VENTILADORES Armee

SAFETY INSTALLATION, OPERATION AND MAINTENANCE SERVICE MANUAL

# HEAVY DUTY FANS

## INTRODUCTION

### GENERAL INFORMATION

This manual is intended to aid in proper installation and operation of Heavy Duty fans manufactured by ARMEE, S.A. de C.V.. Due to the wide variety of arrangements and types of Heavy Duty fans, it is not intended to cover detailed installation procedures. Each purchaser of an ARMEE Heavy Duty fan is furnished with a detailed assembly drawing showing working conditions and a bill of material which is your Parts List. Any special features or installation requirements are described on this drawing to aid in proper installation and startup. A bulletin covering this fan in more detail, and operating performance curves, are available through ARMEE. A convenient Record of Fan Installation is located en the inside back cover of this manual.

It is the responsibility of the purchaser to insure that installation and operation is handled by qualified personnel experienced in this type of equipment. Omission in this manual or on ARMEE assembly drawings of details or operation methods commonly considered good practice by competent erection personnel are not the responsibility of ARMEE, S.A. de C.V..

### SAFETY PRECAUTIONS

The fan you have purchased is a rotating piece of equipment that can become a source of danger to life, and can cause injury if not properly applied. **Maximum operating temperature and speed for which this fan is designed must not be exceeded.** These limits are given in our catalog, or in the order acknowledgment, or on ARMEE, S.A. de C.V. drawings.

Personnel who will operate this fan, or those who will perform maintenance thereon, must be given a copy of this manual to read and warned of the potential hazards of this equipment.

This manual contains general recommendations, but attention must also be paid to the specific safety requirements which apply to the individual installation. Such requirements are outlined in federal, state and local safety codes. Strict compliance with these codes, as well as strict adherence to installation instructions, are the responsibility of the user and are necessary to the safe operation of this fan.

**The elements which connect the driving mechanism to the fan (V-belt drives or couplings) create potential DANGER to personnel and suitable guards must be provided.**

**Bearing assemblies and drive couplings must be covered so that no rotating element can snag clothing or skin.** Shaft cooling wheels or any other rotating part must be covered. Any open sheave, pulley, sprocket, belt, chain, and other similar transmission device must be enclosed by guards.

Another potential hazard is the ability of the fan to convey loose material which can be a projectile. **Ducts must be protected to prevent object from entering the air stream. Place suitable guards over inlets end outlets of fans to prevent the entrance of clothing or flesh into the rotating parts.**

Vibration limiting switches should be provided to detect sudden changes in the operation of the fan, especially when operating a fan under high temperature or in en extremely corrosive atmosphere.

**Any access door in the housing must not be opened when the fan is in operation.** Those on the discharge side of the fan can explode when unbolted.

Proper protection from electrical start of the fan during maintenance is required. **A disconnect switch provided with a padlock to prevent operation of the fan switch is required**. In addition, a disconnect switch should be located at the fan for use by personnel working on the fan.

### RECEIVING and INSPECTION

All shipments are thoroughly inspected prior to shipment F.O.B. Tultitlán, Estado de México. All shipments must be carefully inspected by the Receiving Agent for damage. Any damage must be noted on the carrier's Bill of Lading and a claim filed immediately with the freight company by the receiver. Partial shipments are common on equipment of this type. Make a careful check that all parts shown en the Bill of Lading have been received.

### STORAGE PRECAUTIONS

If storage of equipment is necessary prior to erection, precautions must be taken to prevent damage. The rust preventative paint applied to the fan housing is sufficient in most environments to protect it from damage for a short time outside. The rust preventative compound applied to machined surfaces at ARMEE, such as shafting, bearing pedestals and sole plates, is intended for in-transit protection only. if prolonged outside storage is necessary, additional applications of rust preventative compound, waterproof paper, tarpaulin or plastic covers are the responsibility of the purchaser. Covered equipment must be provided with moisture absorption material. Motors, pedestals, dampers, shafts and bearings should be stored in a temperature controlled building to prevent deterioration prior to erection. Bearings should be tightly sealed to prevent corrosion or buildup of foreign material during storage. In most cases, standard preparation for shipment by bearing, coupling and motor manufacturers is not sufficient for prolonged outdoor storage.

If a wheel and shaft is received as a separate assembly, block each end of the shaft to prevent sagging. When a wheel is located in a fan housing, the wheel should be rotated 180º approximately once every two weeks.

## INSTALLATION

### UNLOADING and HANDLING

#### Rotor Assembly:

Many ARMEE Heavy Duty wheels are furnished as a rotor assembly complete with a shaft and often with a shrink fit between wheel and shaft. This rotor assembly may be shipped on a fabricated steel wheel cradle for ease of handling in shipment and unloading. Remove the rotor assembly from the cradle by placing slings around the shaft as close as possible to either side of the wheel. A spreader bar on the hoisting cables must be used to eliminate damage to the wheel during lifting. (See figure 1). Do not use any part of the wheel rim for lifting purposes. Do not put the sling on that portion of the shaft where the bearings will later be mounted. Rotors must never be lifted by the wheel, blades or sideplates, or allowed to rest on the ground without blocking the shaft ends. Wheels should never be rolled when lifting equipment is available, if rolling becomes necessary, extreme caution must be exercised to prevent damage. A wheel that has been knocked out of round must be re-balanced.
If the fan wheel is separate from the shaft, a wrapped sling or timber may be passed through the hub for lifting. Extreme care must be taken not to damage the finished bore of the hub, or the bearing and hub surfaces of the shaft.

#### Housing:

In unloading and handling large housing sections, an attempt should be made to lift from as many points as possible. Spreader bars must be used to prevent concentrated stresses that can collapse the housing and cause permanent distortion. inlet box and outlet dampers must be handled with care as distortion could cause binding during operation.

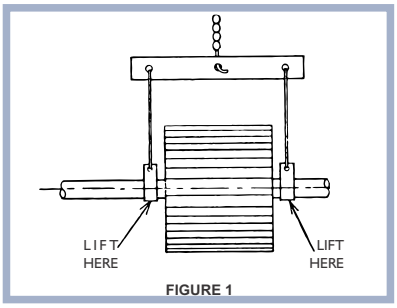


FIGURE 1

Fans covered with special coating or paint must be protected in handling to prevent damage. **Avoid nicks or cuts in the coating which may be difficult and expensive to repair.**

## FOUNDATIONS

**A rigid, level foundation is a must for every fan.** it assures permanent alignment of fan and driving equipment, reduces excess vibration, and minimizes maintenance costs. The sub foundation (soil, stone, rock, et cetera) should be firm enough to prevent uneven settlement of the structure. Foundation bolt locations are found on the assembly drawings.

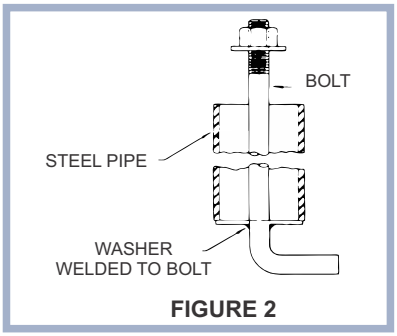


FIGURE 2

### Poured Concrete:

Reinforced poured concrete is the preferred foundation for Heavy Duty fans. The minimum design weight of a concrete foundation should be three times the total assembly weight of the fan and driver. This mass acts as an inertia block and will absorb any normal vibration that might develop as well as hold driver and fan in perfect alignment. it is preferred that the bottom of the base be larger than the top with the degree of taper to the footing course dependent on the available sub foundation. The edges of the foundation should be beveled to prevent chipping and should extend at least 6" beyond the fan structure. A minimum allowance of 1" should be made for shimming and grouting when the top level of the foundation is determined (See figure 3).

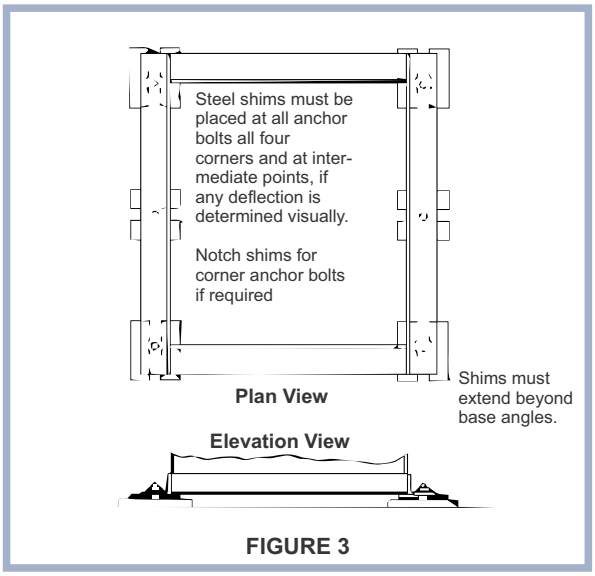


FIGURE 3

Sole plates under the fan pedestals and motor base plate, (figure 7), are recommended for use on concrete foundations. Parts can then be removed without disturbing the cement grout and realignment is easier.

"L" shaped hold down bolts should be used in the concrete, (See figure 2). They should be placed in a metal sleeve or pipe having a diameter 2½ times the hold down bolt diameter to allow minor adjustment after the concrete has cured. When determining the length of anchor bolts, allow 1" extra length for leveling and grout, flange thickness of the fan foundation, nut, washer, and extra threads for draw down. "L" bolts must be positioned so the bottom does not break out of the concrete.B. Structural Steel Foundations:
If the fan is mounted on equipment having parts which cause vibration, it is very important that the fan support be rigid enough to prevent such vibration from being carried to the fan. The resonance frequency of this support must be a minimum of 25% above the maximum fan speed.

When a structural steel foundation is necessary, it must be sufficiently rigid enough to assure permanent alignment. it must be designed to carry, with minimum deflection, the weight of the equipment plus the loads imposed by centrifugal forces set up by the rotating element. In such cases, the design of the structure must permit field revisions (such as knee braces) if initial operation indicates a need for increased stiffness.

## DUCT LOCATION and DESIGN

When locating the foundation, carefully plan the ducting or breaching to the fan to avoid possible air performance problems.

To deliver stable rated performance, fans require smooth, straight distributed flow into the inlet and straight flow out of the outlet for a distance of at least three duct diameters. Where duct turns or abrupt change in duct dimensions are necessary within three duct diameters of fan inlet, flow distributing devices (turning vanes) must be installed (See figures 4 and 5). Where these means are impractical, such as close to the fan outlet. Care must be taken to prevent spiral or vortex flow into fan inlet since these flow conditions frequently cause pulsation or unstable delivery. Contact ARMEE for further information, See Back Cover.

### Duct Connections

**Flexible connections and or expansion joints must be provided at fan inlet and outlet** to isolate the fan from duct static loads, duct temperature expansion loads and from vibration loads. Flexible connections may be multiple bellows expansion joints, banded slip joints or fabric or sheet plastic flexible joints. Flexible connections may require acoustic treatment to reduce noise radiation. Ducts must be separately anchored near the fan.

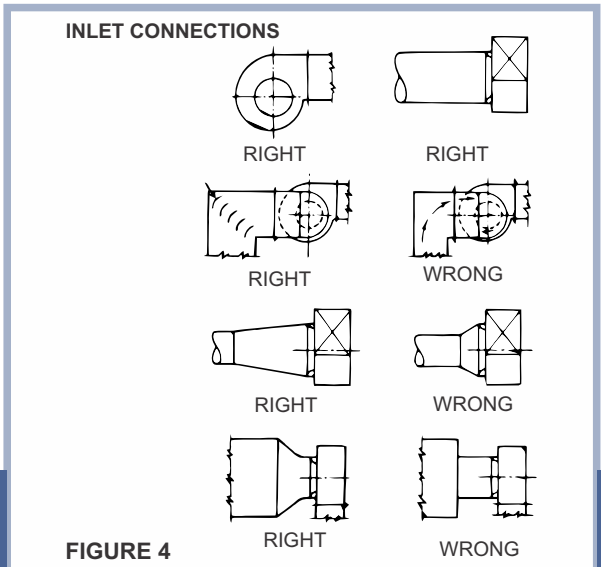


FIGURE 4

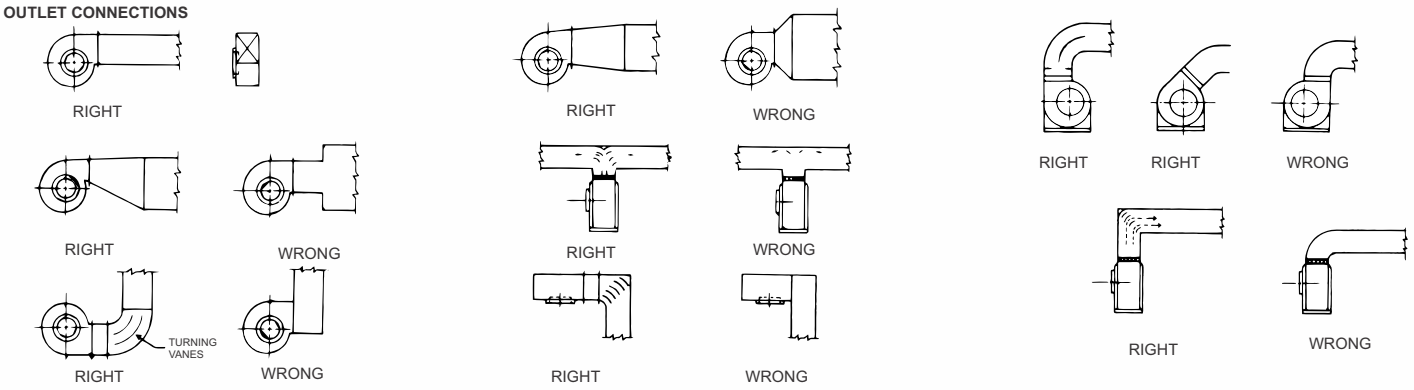



**FIGURE 5**

## FAN ERECTION

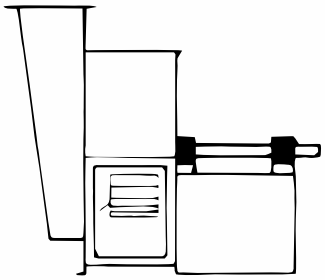
Erection as covered in this section specifically covers Arrangement 3-SISW and 3-DIDW fans with independent pedestals. Although the procedure for installing A/1 or A/8 fans differ slightly, they are generally less complicated to install and incorporate simple modifications of some of the steps outlined. See figure 6.

For arrangement 1 and 8 fans, (fan wheel overhung, bearings on one pedestal), level shaft between bearings, using a spirit level. Shim under pedestal to attain level. Tighten foundation hold down bolts.

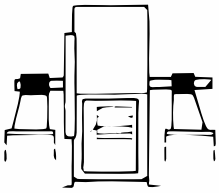
For fans with independent pedestals proceed as follows:

### DRIVE ARRANGEMENTS FOR CENTRIFUGAL FANS

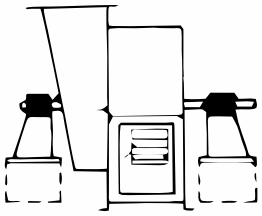
**SW** - Sinlge Width **DW** - Double Width
**SI** - Sinlge Inlet **DI** - Double Inlet



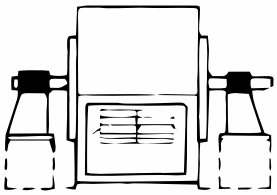
**ARR. 1 SISW WITH INLET BOX** For belt drive or direct connection. Impeller overhung, two bearings on base. Inlet box may be self-supporting.



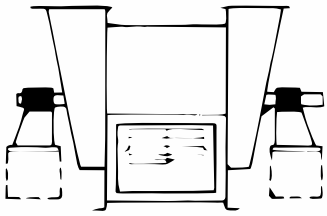
**ARR. 3 SISW WITH INDEPENDENT PEDESTAL** For belt driver or direct connection fan. Housing is self-supporting. One bearing on each side supported by independent pedestals.



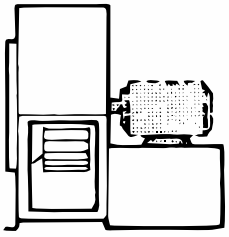
**ARR. 3 SISW WITH INLET BOX AND INDEPENDENT PEDESTALS** For belt drive or direct connection fan. Housing is self-supporting. One bearing on each side supported by independent pedestals with shaft extending through inlet box.



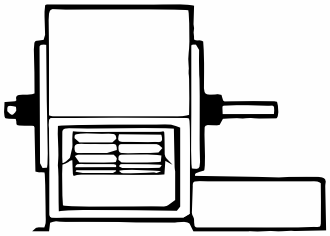
**ARR. 3 DIDW WITH INDEPENDENT PEDESTAL** For belt drive or direct connection fan. Housing is self-supporting. One bearing on each side supported by independent pedestals.



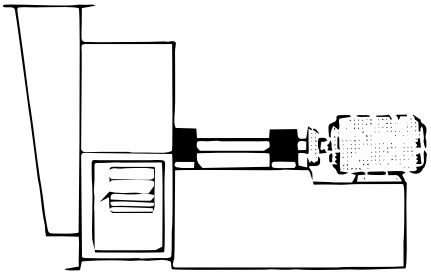
**ARR. 3 DIDW WITH INLET BOX AND INDEPENDENT PEDESTALS** For belt drive or direct connection fan. Housing is self-supporting. One bearing on each side supported by independent pedestals with shaft extending through inlet box.



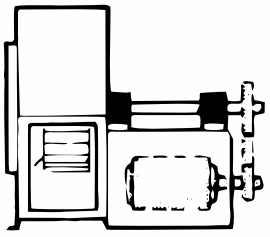
**ARR. 4 SISW** For direct drive. Impeller overhung on prime mover shaft. No bearings on fan. Prime mover base mounted or integrally directly connected.



**ARR. 7 DIDW** For belt drive or ditect connection. Arrangements 3 plus base of prime mover.



**ARR. 8 SISW WITH INLET BOX** For belt drive or direct connection. Impeller overhung, two bearings on base plus extended base for prime mover. Inlet box may be self-supporting.



**ARR. 9 SISW** For belt drive. Impeller overhung, two bearings, with prime mover outside base.

**FIGURE 6**

## Set and Align Housing on Foundation:

If the housing was shipped knocked down, the bottom half must be lifted onto the foundation first.

Place wooden blocks beside the anchor bolts to prevent damage to them while the housing is being moved into proper position. The housing should be lifted from as many points as possible. The use of spreader bars will help minimize distortion. When the housing is properly aligned over the anchor bolts, it should be lifted up one side at a time, the block removed, and the housing lowered carefully onto the foundation. Temporary shims approximately the same thickness as the grout should be placed on either side of each anchor bolt. The shims should be flush with the edge of the base angle and should be approximately 4" wide. These shims will give the housing good support and prevent it from slipping when the anchor bolts are drawn down. See figure 3.

## Set and Align Bearing Pedestals:

The bearing pedestals should be put in place, using shims, to approximate the proper bearing centerline height. The fixed, or drive side, bearing must be leveled at this time using flat shims under the sole plate. Approximately 1/8" should be allowed for shimming between pedestal top and bearing for possible future alignment problems caused by settling of the foundation. In leveling the sole plate, adjusting bolts on the "L" bolts are helpful but after final alignment hard shims must be placed next to each "L" bolt and under the center of the sole plate before grouting. See figure 7. Note that pedestal can be removed from the side without disturbing foundation bolts.

On top of the pedestal, shims running the full length and half the width of the bearing foot, slotted to fit around the mounting bolts, provide the most solid mounting arrangement for later mounting the bearings. Temporarily bolt down bearing pedestals.

## Prepare Rotor Assembly:

All ARMEE Heavy Duty wheels are shipped with a shrink or slip fit to the shaft. Check the proper wheel rotation with the rotation arrow on the drawings on the fan, or the diagrams in figure 8.

Carefully place the wheel on the floor and brace in position. Remove any protective coating from the shaft and hub. Check for rust, corrosion and nicks, If cleanup is necessary, **DO NOT USE EMERY CLOTH** on any bearing surface. Crocus cloth may be used if necessary. Clean and oil the shaft portion which fits into the wheel, as well as the wheel bore itself. Remove all keys and loosen set screws. Check fan assembly drawing for location of wheel on the shaft. **Rotation is as viewed from the drive side. On dual drive units, it is generally from the "fixed" bearing end. Refer to general assembly drawing.**

Lift shaft, using padded slings; carefully slide end into wheel hub and push through until wheel is properly located on shaft as shown on the assembly drawing. Extreme care must be taken not to damage wheel bore or shaft seat. Set keys in position, tighten set screws just enough to hold wheel on shaft during handling. Tighten fully when clearances have been set.

On a rotor with a factory shrink fit, the preparation of the rotor assembly is limited to cleaning up the shaft for installation.

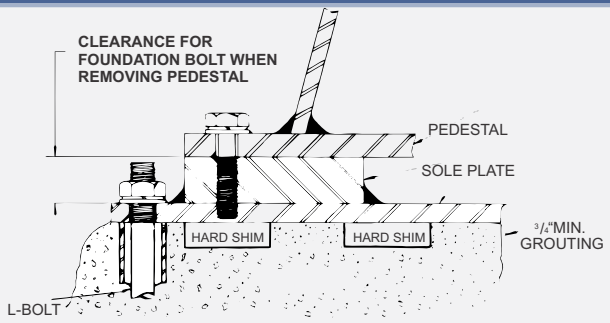
## Set Inlet Cone, Ring, or Inlet Volume Control

At this time, the inlet Cone and retaining rings (or inlet Volume Controls, if furnished) are placed over the shaft end for mounting the rotor assembly in the housing. See figure 9. If inlet volume controls are provided, check for proper rotation. See figure 10. Inlet vanes in the half closed position must pre-spin the air in direction of wheel rotation. On a DIDW fan one inlet vane control is clockwise and the other counter-clockwise. Do not install them reversed. Secure inlet vane controls to wheel for lifting purposes. Do not allow vane center mechanism to rest on shaft as damage will result.

## Prepare Bearings, Set Rotor Assembly:

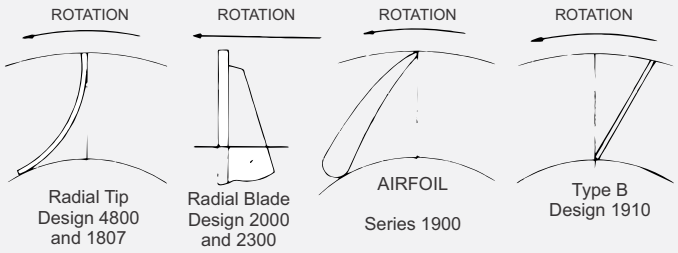
1. For Sleeve Bearings:

Remove bearing caps and clean bearings with solvent. Coat with clean oil and cover to avoid contamination. Clean oil rings and shaft seals. **Do not mix parts between the bearings as they are not interchangeable.** Bolt the lower half of the bearing loosely in place. Again cover to prevent




Section veiw showing pedestal, sole plate and grouting.

FIGURE 7




Direction of Rotation for Various Blade Shapes (Shown for counterclockwise from drive side)

FIGURE 8

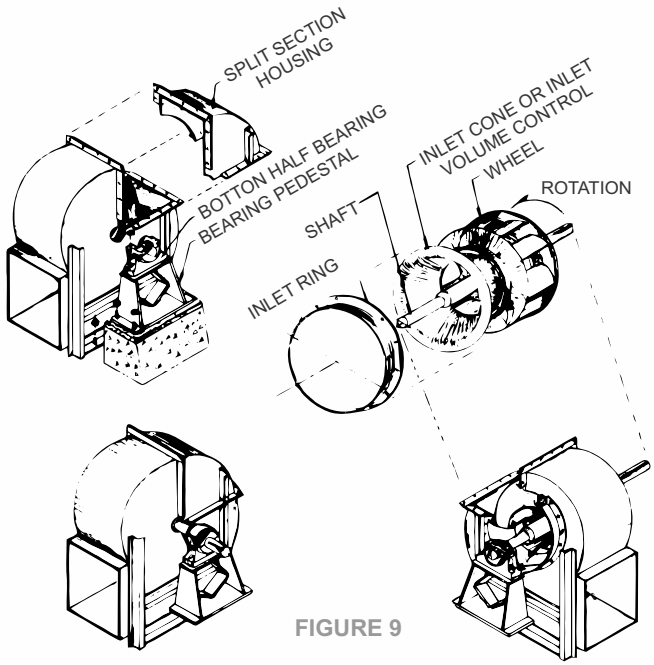



FIGURE 9

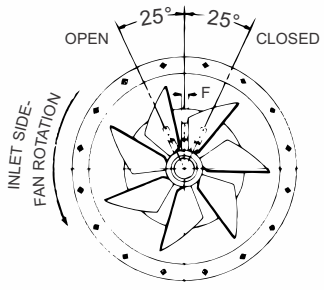



FIGURE 10

contamination. Sling the rotor assembly as previously describes. To prevent damage to the liner in the fixed bearing (having the thrust collars) when putting large rotor assemblies in place follow this procedure: The rotor assembly is to be positioned above the bearing journals and the liner for the fixed bearing is then fastened to the shaft and lowered into the bearing housing with the rotor assembly. **For further information refer to Sleeve Bearing Detail Section.**

**2. For Anti-friction Bearings-Solid Pillow Blocks:**
Non-split pillow blocks are slipped over the shaft ends prior to putting the rotor in place. Check to insure that the floating bearing (unless specified on the assembly drawing) is on the side opposite the driver. See figure 12, Bolt bearings loosely on pedestals. For further information.

**3. For Anti-friction (roller) Bearings-Adapter mount, Split Pillow Block:**
Cleaning of internal parts should not be required as the corrosion preventative compound applied by the manufacturer is compatible with recommended lubricants. Careful inspection of all internal parts is good practice, as any corrosion present is likely to cause problems at a later date. Do not mix parts between bearings as they may not be interchangeable.

The bottom half of the pillow blocks is loosely bolted in place on the pedestals. Open pillow blocks and bearing parts exposed to atmosphere must be covered with a clean cloth to prevent contamination.

The internal parts of the bearing are placed on the shaft ends in the same order that they were removed from the pillow block. See figure 13. Sling the rotor assembly as described previously and lift into place. Put bearing caps in place to prevent contamination prior to final alignment.

## Align Rotor and Housing

As a first step to proper alignment, level the drive side bearing first. The floating bearing will later be shimmed to account for the shaft deflection. See figure 11A. In leveling the bearing, see that the shaft centerline is the proper height for connection to the driver. After shimming of the drive bearing is complete, it should be drawn down. The floating bearing should be shimmed to take up the shaft deflection and should be drawn down in conjunction with the alignment of the inlet cone or inlet volume control.

Wheel to cone alignment details are included on the assembly drawing provided with each fan. The drawing gives a dimension for the inlet cone to wheel backplate distance. Check this alignment before final tightening of pedestals, bearing bolts and bearing locking devices. See figure 11B.

# Adjustments for Expansion

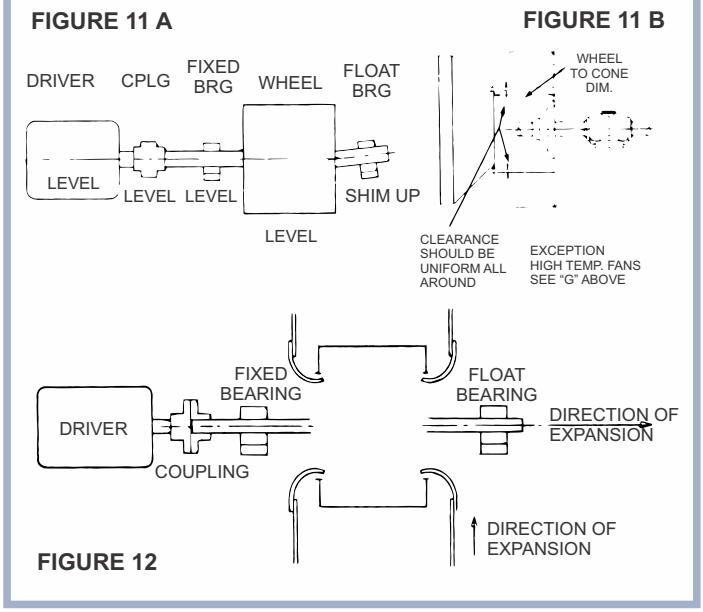
**Induced Draft fans, or other high temperature applications, require wheel and cone adjustments for expansion due to temperature.** This is because the housing expands up from the foundation while the rotor expands concentrically from the shaft centerline as well as axially from the fixed bearing. The following rules of thumb should be used on applications in excess of 300ºF:

1. Axial overlap on double width fans should be approximately twice as much on the drive side as on the floating side.
2. Radial clearance between the wheel and inlet cones should be twice as much at the top as at the bottom.

**For Forced Draft fans or other low temperature applications under 300ºF., care should be taken to duplicate exactly the wheel to cone clearances recommended on the assembly drawing.** Cold settings are shown on the assembly drawing.

## Set and Align Bearings

The setting of the drive side bearing level with the driver and aligning the outboard bearing have been mentioned previously. it is preferable that the drive bearing be set level to facilitate alignment of the driver which is also set level. Any shaft deflection caused by suspension of the rotor weight between the bearings must be accounted for in the outboard bearing by placing shims under it. See figure 11A. Shaft level is placed on the shaft at the journals and compared to the machined surface of the bearing housing until an equal slope is achieved. This equal alignment of the bearings to the




shaft can also be checked by measuring the bearing seal as being equal distance from the shaft all around.

## Align Inlet Cones or Inlet Volume Controls

After the alignment of the rotor assembly, coupling and drives is complete, the inlet cones or IVC's should be repositioned to give proper clearance. Center the cones on the inlet eye of the wheel. At this time, the IVC linkage should be assembled as required. Details of linkage arrangement are supplied on the fan assembly drawing. Install gasketing in housing split, install split portion of housing. Allowance must be made for expansion when operation is to be at elevated temperature. (Refer to the assembly drawing). Tighten all fasteners in foundation, pedestals, etc. that were previously left loose. Install shaft seals if supplied. Turn rotor by hand to make sure it runs freely.

**1. Dodge Sleeve Bearings**
The elliptical shape of sleeve bearing liners makes lining up the bearings square with the shaft relatively simple. When the shaft rests in the liners, there is clearance on both sides the full length of the liners. In squaring up the bearings, a .0015 or .002 shim should be able to run the entire length of the liner at a fixed depth.
After alignment, install oil rings. Sizes up t0 3-7/16" have a single ring; 3-15/16" and up, double rings. Tighten set screws on the rings and be sure that rings rotate freely on shaft. Run dust seal into its groove in the housing and fasten ends together. Next, put a coating of oil on the upper portion of the liner and put in place. Place cap on bearing and tighten stud nuts. The plunger screw must be loose before the stud nuts are tightened. Detail instructions on sleeve bearing assembly can be found in the Bearing Detail Section.

**2. Split Pillow Blocks Spherical Roller Bearings**
The lower half of the pillow block should be bolted loosely to the pedestal. After assembling bearing parts on the shaft in the same order as figure 13, hand tighten the adapter assembly. Be sure that the bearing is properly positioned on the shaft before tightening to the proper clearances. The

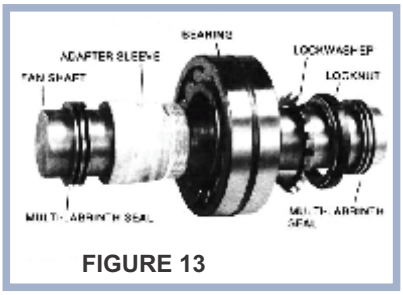



FIGURE 13

space in the expansion or floating bearing should always be on the outboard side or side away from the drive (coupling) bearing. See the bearing assembly instructions in Bearing Detail section.

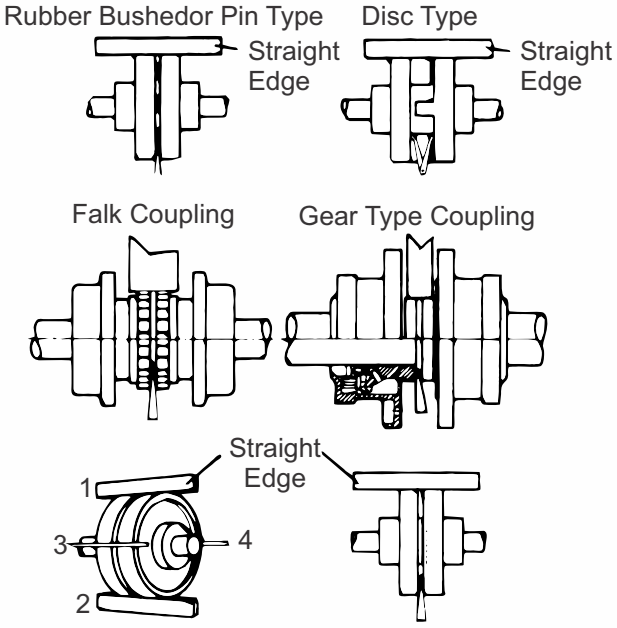
**3. Solid Pillow Block Spherical Roller Bearings**
Slide, tap or press bearings on shaft. Establish final shaft position and tighten bearing to support using SAE Grade 5 mounting bolts. Position locking collar and tighten set screws to the torque shown in table VIII. For further details.

## Flexible Coupling Installation and Alignment

These instructions cover, in general, the installation of flexible couplings of the pin, gear, or grid types.

1. Before mounting coupling(s), be sure all bearing(s), inlet vane(s), etc., have been installed.
2. Install each coupling half cover with "O" ring on its shaft.
3. Determine which direction, long or short shank of coupling hub should be located; see manufacturer's manual.
4. Heat coupling hub to approximately 300ºF by means of hot oil bath or oven. Do not apply flame to hub teeth.
5. Install coupling hub(s) on shaft. Hub and shaft face should be flush.
6. Key the couplings to the shafts while the hub(s) are still hot.
7. Adjust the clearance between the coupling faces. The proper clearance dimension is listed on the assembly drawings and included in manufacturer's information. This dimension may also be stamped on the coupling hubs.
8. When a sleeve bearing motor is used, locate it so that when the motor rotor is closest to the fan, the motor shaft will not touch the fan shaft. If the motor shaft has its magnetic center marked, align it in this position; otherwise equally divide the maximum play to obtain the mechanical center.

## Coupling Aligment




Check all types at four positions 90° apart as shown.

FIGURE 14

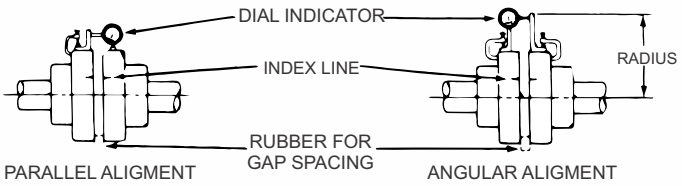



FIGURE 15

**TABLE I**
**COUPLING LUBRICANTS Co.**

| Lubricant Manufacturer | General | Moist or Wet | High Torque | 150º-300ºF | Class III |
|---|---|---|---|---|---|
| American Lubricants Co. | Albuco Bison 1650 | (same) | (same) | (same) | (same) |
| Atlantic Richfield Co. | Arco MP | Arco MP | Arco EP or Moly D | Dominion H2 | Dominion H3 |
| Amoco | Amolith #2 | Amolith #2 | Amolith #2 | Rykon EP-2 | Amoco CPLG Grease |
| Chevron USA, Inc. | Duralith EP-2 | Duralith EP-2 | Duralith EP-2 | Duralith EP-2 | NL Gear Compound 460 |
| Cities Service Oil Co. | Citgo AP or HEP-2 | AP or HEP-2 | AP or HEP-2 | AP or HEP-2 | Citgo AP or EP Com pound 130 |
| Continental Oil Co. | Super Sta Grease | HD Calcium Grease | HD Calcium | HD Calcium | HD Calcium, Transmision Oil No. 140 |
| Far Best | Molyvis ST-200 | (same) | (same) | (same) | - |
| Fiske Bros. Refining Co. | Lubriplate 630-AA | Lubriplate 630-AA | Lubriplate 630-AA | Lubriplate 1200-2 | Lubriplate No. 8 |
| Gulf Oil Co. | Gulfcrown EP #2 | Gulfcrown EP #2 | Gulfcrown EP #2 | Hi-Temp Grease | Precision No. 3 |
| Exxon Co. | Pen-O-Lead EP - 350 | Rolubricant EP-300 | Rolubricant EP-350 | Unirex N2 | Unirex N2 or Nuto No. 146 |
| Kendall Refining Co. | Kenlube L -421 or Waverly Torque Lube A | L-421 or Torque Lube A | -421 or Torque Lube A | L-421 or Torque Lube A | L-427 |
| Mobil Oil Co. | Mobilux EP-O | Mobilux EP-O | Mobil Temp 78 | Mobil Temp 78 | Mobil No. 28 |
| Pennzoil Co. | Pennlith 711 or 712 | Pennlith 711 or 712 | Pennlith 711 or 712 | Pennlith 712 or Bearing Lube 706 | Hi Speed Pennlith 712 or Bearing Lube 706 |
| Suntech, Inc. | Sunaplex 991 EP or Prestige 741 EP | (same) | (same) | (same) | - |
| Syn-Tech | 3913-G1 | (same) | (same) | (same) | (same) |
| Tenneco Chemicals, Inc | Anderol 786 | (same) | (same) | (same) | (same) |
| Texaco, Inc. | Multifak EP-2 | Multifak EP-2 | Multifak EP-2 | Thermatex EP-2 | Thermatex EP-2 |
| Union Oil Co. of Calif. | UNOBA EP-2 | UNOBA EP-2 | UNOBA EP-2 | UNOBA EP-2 | MP Gear Lube 140 |

For low temp. (-65º), Aeroshell by Shell Oil Co., Anderol 793 by Tenneco Chemicals, Inc. & Mobil Grease #28 by Mobil Oil Co.

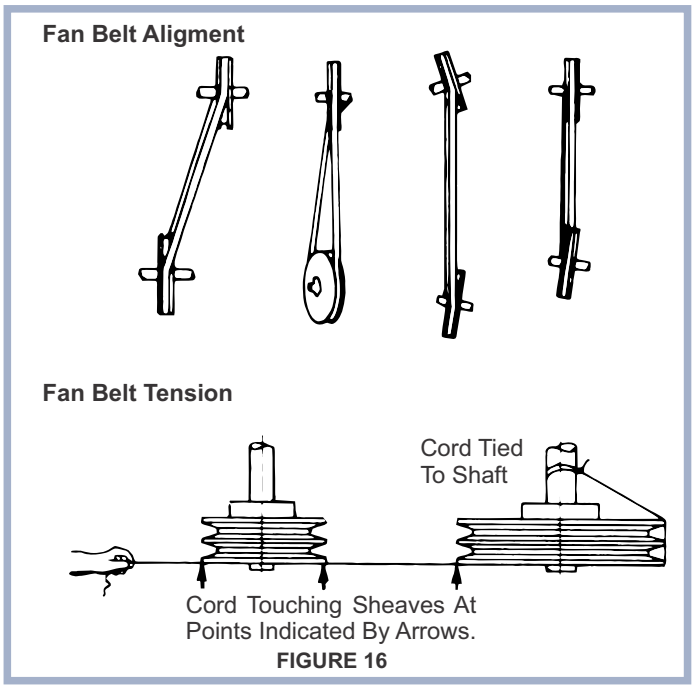


FIGURE 16

Align in this position.
9. With tapered wedge, feeler gauges, or dial indicator, observe that the faces of the fan and driver couplings are parallel.
10. Align the shafts until a straightedge appears to be parallel to the shafts. Repeat at three additional points at 90º from each other. Recheck angular alignment and hub separation. (See Figure 14.)
11. For more accurate alignment, use a dial indicator clamped on one hub, with the dial indicator button resting on the other hub. Rotate the hub on which the indicator is clamped, and observe the indicator reading. Take readings at four locations, 90º apart. With correct alignment, the faces of the couplings should be parallel within .001 per inch of shaft diameter, in both parallel and angular planes. (See Figure 15.)
12. Where large turbines or motors are used as drivers, the driver side of the coupling should be set low by a few thousandths to allow for the driver to heat up during operation when it will expand and bring the coupling into alignment.
A rule of the thumb for initial alignment of a large motor is: Set driver low .001" for each 1" of shaft diameter; i.e. 1" shaft motor low by .001", 2" shaft motor low by .002". Set turbines low by .001 ' per inch of turbine height from mounting feet to center line of shaft. After unit has operated and thermal expansion is complete, coupling alignment should be checked and corrected if necessary.
13. After completing the coupling alignment, clean both sides of the coupling thoroughly, and inspect the gasket for tears. cracks or other damage.
14. Install the gasket between the coupling halves. Draw together the coupling flanges keeping gasket holes in line with bolt holes. Insert and tighten bolts, lockwashers and nuts.
Lubricate in accordance with type of operating condition. See Table I.

## SPECIAL NOTE ON ALIGNMENT:

On any completely assembled fan, where ARMEE has mounted the motor and coupling, it is required that the alignment be rechecked after the fan is set on its permanent foundation. it is not possible to hold alignment during shipment or when set on a different foundation. Alignment must be redone, if necessary, and the coupling lubricated.

The lubricants listed below are recommended by the lubricant manufacturers for the indicated conditions. This list is solely for our costumers' convenience and does not constitute an endorsement. The listing is not intended to be complete nor necessarily current due to continuous research and improvement by the various manufacturers.

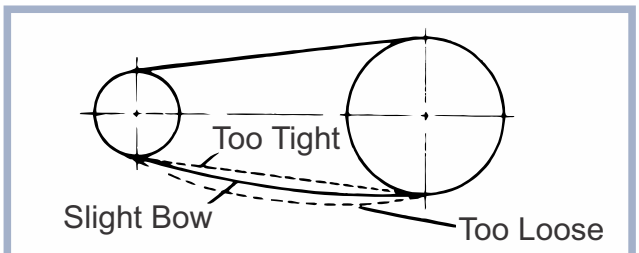


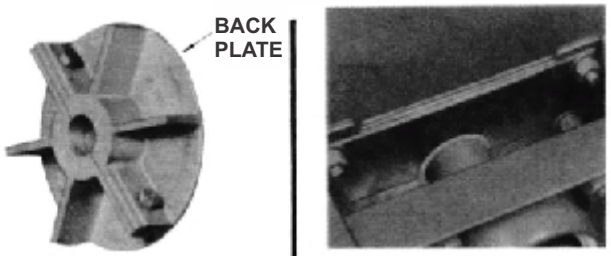
FIGURE 17

## V-BELT FAN DRIVE ALIGNMENT

Proper alignment, adjustment and balance of the V-Belt drive is essential to smooth fan operation and life. The following should be checked:
1. Fan and motor shafts must be parallel; adjust and shim motor as required. See Figure 16.
2. Fan and motor sheaves must be aligned axially. See Figure 16.
3. Adjustable motor sheave grooves must have no noticeable eccentricity.
4. Fan and motor sheave balance should be checked when there is any vibration.
5. Belts must have proper tension; follow drive manufacturer's instructions.
6. Belts either too loose or too tight cause vibration and excessive wear. See Figure

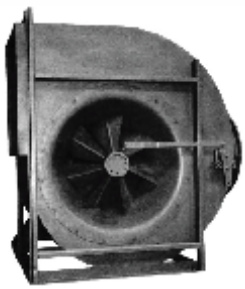
## Belt Tension Adjustment

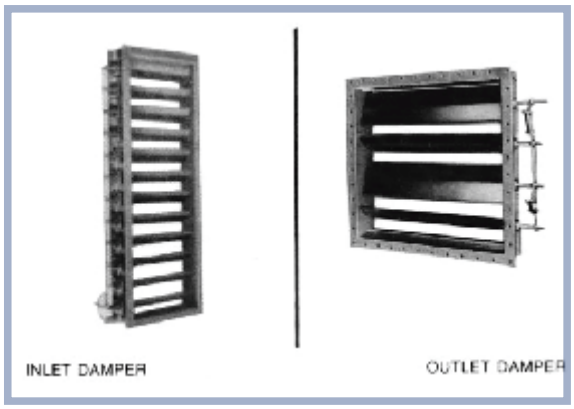
Step 1: With all belts in their proper grooves, adjust the centers to take up all slack and until the belts are fairly taut.
Step 2. Start the drive and continue to adjust until the belts have only a slight



SHAFT COOLER


SHAFT SEAL


INLET VANE CONTROL




bow on the slack side of the drive while operating under load. See sketch above.
Step 3. After a few days operation the belts will seat themselves in the sheave grooves and it may become necessary to readjust so that the drive again shows a slight "bow" in the slack side.
The drive is now properly tensioned and should operate satisfactorily with only en occasional readjustment to compensate for belt and groove wear.

### Grouting Unit

After completion of all installation and alignment it is recommended that a Service Engineer check the installation prior to grouting. This service is available on a daily fee plus expenses basis through ARMEE. After verification of alignment, grouting can be completed. There are a number of commercial non-shrinking grouts available such as 5 star grout having aluminum chips or Embaco with steel chips. Allow 72 hours after grouting before startup.

## ACCESSORY INSTALLATION

**Shaft Coolers-** have split cast aluminum radial bladed wheels, designed to dissipate heat conducting down the shaft toward the bearing. The two halves are bolted together around the fan shaft with the backplate toward the fan housing and the cooling fins drawing air over the bearing. Consult assembly drawing for proper location. An expanded metal guard must be installed over this wheel.

**Shaft seals** are compressed fibrous material, split type furnished as a standard on most fans, both on the inlet box and drive side of the fan.

**Inlet Volume Controls (IVC)** are inlet cones with variable inlet vanes mounted in them for regulation of fan volume and power. On double inlet units, interconnecting linkage assures simultaneous operation. See Figure 10 on how to check that the vanes are spinning the inlet air in the direction of wheel rotation.

**Linkage assembly details** are provided on the fan assembly drawing. IVC's are furnished for manual operation with locking quadrant or for automatic operation using an electric or pneumatic operator furnished by others.

**Inlet Box Dampers** are provided for volume control and power savings similar to that achieved with the IVC. The damper comes in a separate channel iron frame with damper axles running parallel to the fan shaft. When partially closed, the blades pre-spin the air the in the direction of wheel rotation. Units operating in excess of 300ºF. Are provided with flanged ball bearings mounted on stand off channels, and cast stuffing boxes containing braided fibrous packing to prevent leakage. For units shipped knocked down, or DID units, detailed linkage mounting information is on the fan assembly drawings. At installation make sure they pre-spin the air in direction of wheel rotation.

**Outlet Dampers** are mounted in a separate channel frame and bolt to the discharge outlet of the fan for volume control. The damper blades are double surface and are opposed blade. Dampers operating in excess of 300ºF. Are provided with flanged ball bearings mounted on remount channels and cast stuffing boxes with braided fibrous packing to prevent leakage.

**Note: On high temperature dampers (above 300ºF.) the set screws should not be tightened in the damper axle bearings on the side opposite the operating linkage.** This allows the damper shaft to expand away from the locked bearings on the linkage side.

### Damper Inspection

Whether damper is received installed on the fan or shipped separately, check all the levers, linkage and blade hardware to see that they are secure. Operate the control handle manually to check that all the blades are operating freely, open fully and close tightly.

### Damper Installation

When installing dampers in the field, refer to the assembly drawing to assure that damper linkage is in the proper position in the correct rotation. **Desired fan performance may not be obtained if proper damper blade rotation shown on drawing is not observed.**

Double width fans using two dampers operate with single control arm and shaft connecting the two dampers. **Blades in both dampers must fully open and close together.** The connecting shaft often is in two pieces and although a set screw is provided in the coupling as an aid for assembly, **this section should be field welded to the shaft after the damper blades are synchronized.** Fans operating at higher temperatures have shaft coupling arrangement to provide for expansion, do not weld both ends to the shaft.
**Do not insulate dampers with ball bearings if above 180ºF. or enclose exposed shaft and bearings in a manner that would restrict natural cooling by ambient air.**

## OPERATION

### INITIAL STARTUP

The following general check lists should act as an aid. It is not intended to cover all contingencies and it is assumed that the installing contractor is experienced in installing this type of equipment, and will follow all good initial startup procedures.

### OPERATION OF FAN

Assuming that the equipment has been installed in accordance with these instructions and those of the manufacturers of components, and that a check has been made for tightness of all hardware and mounting bolts, the fan will be ready to operate after some final safety checks to prevent injury to personnel or damage to the equipment.

1. Lock out power source.
2. Check bearings for alignment, proper lubrication, tolerance, locking collars tight, cleanliness, burrs, or corrosion, and water connections for cooling, if required.
3. Check keys and wheel set screws for tightness. Check foundation bolts for tightness.
4. Check in housing and duct work for extraneous matter and debris. Secure all access doors.
5. Check wheel position for proper clearance at inlet.
6. Turn wheel over by hand, if possible, to see that it rotates freely.
7. Close inlet Volume Control and/or dampers to lessen starting load on driver.

## Warning

**Do not operate this fan in the stall/surge region. Operation of this equipment in the stall/surge region is extremely dangerous and may result in damage to the equipment as well as nearby personnel or other**

**equipment. Operate this fan only in accordance with the installation, operation and maintenance manual.**

## AERODYNAMIC PULSATIONS

Under certain conditions, a fan may experience damaging pulsations. This is not always obvious. It is characterized by a rumbling sound and vibration in the fan and ducts. There are two main causes, and the method of detection is different for each. Detection is important, for such pulsations can cause bearing failures or weld failures in the fan or ductwork.

First, the system resistance may be too high. The fan could go into stall if restricted beyond the design range of operation. This can happen if the actual resistance exceeds that which was specified. This condition may be detected by somehow reducing the system resistance in a controlled manner and listening for a change to smooth flow.

Second, the air controller may be the cause. This would be either a pre-spin inlet damper or an inlet vane control. At moderate openings, say 20 to 60 percent open, a significantly higher rumbling sound can occur. This can be detected by listening and feeling as the air controller is closed from the wide open position. If the rumbling is present and long term operation is desired at this capacity setting, it is recommended that the inlet air controller be opened to the point where smooth flow is obtained, then use an outlet damper to return to the desired capacity. This combination of control will greatly reduce the amplitude of the pulsations.

8. Supply water to water cooled bearings according to instructions.
9. Start fan with driver, check for rotation in proper direction.
10. Start equipment in accord with recommendations of manufacturers of starting equipment and driver unit.
11. Allow unit to reach full speed, then shut down. During this short period check for vibration or any unusual noise. if any are observed, locate the cause and correct.
12. Lock the power source in "OFF" position.
13. Recheck for tightness of hold down bolts, all set screws and keys, and tighten if necessary. Initial start up has tendency to relieve the tightness of nuts, bolts and set screws.

Assuming unit operates satisfactorily, the run in period must be at least eight hours. Observe bearings a minimum of once each hour during the first eight hours of operation. **Over greasing may cause bearings to heat up.**

There need be no concern if the bare hand can be held on the bearing for one second. A bearing full of grease will heat up and then gradually cool down to 140º-160ºF.

Oil rings of sleeve bearings should rotate freely and carry oil. This can be checked by removing the inspection caps and the use of a flash light to illuminate the rings. Check the equipment for vibration. If vibration is excessive, stop fan and determine the cause of vibration. **Do not operate until cause has been corrected.**

## DOWELING OF BEARINGS

Bearings must not be doweled before the equipment has run 30 days. This allows for foundation settle or shift. Alignment of all components must be carefully checked and location of bearings fixed. Holes are drilled through the base of the bearings and pedestals, then reamed to size to fit suitable dowel pins. Dowel pins are then driven into place. Threaded pins may be used if so desired.

## WARNING

**Never allow the fan rotating assembly to sit idle in temperature above 200ºF.**

## Fan Balance

Heavy rotors and high speeds make static and dynamic balancing a necessity. This balancing is carefully done at our plant by experienced personnel. Occasionally, mishaps in transportation, handling, operation, or wear, will necessitate re-balancing in the field. The impeller must be re-balanced when mounted on a soft foundation and coupled to its own driver to suit the foundation peculiarities. **However, fan rotors can not be balanced or operated on inadequately supported or weak foundations.**

Balancing impellers is a delicate operation and requires specialized knowledge, experience and careful procedure. **A balance weight of a few ounces incorrectly placed may cause serious damage.** For these reasons we strongly recommend that an experienced, Equipos Electromecánicos factory representative, be contacted.

**Running fan(s) with high vibration (see "Bearing Vibration Limits", Table II) could result in personal injury or property damage.**

## Bearing Vibration Limits (See Table II )

Vibration amplitudes shown in mils (1 mil = 0.001") are measured in any of three planes on either bearing housing, vertical, horizontal and axial.

**Alarm** values are a warning that vibration must be corrected at the earliest possible moment (short term hours). **Long term**

| Vibration in Mils (Peak to Peak) | | | |
|---|---|---|---|
| Maximum or Design RPM | Normal=2865/RPM * | Alarm=4200/RPM * | Shut-Down=9550/RPM* |
| 400 | 7.1 | 10.5 | 23.9 |
| 600 | 4.8 | 7.0 | 15.9 |
| 800 | 3.6 | 5.3 | 11.9 |
| 1000 | 2.9 | 4.2 | 9.6 |
| 1200 | 2.4 | 3.5 | 7.8 |
| 1400 | 2.0 | 3.0 | 6.8 |
| 1600 | 1.8 | 2.6 | 6.0 |
| 1800 | 1.6 | 2.3 | 5.3 |
| 2000 | 1.4 | 2.1 | 4.8 |
| 2200 | 1.3 | 1.9 | 4.3 |
| 2400 | 1.2 | 1.8 | 4.0 |
| 2600 | 1.1 | 1.6 | 3.7 |
| 2800 | 1.0 | 1.5 | 3.4 |
| 3000 | 0.9 | 1.4 | 3.2 |
| 3200 | 0.9 | 1.3 | 3.0 |
| 3400 | 0.8 | 1.2 | 2.8 |
| 3600 | 0.8 | 1.2 | 2.7 |
| 3800 | 0.7 | 1.1 | 2.5 |
| 4000 | 0.7 | 1.1 | 2.4 |
| Aprox. Velocity (in.) Sec. | 0.15 | 0.22 | 0.5 |

**operation, at or exceeding ALARM values greatly reduces rotor and bearing life-hours and voids the ARMEE warranty. SHUT-DOWN limit signals hazardous operation and requires immediate repair. Operation at this limit voids the ARMEE warranty and could result in personal injury or property damage.**

### Causes of Vibration
Refer to Trouble-Shooting Guide.

Table II

## VIBRATION SEVERITY CHART
*Not to exceed given maximum or designed RPM.

## MAINTENANCE

To insure long life and trouble free service, a frequent and regular check of all lubricants in bearings and couplings should be made. Sleeve bearings should be drained, flushed and refilled with clean oil after the first month, and each six months thereafter. Other types of bearings should be maintained in accordance with manufacturer's recommendations.

A preventive maintenance schedule is a necessity for extended fan life. Establish a lubrication schedule based on time periods suggested in lubrication instructions and by motor manufacturer.

After approximately one (1) month of operation, all base, hub, bearing, pedestal, etc. bolts should be re-tightened.

Potentially damaging conditions are often signaled in advance by change in vibration and sound. A simple, regular audio-visual inspection of fan operation leads to correction of the condition before expensive damage occurs. Vibration levels should be checked by an approved technician using electronic balancing equipment.

Where air handled by the fan contains corrosive, erosive or sticky materials, fan should be shut down regularly for inspection, cleaning and reconditioning of interior parts.

### Mechanical integrity
Certain operating conditions reduce the built-in strength of the fan impeller and may cause unsafe operation. it is the users responsibility to inspect for these conditions as frequently as necessary and to make correction as required. Failure to comply with the following limits voids ARMEE´s warrantee.

### Temperature Changes
Temperature change rate exceeding 5ºF per minute and temperature fluctuations exceeding 100ºF must not be applied to fan inlet air.

### Maximum Safe Speed and Temperature
Operation exceeding maximum safe R.P.M. and temperature even for a short time causes over-stressing or fatigue cracking of the impeller resulting in unsafe condition. Maximum safe speed and maximum safe temperature are shown on fan assembly drawings, catalogs or order acknowledgment.

### REPLACEMENT PARTS
Renewal, repair or replacement parts are not necessarily stocked by ARMEE. If your fan is important to plant operation please order spare parts.

**NOTE:** When ordering parts the following information is necessary:
**From Nameplate on Fan:** FAN TYPE, SIZE AND SERIAL NUMBER or
**From Original Purchaser:** FAN TYPE, SIZE, PURCHASE ORDER NUMBER AND CUSTOMER DRAWING NUMBER OF THE FAN.
**Replacing Motor:** FRAME NUMBER, MAKE, HP, RPM AND ELECTRICAL CHARACTERISTICS.
**Replacing Coupling:** MAKE, BORE FOR DRIVE HUB, BORE FOR DRIVEN HUB AND SIZE MUST REFER TO FAN DRAWING FOR SHRINK FIT.
**Replacing V Drives:** ORDER FROM NEAREST DRIVE SUPPLIER, GIVE NUMBERS FROM SHEAVES AND BELTS.

**Note:** Repairs for motors should be ordered from the nearest authorized motor service station for the make of motor furnished. Check the yellow pages of your telephone directory.

## TROUBLE-SHOOTING GUIDE

| PROBLEM | CAUSE | REMEDY |
|---|---|---|
| VIBRATION | Wheel or rotor is out of balance. | Check the wheel for any dirt or foreign material, especially hard-to-see places like the backside of the wheel and the underside of the blades.<br>Airfoil blades are usually hollow. When exposed to rain or excessive moisture they can get water inside of them. Drilling one 3/16" drain hole in the upper surface of each blade near the trailing edge should cure the problem. Re-balancing is usually not necessary.<br>Inspect the wheel for erosion or corrosion. Usually wheel erosion will occur at the leading edge of the blade. On a paddle wheel type fan the outer blade tip may also be worn. An airfoil wheel exposed to sand or abrasive dust can actually develop pin holes in the leading edge of the blades. Do all you can to eliminate these damaging conditions and then re-balance the wheel. If the wheel is seriously damaged it will have to be replaced. |
| | Improper or loose mounting | Foundation bolts and bearing mounting bolts can loosen themselves. Make sure they are tight. |
| | Loose set screws that hold the wheel to the shaft. | Again tighten the screws, but first be certain the wheel hasn't shifted on the shaft or is rubbing on the inlet cone or drive side of the housing. |
| | Bent fan shaft. | First, check the shaft with a dial indicator. If bent, it should be replaced as soon as possible to avoid replacing the entire fan. |
| | Misaligned V-belt drive | Realign assembly so fan and motor shaft are parallel and faces of sheaves (pulleys) are flush to a straight edge. We've found that a taut string will work fine. |
| | Fan wheel turbulence due to the rotor running backwards | Since blade angles and shapes vary greatly, it is easy to misread rotor direction. Check for correct wheel rotation, clockwise or counter clockwise, as seen from the drive side. |
| | Air pulsation | Fan may be operating in the stall area of its performance curve. That means it is oversized for your particular system or the system resistance is higher than intended. You can lower the system resistance by cleaning the filters or opening the dampers. |
| NOISE | Foreign material in the fan housing. | This could be anything from a loosened bolt to somebody's lunch bag. Inspect the wheel and inside of fan housing and clean thoroughly. |
| | Squealing V-belts. | The belts are either loose or misaligned. If belts show wear, you are better off to replace them now and avoid a future breakdown. |
| | Worn ball or roller bearings (Howling, screeching or clicking). | Change the bearings immediately before they cause additional damage. Failing bearings tend to wear the shaft, so you want to be absolutely certain the shaft is full size before installing those new bearings. "Mike" the shaft both under the bearing next to it and compare the two readings. If they don't match replace the shaft. New bearings installed on a worn shaft will not last long. |
| | Bearing seal misaligned (High pitch squeal). | Realign the face of the bearing so that it is perpendicular to the shaft. |
| | If the fan housing has a metal shaft seal it could be misaligned and rubbing on the shaft. | Loosen seal plate bolts, re-center the seal on the fan shaft and tighten the bolts. If the seal is fiberglass, cork or rubber, be sure the metal backing plate does not touch the shaft. |
| OVERHEATED BEARINGS (See Note Bellow) | Bearings may be worn and failing. | Replace the bearings. Remember to also check the shaft (refer back to the NOISE section). |
| | Improper grease. | Use a lithium base, high speed, channeling type grease. Do not use high temperature or general purpose grease. |
| | Over-greasing. | If you allow the bearing to run for a few hours it will normally purge itself of the extra grease. You can simply remove excess grease from split roller bearings by lifting the top half of the block for access. |
| | Bearing exposed to "heat soak" from an oven or dryer after shut down. | "Heat soak" occurs when a fan is idle and it's shaft cooling wheel can no longer cool the inboard bearing. Heat from inside the fan can then actually cook the grease. A 15 minute fan run after the oven heat is turned off will cool the fan shaft and protect the bearing. |
| | Loose V-belts may cause belt slippage and friction heating resulting in hot bearings, shafts or sheaves. | Tighten belt to the proper tension. A good rule of thumb- you should be able to depress the belt the same distance as the thickness of the belt. |
| | Excessive V-belt tension. | Belt may be too tight. Adjust to correct tension. |
| POOR AIR PERFORMANCE | Fan rotation incorrect | Refer to the Vibration section. An easy way to change rotation on most 3-phase motors is to reverse any two motor leads. |
| | Abrupt turn in the duct close to the fan discharge or air pre-spin caused by ductwork elbows at he inlet | Install turning vanes or elbow splitters in the duct. If air performance is still inadequate, the discharge position may have to be changed. |
| | If fan has an Inlet Volume Control is it improperly installed | Be sure the IVC is installed with pre-spin of the air in direction of wheel rotation when the IVC is partially closed. |
| | Off-center wheel | This can occur on double width, double inlet fans. Center the fan between the inlet cones to avoid overloading one side of the wheel while starving the other. |
| | Fan horsepower unexpectedly low | Correct one or more of the following conditions.<br>Air pre-spin into the fan inlet.<br>Fan drive sheaves set for too low a fan speed.<br>Resistance to airflow, such as caused by a closed damper, much higher than calculated. |
| | Fan horsepower unexpectedly high. | Be sure fan speed is not too high. Fan may be operating without ductwork at low resistance so that too much air is flowing.<br>The fan may be handling ambient air when it was originally intended for hot, less dense air.<br>Fan may be running backwards. |

**NOTE:** Ball or roller bearings tend to heat up when they have been over-greased and will cool down to their normal running level when the excess grease oozes out. The normal operating temperature of a bearing may be well above the 140º which is "hot" to touch. Temperatures over this have to be read with instruments and anything over 180º should be questioned. If you put a drop of water on the bearing and it sizzles, the bearing is in distress and should be changed before it seizes and ruins the shaft.

VENTILADORES Armee

## Record of Fan Installation

Job Site: _____ System: _____
Fan Size: _____ Armee Fan Serial No. _____
Design: _____ Class: _____ Fan Assembly Dwg.#: _____
Fan Rated CFM: _____ Fan Rated Static Press.: _____ Fan Rated BHP: _____
Maximum Operating Temp.: _____ ºF. _____ Fan Maximum Operation Speed: _____
Size Bearings: _____ Type: _____ MFG'R.: _____
Size Coupling: _____ Type: _____ MFG'R.: _____
Motor HP.: _____ RPM: _____ Frame Seze: _____ MFG'R.: _____
Date Fan Shipped: _____ Date Installation Completed: _____ Date Fan Start: _____
Name ARMEE Service Engr.: _____ Name Millwright in Charge: _____
Fan Purchased From: _____ Installing Contractor: _____

**WARRANTY:** ARMEE warrants products of its manufacture to be free of defects in material and werkmanship for aperiod of one year from the date of original shipment. This warranty is subject to the following terms and limitations:

1) Alll products must be properly installed, cared for and operated under normal conditions and with adequate supervision.
2) ARMEE will not be liable or responsible for (y) any corrosion or fouling caused by any foreign substance, or (ii) any defects caused by adjustments, alterations or repairs made or attempted outside of ARMEE's factory, except upon the prior written consent of ARMEE.
3) Since no currently known form of construction, material, alloy or or coating will successfully resist all abrasion, erosion, corrosion, or deterioration from excessive heat or vibration, this warranty does not extend to any damage or defect caused by any of those conditions.
4) Research undertaken by the Air Movement and Control Association, Inc., in cooperation with test code commitees of the engineering societies reveals thus far that no practical method exists for testing the suitability of fans in a specific system. ARMEE THEREFORE DOES NOT WARRANT AND SPECIFICALLY EXCLUDES ANY WARRANTY THAT ITS PRODUCTS ARE FIT FOR A PARTICULAR PURPOSE OR USE. Responsability for determining the fitness of our products for intended use is the purchaser's.
5) ARMEE DOES NOT PROVIDE ANY WARRANTY (EXPRESS OR IMPLIED) WITH RESPECT TO COMPONENT PARTS (MOTORS, SWITCHES, CONTROLS OR ACCESSORIES) WHICH ARE MANUFACTURED BY OTHERS. However, these products are usually warranted separately by their respective manufacturers.
6) ARMEE DOES NOT WARRANT ITS PRODUCTS TO BE IN COMPLIANCE WITH THE OCCUPATIONAL SAFETY AND HEALTH ACT ("OSHA") AS AMENDED OR ANY REGULATIONS THEREUNDER. Compliance with OSHA is the exclusive responsability of the user of the equipment.
7) ALL OTHER WARRANTIES, WHETHER EXPRESS OR IMPLIED, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE HEREBY EXCLUDED.
8) This warranty may not be modified except by written agreement signed by an officer of ARMEE.

**LIMITATION OF LIABILITY:** ARMEE's liability for any purposes limited to repairing or replacing at its factory any defective part or parts which shall, within one year after original shipment, be returned to its factory, transportation charges prepaid. Repair or replacement of defective parts shall be the purchaser's sole and exclusive remedy. Under no circumstances will ARMEE be liable for any injury to persons or property, nor will ARMEE be liable for any damages of any kind, whether incidental, consequential or otherwise, whether arising out of breach of contract, breach of warranty, tort liability, strict liability or otherwise. If the goods, however, prove to be so defective as to preclude remedying the defect by repair or replacement, the purchaser's sole and exclusive remedy and ARMEE sole and exclusive liability will be refund of the purchase price. Purchaser will defend, indemnify and hold ARMEE harmless against any claims for liability or damages which are made against ARMEE and which are directly or indirectly related to ARMEE's sale of products to purchaser.

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