design of a unit in order to handling	Design of a multi-section unit with basement for lifting by forklift or rope; locking of vibration isolators during transport	UNI EN 292
1.3.2 Risk of breakage during functioning	Operation conditions stated on the as-built drawing; frequency of maintenance listed in the instruction handbook	UNI EN 292
1.3.3 Risk due to surfaces and projection of objects	Casing tested till 400 mm of pressure, fan dimensioning within operation limits, mesh for no ducted fan and warnings described in the maintenance and operation handbook	UNI EN 292
1.3.4 Risk due to surfaces, edges and corners	Sharp corner of extruded aluminium profiles rounded off to 6mm ray	UNI EN 292
1.3.7 Prevention measures against moving elements	Access door open able with a special tool ; written warning fitted on the access door. Optional measures are to be required during commercial agreement and stated on the as-built drawing	UNI EN 292
1.3.8 Estimated prevention measures against moving elements		
1.41.1 General requirements		
1.4.2.1 Fixed protection		
1.5.1 Risk due to electric power	Wiring diagrams inside motor terminal box. (see also paragraph 2.9)	UNI EN 292 CEI EN 60204-1
1.5.6 Risk of fire	Fire-retardant polyurethane or mineral wool panels type sandwich	UNI EN 292
1.5.7 Risk of explosion	Should any risk of explosive atmosphere, supply of electric motor and explosion-proof fan occur	UNI EN 292
1.5.8 Risk due to noise	Noise level stated on the as-built drawing data sheet. Should not such noise meet given conditions, both required for machine room and other room, measures will be taken as follows: - additional insulation into section - silencer on the supply fan section	UNI EN 292
1.5.9 Risk of vibration	Fans and motors mounted on basement isolated by vibration isolators and flexible connections on fans	UNI EN 292
1.5.14 Risk of being imprisoned inside the unit	Access door provided with hinges which allow opening from the inside	UNI EN 292
1.6.1 Maintenance of the unit	See Installation, Use and Maintenance handbook	UNI EN 292
1.6.4 Workman corrective maintenance	Design according to SOP 003; see chapter "Safety" in the handbook for a safety maintenance	UNI EN 292
1.7.0 Warning device	Written warning in proximity to electri-	UNI EN 292

	cal and rotating parts	
1.7.2 Warning about further risks	Written warnings near pipe connections	UNI EN 292
1.7.3 Marking	Marking on metal name plate displayed on the outside the fan section access door. Operation conditions and overall dimensions stated on the as-built drawing.	UNI EN 292
1.7.4 Information for use	Installation, Use and Maintenance handbook, As-built drawings and possible attached schemes form an integral part of 'Information for use'.	UNI EN 292

2.8. PREVENTION MEASURES ARE TO TAKEN BY INSTALLER OR THE PERSON IN CHARGE OF INSTALLING CONTROL AND START-UP DEVICES

Essential Health & Safety requirements laid down in annexe I of EEC MACHINERY DIRECTIVE 98/37/EC		
Applicable points in EEC MACHINERY DIRECTIVE	Measures to take:	Ref. to harmonised procedure
1.2.1 Safety and reliability of control system 1.2.2 Control device 1.2.3 Start-up 1.2.4 Emergency stopping device	Control system, Start-up and Stopping according to standards in force	UNI EN 292 CEI EN 60204-1
1.2.5 Operation modal selector switch	Should not start-up and stopping devices be in proximity to the unit, it shall be provide with an additional lockable isolating switch placed outside the air handling unit, near the fan section access door in order to guarantee safe maintenance.	UNI EN 292 CEI EN 60204-1
1.5.1 Risk due to electrical power	Grounding of an electric motor according to standards in force	UNI EN 292 CEI EN 60204-1

2.9. RECOMMENDED SAFETY PRACTISES

This publication explains the proper use and installation of centrifugal fans in order to warn operating and maintenance personnel of the commonly recognised dangers associated with this equipment. In addition to following the manufacturer's installation instructions, care must be taken to ensure compliance with federal, state and local rules, regulations codes and standards.

2.9.1. PERSONNEL SAFETY ACCESSORIES

Centrifugal fans in air handling unit are located inside a casing opportunely sealed so accessibility to these fans is occasional or infrequent. For this reason, protective devices are offered as optional accessories only at specific user's request.

However as in the case with other machinery involving moving parts, common sense and caution will preserve personal safety.

The available guarding devices are:

- 1) *Lockout switches* and suitable warnings. In such cases, maintenance personnel should engage the lock-out switch before undertaking any maintenance or repairs.
- 2) *Inlet and outlet guards*. Centrifugal fans are usually connected directly to ductwork which will prevent the contact with the internal moving parts. In case there is an exposed inlet or outlet which could represent a danger, It can be installed a suitable guard as the one represented in fig 2.10-1.
- 3) *Drive guards*. A typical centrifugal fan drive guard may vary with the arrangement. Safety guards shall be used when drive systems are accessible to personnel (see fig 2.10-2).In restricted areas, omission of the back cover may be acceptable.

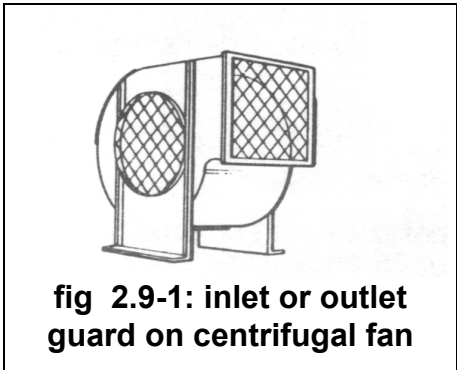


fig 2.9-1: inlet or outlet guard on centrifugal fan

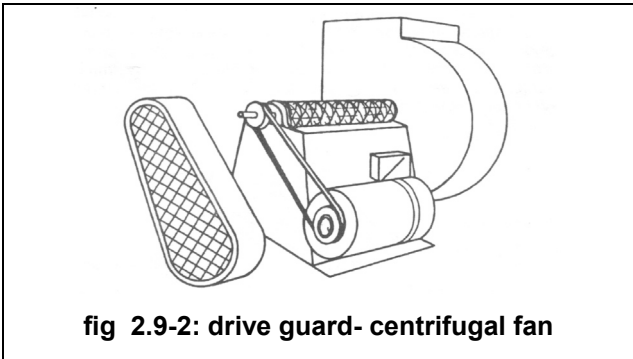


fig 2.9-2: drive guard- centrifugal fan

2.9..2. THE HIDDEN DANGER

In addition to the dangers of rotating machinery, fans present another potential danger by virtue of their ability to draw in loose material. Solid objects passing through a fan represent potentially dangerous projectiles. Solid objects can cause fan failure by physically damaging the impeller blades.

Whatever there is the possibility of solid objects being drawn into a remote intake, the intake shall be guarded at all this times. In the event the guard is removed for any reason, the fan must be disconnected and locked out.

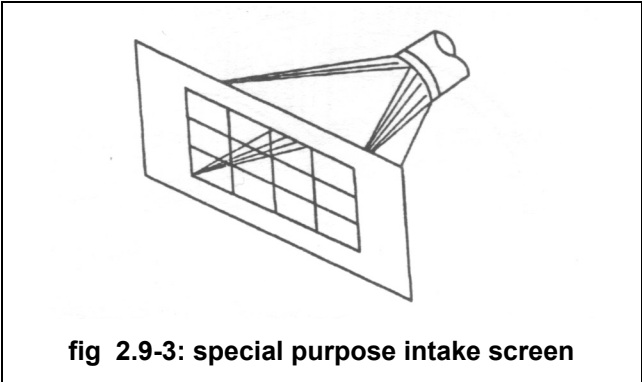


fig 2.9-3: special purpose intake screen

Where fans are installed over an occupied area, safety guards should be provided to prevent dropped objects from entering this area during installation and maintenance.

Access doors to a fan or duct system should not be opened with the fan in operation or coasting to a stop. Power shall be locked out prior to access into a fan or ductwork. Even when locked out electrically, fans may cause injury or damage if the impeller is subject to "wind milling". The impeller should be secured to physically restrict rotational movement.

On the downstream (or pressure) side of the system, realising the door with the system in operation may result in an explosive opening. On the upstream (or suction) side the inflow may be sufficient to draw in tools and clothing, etc, and create a danger.

The access door in air handling unit is always locked out by a special lock and to open the door it is necessary a key so it is impossible to open it by chance.

The stroboscopic effect of certain lights in combination with certain fan speeds may cause a rotating assembly to appear stopped.

2.9..3. START UP CHECK LIST

Before putting any fan into operation the manufacturers' instructions must be followed. In addition, the following check list must be completed.

- There is possibility of collection of debris such as duct/insulation materials, tapes etc used during installation of the system. Hence it must be ensured that all the sections of the unit are thoroughly cleaned. In case units are supplied with peraluman panels, polythene protective film must be peeled off and it must be ensured that no traces of film is left loose within the unit.
- Ensure all panels, if removed during installation, are in position.
- Ensure all electrical wiring in carried out to local standards and all components are provided with safety, protecting and isolating devices.
- Remove all filters including panel filters: install low efficiency filters such as gauze bags or a set of throw away type filters.
- Ensure all dampers are opened.
- Check water/steam/refrigerant coil connection for any leaks. Ensure that all the air in the system and coil is vented out. Check coil face free from debris.
- Add water in the condensate drain pan to prime the trap and ensure free flow of water into the drain.
- Ensure that minimum water levels are maintained in electrical Pan Humidifier/Air Washers.

Fan start up

- 1) Screw out security nuts of antivibration mounts.
- 2) Lock out the primary and secondary power sources.
- 3) A complete inspection shall be made of all the ductwork and the interior of the fan. Make certain there is no foreign material which can be drawn into or blown through the fan or ductwork. Eyes should be protected against undetected foreign material through the use of safety goggles or other appropriate means.
- 4) Make sure the foundation or mounting arrangement and the duct connection are adequately designed in accordance with recognised acceptable engineering practises and with the fan manufacturer's recommendations.
- 5) Check and tighten all hold-down (securing) bolts.
- 6) Check the fan assembly and bearings for proper grounding to prevent static electricity discharge.
- 7) Spin the impeller to determine whether it rotates freely and is not grossly out of balance.
- 8) Inspect impeller for proper rotation for the fan design.
- 9) Check all set screws and tighten, if necessary.
- 10) Check belt drive or coupling alignment; use recommended belt tension.
- 11) Check the belt drive for proper sheave selection and make sure they are not reversed (excessive speeds could develop).
- 12) Properly secure all safety guards.
- 13) Secure all access door to the fan and ductwork.
- 14) Momentarily energise the fan to check the direction of rotation.
- 15) Switch on the electrical supply and allow the fan to reach full speed.

Check carefully for:

- a) Excessive vibration
- b) Unusual noise
- c) Proper belt alignment
- d) Proper lubrication

e) Proper amperage and voltage values

If any problem is indicated, SWITCH OFF IMMEDIATELY.

Lock out the electrical supply, secure the fan impeller if there is a potential for windmilling (impeller turning due to a draft through the system).Check carefully for the cause of the trouble and correct as necessary.

Even if the fan appears to be operating satisfactory, shut down after a brief period and recheck items 5) through 12) as the initial start up may have loosened the bolts and set screws.

- After ensuring that there are no leaks between joints of section and system is clean, stop the fan. Dispose off low efficiency filters. Install Panel/Bag/Absolute filters, as supplied.
- Restart the fan. In case of a stand-by fan and motor are supplied, ensure that no short circuiting of air occurs.
- In case fan is connected to a stand by motor for automatic change over, do not touch the terminal of stand by motor, even though motor is idle. Ensure that belts are removed and the power is isolated.
- Adjust dampers position to obtain the rated air volume.
- In case fans are supplied with variable pitch pulley (up to 7.5 kW), adjust the same to the desired position.
- Ensure that the air volume are within the specified limits.
- Check the motor current and ensure the same is within the rated (name plate) data.
- Check ON-OFF temperature across coils and adjust water/steam flows accordingly. Check the functioning of controls.
- Check the functioning of humidifier by adjusting the humidistat control.
- Check the operation of heater batteries by adjusting thermostat. Check the functioning of controls such as air flow switch, fan interlock, over heat protection etc.
- Check the pressure drop across the filters and ensure that the same is within the limits.

The fan has been put into operation but, during the first eight hours of running, it should be periodically observed and checked for excessive vibration and noise. At this time checks should also be made of motor input current and motor and bearing temperatures to ensure that they do not exceed manufacturer's recommendations.

After eight hours of satisfactory operation, the fan should be shut down to check the following items and adjust, if necessary (lock-out power).

- 1) All set screws and hold-down bolts
- 2) Drive coupling alignment
- 3) Belt drive alignment
- 4) Bearing housing temperature
- 5) Belt drive tension

After twenty-four hours of satisfactory operation the fan should be shut down (locked out) and the drive belt tension should be readjusted to recommended tension.

2.9.4. AFTER 2 WEEKS OPERATION

After start up and initial operation of approximately 2 weeks, it is recommended to have the following checks.

- Bearings temperature immediately after stoppage. This is not to exceed 70°C; Lubricate if necessary.
- Belt tension.
- Pulley alignment.
- Motor running current.
- Filter condition.
- Condensate and drain to see flow.
- Operation of controls.

WARNING SIGNS

A preventive maintenance program is an important aspect of an effective safety program. Investigate any changes to the fan. Refer to Chapter 3 “*troubleshooting*”, for a more detailed explanation of investigating procedures. Consult your manufacturer or other qualified consultant with question concerning changes observed during periodic inspections.

- 1) *Excessive vibration*: if excessive vibration is observed stop the fan until the cause is corrected. Check for material build-up on impeller. Generally this will show up as material flaking off the fan impeller and causing an imbalance which may lead to fatigue failure of the impeller.
- 2) *Noise*: changes to the sound level may indicate troubleshooting is needed.
- 3) *High motor temperatures*: check that cooling air to the motor has not been deviated or blocked by dirty guards or similar obstacles. Check the input amperage. An increase in amperage may indicate that some major changes has been made in the system.
- 4) *High bearing temperatures*: this condition is usually caused by improper lubrication; this can be either "over", "under" or "unsuitable" lubrication. In any case if the cause of the trouble is not easily seen, experienced personnel must examine the equipment before it is put back in operation.

2.9.6. ROUTINE MAINTENANCE

Maintenance should be performed by experienced and trained personnel. Do not attempt maintenance unless the electrical supply has been locked out or tagged out and the impeller has been secured.

- a) Under normal circumstances, handling clean air, the system should require *cleaning* only about once a year. However, *the fan and the system should be checked at regular intervals* to detect any unusual accumulation.
- b) *The fan impeller should be especially checked for build-up of material or dirt* which may cause an imbalance with resulting undue wear on bearings and belt drives. A regular maintenance program should be established as needed to prevent material build up.

Periodic inspection of the rotating assembly must be made to detect any indication of weakening of the rotor because of corrosion, erosion, or metal fatigue.

3. TROUBLESHOOTING

A preventive maintenance program is an important aspect of an effective safety program. It is fundamental to keep any part of the system controlled in order to point out promptly any changes to the right working.

In any case it is suitable to consult the manufacturer or other qualified consultant with question concerning changes observed during periodic inspections.

3.1. PROCEDURE FOR TROUBLESHOOTING

- 1) Look in the "**Master Troubleshooting Chart**" for an index tag which corresponds to with the apparent problem.
- 2) Check each of the probable causes listed.
- 3) If the cause of the trouble is not found proceed through the "**System Checklist**".
- 4) If the problem has still not be solved, it is now advisable to contact the representative of fan manufacturer. He should be given the results of the "**System Checklist**" and some "**additional information**" which are particularly interesting for the manufacturer.
- 5) The fan manufacturer or his representative will analyse the information submitted (as outlined on page 31).With this information and, if necessary, an on-site inspection he should be able to explain why the system is not achieving its design performance and may recommend changes in the system or the fan installation which will overcome the problem.

3.2. SAFETY PRECAUTION

Before checking the fan and system it will be necessary to shut down the fan. During inspection the fan must be electrically isolated and all disconnect switches and others controls locked in the "OFF" position. Where this in location remote from the fan, prominent "DO NOT START" signs should also be in place.

3.3. MASTER TROUBLESHOOTING CHART

See **Appendix** SYSTEM CHECKLIST

Poor system performance may arise from a number of causes including:

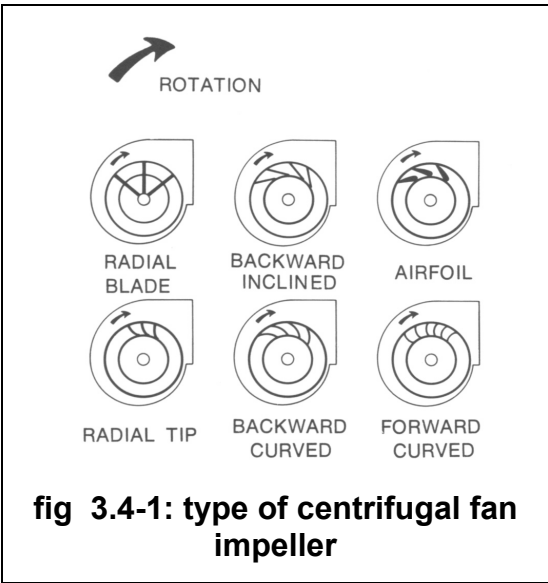
- improper installation or assembly of the fan
- damage in handling or transit
- system design error
- deterioration of the system
- faulty controls
- poor fan selection
- a combination of several factor

A systematic check of items listed should identify the problem or problems and allow suitable corrective action to be taken.

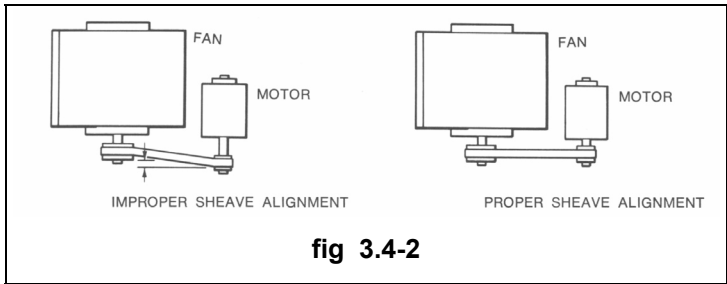
3.4. SYSTEM CHECKLIST

A) While the impeller is coasting to a stop, see if it is rotating in the proper direction (see fig 3.4-1)

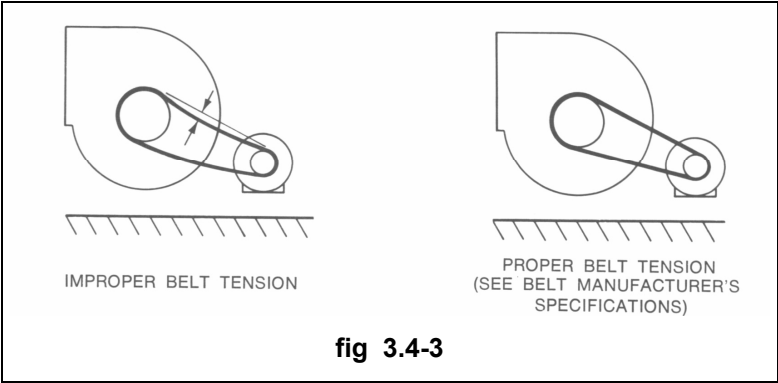
B) Make certain the impeller is of the correct rotation for the housing and not installed backwards. [Fan manufacturer describe the *rotation of centrifugal fan impeller* as being "clockwise" or "counterclockwise" when viewing the DRIVE SIDE (see AMCA Standards 2406)].



C) If the fan is belt driven:
 1) are the drive pulley (motor sheave) and the driven pulley (fan sheave) in alignment ? Improper alignment of the sheave can cause excessive power (high amperage) and squealing belts (see fig 3.4-2).



2) are the belts loose ? Loose belts can cause slipping, leading to squealing and/or low fan speed along with hot sheaves, bearings, shafts and motor. Belts should be tensioned to the belt manufacturer's recommendations. Tension of the drive belts should be adjusted for stretching after the first forty-eight hours of operation. Caution! excessive belt tension will reduce fan and motor bearing life (see fig 3.4-3).

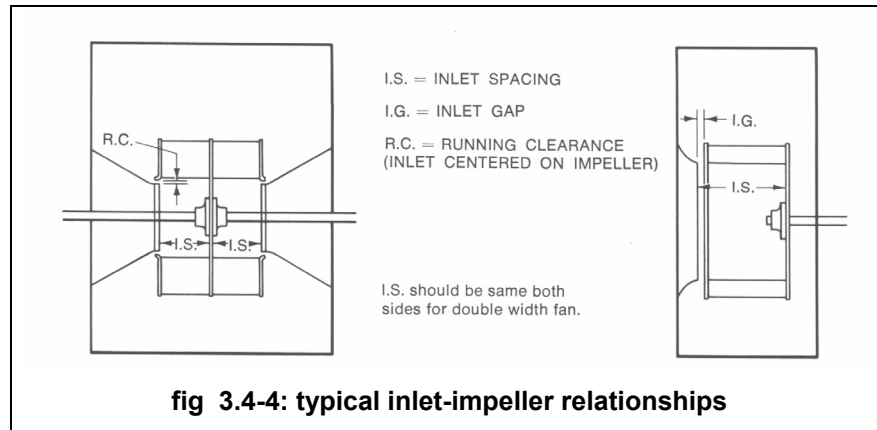


3) are the belts and/or sheaves worn ? If so, an immediate replacement could save down time at a later date. Replacement belts should be a new set of *matched* belts.

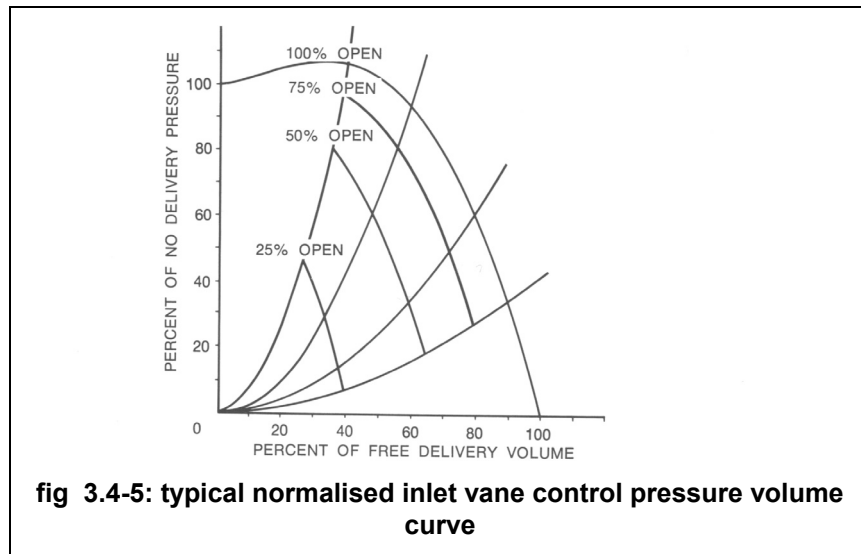
D) Check the flow surfaces (passages between the inlets, impeller blades and inside of housing) for cleanliness. A millimetre build-up of dirt on the flow surfaces could impair fan performance.

E) Are there any gouges, tears, holes, erosion or corrosion in the impeller blades, rims or backplate; inlet and/or housing ? If so, report the approximate size and location to the fan manufacturer.

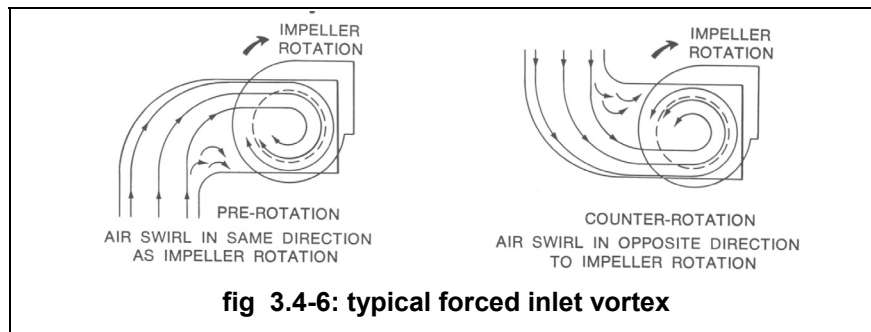
- F) Is any foreign matter trapped in the impeller, housing or ductwork (loose insulation, papers, ice, etc) ? If so, remove.
- G) Are coils, heaters, filters, ducts, etc dirt laden ? If so, clean or replace. Remove any non-essential obstruction to flow in elbows, shutters, transformations, dampers, bird-screens, etc.
- H) Have all the parts supplied with the fan been installed ?
- I) Are there any obstruction to flow near the fan inlets ? Objects such as pipes, ductwork, columns, belt guards, belt drives, etc could adversely affect the output of the fan.
- J) Are the fan outlet connections correctly designed and installed ? Duct takeoffs, or obstructions in the fan outlet could adversely affect the output of the fan.
- K) See fig 3.4-4 for typical inlet-impeller relationships. A few simple measurements as indicated on fig 3.4-4 can tell the manufacturer if a problem exists in this area (several measurement should be taken around the entire inlet circumference).



- D) Are turning vanes installed in elbows close to the fan inlet or discharge ?
- E) If the fan is equipped with variable inlet vane or inlet damper control, check the operation as follows:
 - 1) Do not rely on the control arm position alone for locating the position of the vane/damper blades without first checking visually to see that the vane/damper position agrees with the position of the control arm.
 - 2) If the unit is double width fan equipped with variable inlet vanes or damper control, both inlet vanes/dampers must be synchronised (the inlet vanes/dampers must be in the same relative position with respect to the impeller on both inlets). If the inlet vanes/dampers are not synchronised, there will be an unbalance flow between inlets resulting in deficient air performance, unbalance thrust on bearing and/or a surge condition in the fan.
 - 3) Make certain that variable inlet vanes are of the proper rotation with respect to the impeller. As the vanes close, they should cause the entering air to spin in the same direction as the impeller.
 - 4) Are the inlet vanes/dampers correctly positioned for the designed operating conditions ? If not, the desired pressure-volume of the fan will not be realised (see fig 3.4-5).



- D) Inspect any duct-work or plenums approaching the fan inlets for the possibility of inducing swirl of air into the inlet (see fig 3.4-6).



After completing the above steps and securing the fan, remove all OUT signs on disconnected switches and override systems and put the unit back into operation.

- D) Inspect the entire system including the fan, fan plenum and all ductwork for leaks. Leaks may be detected by sound, smoke, feel, soapy solution, etc. Some common leak sources are access doors, coils, duct seams, fan outlet connection etc which must be sealed.

3.5. ADDITIONAL INFORMATION (FAN MANUFACTURER'S ANALYSIS)

If the cause of the trouble has still not be found after completing the "system checklist", the fan manufacturer should be consulted.

The fan manufacturer will review the information provided concerning the system and apply his own special knowledge and experience to the problem.

To make a complete analysis of the problem, in addition to the results of the "system checklist", the manufacturer will need:

- A) Complete plans (drawings) including all ductwork, location, size, model and manufacturer of all fans, motors, coils, dampers, etc. with all pertinent dimensions for the complete system as actually installed. The original engineering drawings may not be representative of the actual installation.
- B) If the problem is failure of the process or system to achieve design performance the measured performance figures and design performance figures should be supplied.
- C) A copy of the system design calculations.
- D) A copy of the specifications and any addendum.

- E) If a separate air performance test has been conducted on the installed fan, a statement of measured fan performance along with a copy of the test data, the type of test and instrumentation, and the location of the flow rate pressure determination should be supplied.

A statement of fan performance should contain:

- 1) fan total pressure rise or fan static pressure
- 2) flow rate
- 3) power (amperage)
- 4) fan speed
- 5) gas density

Among other actions he will:

- 1) Access the probable accuracy of the field performance measurements.
- 2) Check whether the fan selection is correct for the application.
- 3) Examine the system drawings (plans) in order to individualise any eventual change in the system performance curve in respect to the system design calculations or the original fan selection.
- 4) Make the appropriate corrections.

3.6. CONCLUSION

By intelligent application of the procedures outlined in this manual it should be possible to find the cause of performance problem in any air moving system.

Identification of problem associated directly with the fan may require the assistance of the fan manufacturer.

Recognition of the cause of the trouble will usually be a major step towards curing it. Corrective measures may include alterations to the system, modification to the fan outlet or inlet connections, adjustments to the fan etc. in many cases an increase in the fan speed may be decided upon but it is extremely important that the fan shall not be operated above its catalogued maximum speed or the maximum speed recommended by the manufacturer.

The information obtained through the checklists in this manual should also help in allocating responsibility for the necessary corrective action. In most cases, if the troubleshooting procedure has been followed carefully and impartially it will be apparent whether the system has been built and installed in accordance with the design drawings, whether the fan was properly selected, or the fan is not performing up to its published ratings.

PROBLEM	SOURCE	PROBABLE CAUSE
NOISE	A-1 IMPELLER HITTING INLET RING	<ul style="list-style-type: none"> a) impeller not centred in inlet ring b) inlet ring damaged c) crooked or damaged impeller d) shaft loose in bearing e) impeller loose on shaft f) bearing loose in bearing support
	A-2 IMPELLER HITTING CUT OFF	<ul style="list-style-type: none"> a) cut-off not secure in housing b) cut-off damaged c) cut-off improperly positioned
	A-3 DRIVE	<ul style="list-style-type: none"> a) sheave not tight on shaft (motor and/or fan) b) belts hitting belt tube c) belts too loose. Adjust for belt stretching after 48 hours operating d) belts too tight e) belts wrong section f) belts not "matched" in length on multi-belt drive g) variable pitch sheaves not adjusted so each groove has same pitch diameter (multi-belt drives) h) misaligned sheaves i) belts worn j) motor, motor base or fan not securely anchored k) belts oily or dirty l) improper drive selection
	A-4 COUPLING	<ul style="list-style-type: none"> a) coupling unbalanced, misaligned, loose or may need lubricant
	A-5 BEARING	<ul style="list-style-type: none"> a) defective bearing b) needs lubrication c) loose on bearing support d) loose on shaft e) seals misaligned f) foreign material inside bearing g) worn bearing h) fretting corrosion between inner race and shaf
	A-6 SHAFT SEAL SQUEAL	<ul style="list-style-type: none"> a) needs lubrication b) misaligned

PROBLEM	SOURCE	PROBABLE CAUSE
NOISE	A-7 IMPELLER	<ul style="list-style-type: none"> a) loose on shaft b) defective impeller. <i>Do not run the fan. Contact manufacturer</i> c) unbalance d) coating loose e) worn as result of abrasive or corrosive material moving through flow passages
	A-8 HOUSING	<ul style="list-style-type: none"> a) foreign material in housing b) cut-off or other part loose (rattling during operation)
	A-9 ELECTRICAL	<ul style="list-style-type: none"> a) lead-in cable not secure b) AC hum in motor or relay c) starting relay chatter d) noisy motor bearings e) single phasing a 3 phase motor
	A-10 SHAFT	<ul style="list-style-type: none"> a) bent b) undersized. May cause noise at impeller, bearing or sheave. c) if more than two bearings are on shaft, they must be properly aligned.
	A-11 HIGH AIR VELOCITY	<ul style="list-style-type: none"> a) duct work too small for application b) fan selection too small for application c) register or grilles too small for application d) heating or cooling coils with insufficient face area for application
	A-12 OBSTRUCTION IN HIGH VELOCITY GAS STREAM MAY CAUSE RATTLE, OR PURE TONE WHISTLE	<ul style="list-style-type: none"> a) dampers b) registers c) grilles d) sharp elbows e) sudden expansion in duct work f) sudden contraction in duct work g) turning vanes
	A-13 PULSATION OR SURGE	<ul style="list-style-type: none"> a) restricted system causes to operate at poor point of rating b) fan too large for application c) ducts vibrate at same frequency as fan pulsation
	A-14 GAS VELOCITY THROUGH CRACKS, HOLES OR PAST OBSTRUCTIONS	<ul style="list-style-type: none"> a) leaks in duct work b) fins on coils c) register or grilles

PROBLEM	SOURCE	PROBABLE CAUSE
NOISE	A-15 RATTLES AND/OR RUMBLES	<ul style="list-style-type: none"> a) vibrating duct work b) vibrating cabinet parts c) vibrating parts not isolated from building
	B-1 FAN	<ul style="list-style-type: none"> a) forward curved impeller installed backwards b) fan running backwards c) cut-off missing or improperly installed d) impeller not centred with inlet collar(s) e) fan speed too slow
INSUFFICIENT AIR FLOW	B-2 DUCT SYSTEM	<ul style="list-style-type: none"> a) actual system is more restrictive (more resistance to flow) than expected b) dampers closed c) registers closed d) leaks in supply ducts e) insulating duct liner loose
	B-3 FILTERS	<ul style="list-style-type: none"> a) dirty or clogged
	B-4 COILS	<ul style="list-style-type: none"> a) dirty or clogged
	B-5 RECIRCULATION	<ul style="list-style-type: none"> a) internal cabinet leaks in bulkhead separating fan outlet (pressure zone) from fan inlets (suction zone) b) leaks around fan outlet at connection through cabinet bulkhead
	B-6 OBSTRUCTED FAN INLETS	<ul style="list-style-type: none"> a) elbows, cabinet walls or other obstructions restrict air flow. Inlet obstructions cause more restrictive systems but do not cause increased negative pressure readings near the fan inlet(s). Fan speed may be increased to counteract the effect of restricted fan inlet(s)
	B-7 NO STRAIGHT DUCT AT FAN OUTLET	<ul style="list-style-type: none"> a) fans which are normally used in duct system are tested with a length of straight duct at the fan outlet. If there is no straight duct at the fan outlet, decreased performance will result. If it is not practical to install a straight section of duct at the fan outlet, the fan speed may be increased to overcome this pressure loss.
	B-8 OBSTRUCTIONS IN HIGH VELOCITY AIR STREAM	<ul style="list-style-type: none"> a) obstruction near fan outlet b) sharp elbows near fan outlet c) improperly designed turning vanes d) projections, dampers or other obstruction in part of system where air velocity is high

PROBLEM	SOURCE	PROBABLE CAUSE
TOO MUCH AIR FLOW	C-1 SYSTEM	<ul style="list-style-type: none"> a) oversized duct work b) access door open c) registers or grilles not installed d) dampers set to by-pass coils e) filter(s) not in place
	C-2 FAN	<ul style="list-style-type: none"> a) backward inclined impeller installed backwards (power will be high) b) fan speed too fast
STATIC PRESSURE WRONG	D-1 SYSTEM, FAN OR INTERPRETATION OF MEASUREMENTS	<p>general discussion: The velocity pressure at any point of measurement is a function of the velocity of the air or gas and its density. The static pressure at a point of measurement in the system is a function of system design (resistance to flow), air density and the amount of air flowing through the system. The static pressure measured in a "loose" or oversized system will be less than the static pressure in a "tight" or undersized system for the same flow rate. In most systems, pressure measurements are indicators of how the installation is operating. These measurements are the result of air flow and such are useful indicators in defining systems characteristics. Field static pressure measurements rarely correspond with laboratory static pressure measurements unless the fan inlet and fan outlet conditions of the installation are exactly the same as inlet and outlet conditions in the laboratory. Also see D-2 through D-6, E-2, F-1, and G-1, for specific cases.</p>
	D-2 SYSTEM	<ul style="list-style-type: none"> a) system has less resistance to flow than expected. This is a common occurrence. Fan speed may be reduced to obtain desired flow rate. This will reduce power (operating cost).
	D-3 GAS DENSITY	<ul style="list-style-type: none"> a) pressure will be less with high temperature gases or high altitudes
	D-4 FAN	<ul style="list-style-type: none"> a) Backward inclined impeller installed backwards. Power will be high b) fan speed too high

PROBLEM	SOURCE	PROBABLE CAUSE
static pressure low, flow rate low	D-5 SYSTEM	a) fan inlet and/or outlet conditions not same as tested. See general discussion (D-1). Also see B-1 through B-8.
static pressure high, flow rate low	D-6 SYSTEM	a) obstruction in system b) dirty filters c) dirty coils d) system too restricted Also see B-1 through B-8.
POWER HIGH	E-1 FAN	a) backward inclined impeller installed backwards b) fan speed too high
	E-2 SYSTEM	a) oversized duct work b) face and by-pass dampers oriented so coil dampers are open at the same time by-pass dampers are open c) filter(s) left out d) access door open
	E-3 GAS DENSITY	a) calculated horse power requirements based on light gas (e.g. high temperature) but actual gas is heavy (e.g. cold start up)
	E-4 FAN SELECTION	a) fan not operating at efficient point of rating. Fan size or type may not be best for application
FAN DOES NOT OPERATE	F-1 ELECTRICAL OR MECHANICAL	Mechanical and electrical problems are usually straightforward and are normally analysed in a routine manner by service personnel. In this category are such item as: a) blown fuses b) broken belts c) loose pulleys d) electricity turned off e) impeller touching scroll f) wrong voltage g) motor too small and overload protector has broken circuit

PROBLEM	SOURCE	PROBABLE CAUSE
PREMATURE FAILURE	<p>G-1 BELTS, BEARINGS, SHEAVES, IMPELLER, HUBS, ETC.</p>	<p>general discussion: Each fan component is designed to operate satisfactory for a reasonable life time. Fan intended for heavy duty service are made especially for that type of service. For example, Class I fans are intended for operation below certain limits of pressure and outlet velocity. Class II fans are designed for higher operating limits (see AMCA standards 2408). Not all components are limited by the same factors, e.g. limiting factors may be power, round per minutes, temperature, impeller tip speed, torque, corrosive atmospheres, expected life, etc. Also see A-3, A-5, A-6.</p>
	G-2 COUPLINGS	see item A-4
	G-3 SHAFT	also see A-10



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