fanTR
TECHNOLOGY RESOURCES

IN THE AIR,
BY YOUR SIDE
WE ALWAYS
INNOVATE

PRODUCT MANUAL

Disc and ring fan models
for
Wet Cooling Towers

Technical manual of industrial fans applied in cooling systems.

Description of the equipment, technical characteristics,
installation and maintenance.

Version A03

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CONTENTS

Fan Technology Resources, also known as FanTR, appreciate the confidence you have placed in us to provide the products and solutions for your project.

FanTR Advanced Fans are manufactured with rigid specifications and control to meet the characteristics required by the project and to operate smoothly with maximum efficiency under aggressive environmental conditions.

The instructions for handling, assembly and maintenance are presented in this manual and should be carefully followed to fully obtain the outstanding performance and high durability required for this equipment.

Any further information or assistance concerning these procedures, or any other technical aspect of this equipment can be obtained by contacting the FanTR Technical Department:

Phone: +55 11 4025-1670

E-mail: fantr@fantr.com

I. FanTR warrants this product. For further information about warranty, coverage, acceptance and terms, the Warranty Terms document should be consulted.

II. Not following the instructions presented in this document could cause exposure to dangerous situations and may lead to loss of equipment warranty.

III. Other documents are crucial for a complete understanding of the instructions content of this manual. FanTR provides the Fan Datasheet and FDV Drawings. These documents feature technical appointments as components, materials, operational conditions, and others that may be of interest or value.

1. DISC AND RING ARRANGEMENT

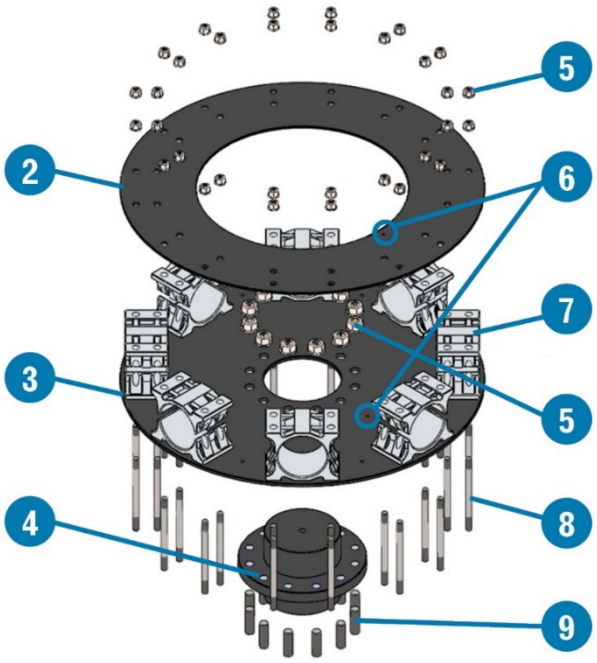

Figure 1 - Fan assembly

Item #	Item
01	Blade
02	Ring
03	Disc
04	Coupling flange
05	Hub's Flat washer and Nut
06	Alignment Hole
07	Clamp
08	Clamp's Stud
09	Hub's Bolt

Table 1 - List of items

Figure 2 - Nameplate template

2. OPERATIONAL MANUAL

2.1. Introduction

This manual presents the instructions for the operation of the FanTR Advanced Fans, specially developed for industrial processes and applications. Fan details for assembly can be viewed on FDV document.

The design of these Fans considers operation in chemically aggressive environments, in a continuous regime and with minimal maintenance.

All pieces from the same project are equally balanced and interchangeable, including blades, discs and coupling flanges.

2.2. Storage

Despite being manufactured to operate in aggressive environments, a list of cautions is listed below to avoid any change to the products characteristics during storage.

Blades stay in their original shipping fixtures until they are needed for installation. If they are out of the frames, they should preferably be stored in a roofed warehouse.

However, they can be stored on site under a breathable tarpaulin, with leading edge downwards on cushioned supports according to the **Figure 3** - Blade support.

Figure 3 - Blade support

2.2.1. Protection

During the storage period, the blades shall be protected against temperatures higher than 55°C (130°F) and against continuous contact with humidity, solvents and other chemical products.

2.2.2. Impacts

Unnecessary mechanical loading on the blades as well as impacts with any other parts shall be avoided. Do not rest any materials on top of the blades and do not climb or stand on them before or after installation.

2.2.3. Unloading

The fan parts can be shipped in two types of packages. In both types there may be wood chocks as shown in **Figure 4** fixed on the floor to avoid movement during transportation. Remove the wood chocks before beginning the unloading process.

Figure 4 - Wood chocks

- Wooden Shipping Fixture (blades, hubs & hardware)

According to the pictures:

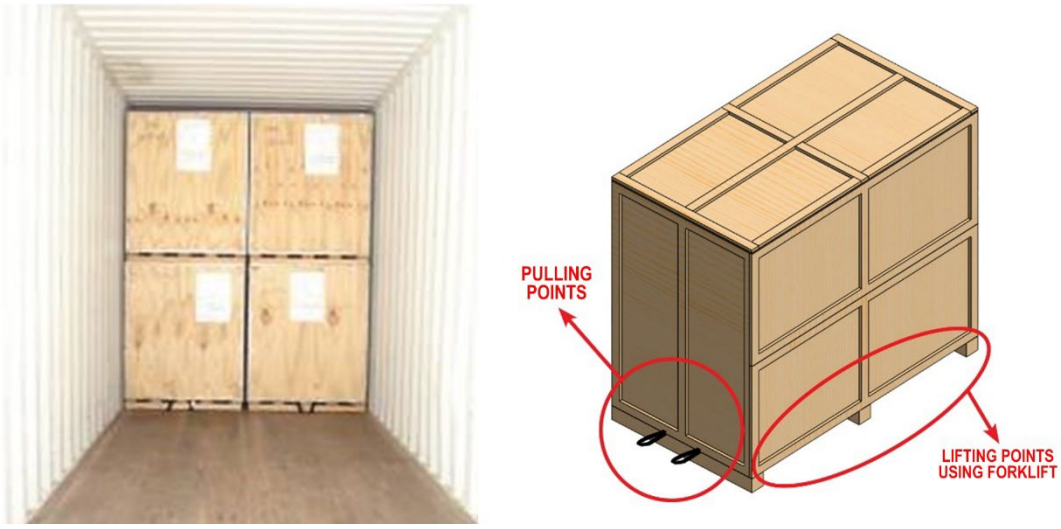

Figure 5 - Wooden shipping fixture / pulling points.

i - Open the container carefully because the packages may have possibly shifted during the transportation.

ii - Use the forklift and support the wood package from its bottom.

To help pulling the wood package from inside of the container, FanTR installed pulling points in the lower part of the front of the wood packages according to the **Figure 5**.

This way, using a metal bar to connect the pulling points to the forklift, pull the package until the front end of the container.

In this position, the package of hubs and hardware can be easily taken out from the container using the forklift. Although, in the case of the blades packages it is necessary to pull a little bit more to have access to its lateral side, because this is where the lift points of the wood packages of the blades are located (forklift position).

- Metallic Shipping Fixture (blades only)

In order to pull the frames out of the container, attach a steel cable or a rope capable of pulling 6 tons to metallic structure. Pull it out of the container until you can access the lifting points, as indicated in **Figure 6**, and lift with the forklift.

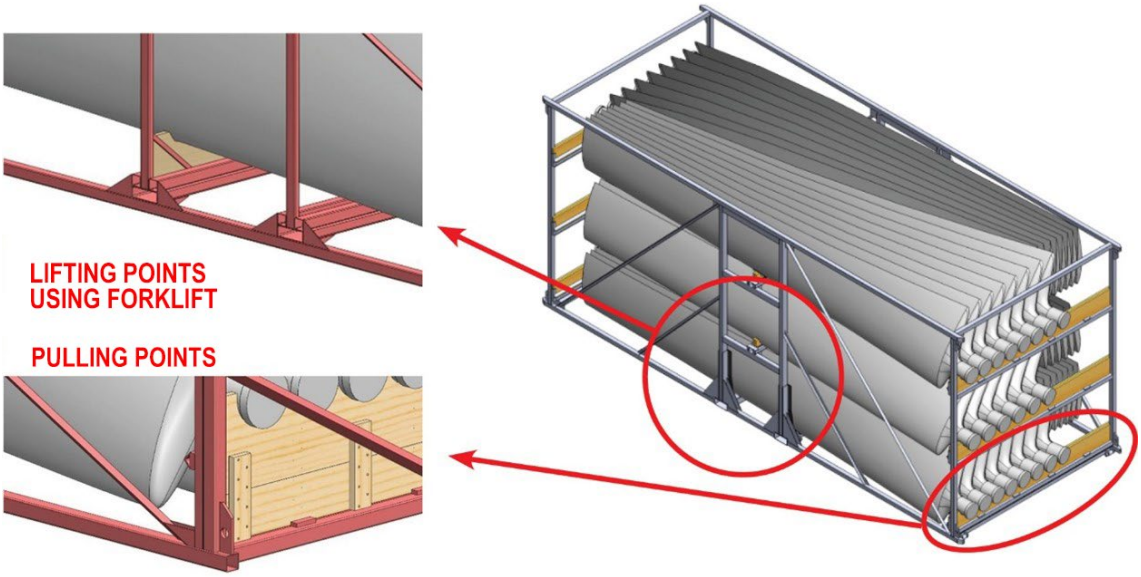

Figure 6 - Metallic Fixture

2.3. Handling

The blades shall be handled with care, avoiding shocks on their surface, which could damage the laminate surface and reduce its resistance to the attack of corrosive agents.

Strong impacts can also damage the structural resistance of the blades or their aerodynamic shape, compromising the correct fan performance.

CAUTION:

DO NOT USE KNIVES OR ANY OTHER SHARP OBJECTS TO REMOVE THE PLASTIC PROTECTION OF THE BLADE AS THESE COULD DAMAGE THE BLADE SURFACE.

2.3.1. Lifting by hand

A minimum of two workers can carry the blades manually. It is recommended to always lay the blades on a clean and protected surface, preferably on cushioned supports.

2.3.2. Lifting by slings

A minimum of two lifting slings MUST be used per blade. The slings must have minimum of 4” width and 230 kg (500 lb) capacity each. Use preferably choker or basket hitches.

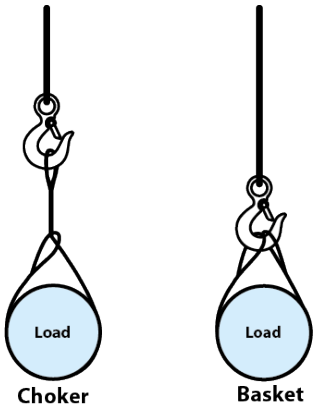

Figure 7 - "Chocker" and "basket" lifting models

Place one sling in the neck of the blade and another in a position that represents 75% the length of the blade as indicated by **Figure 8**.

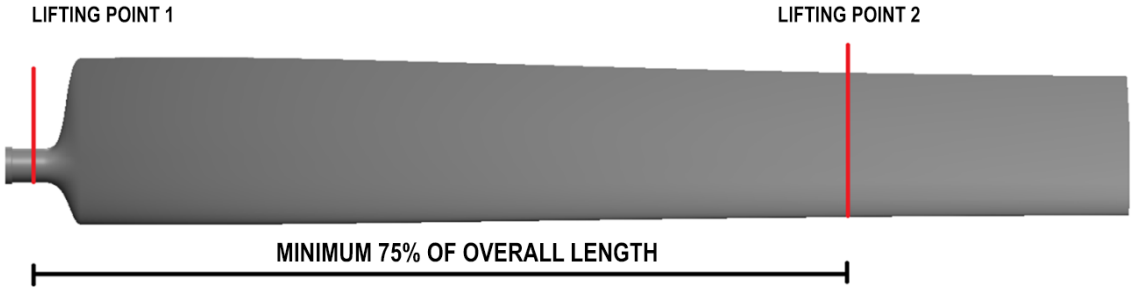

Figure 8 - Blade's lifting points

3. ASSEMBLY

3.1. Required tools

Below there is a list of recommended tools and equipment for fans erection.

Item	Description tools and materials
01	Fan
02	Hardware as FDV
03	Manual Torque wrench* (used to apply torque values lower than 100 kgf.m (723 lbf.ft)). If the specified torque is greater than 100 kgf.m (723 lbf.ft), a proper multiplier shall be used to reduce the human effort. The multiplier shall have a current calibration certificate. Do not use hydraulic, pneumatic or electric torque wrench. *± 4% accuracy.
04	Ratchet
05	Forklift
06	Harnesses
07	Yo-yo´s: self-retracting mechanism to be used when it is necessary to work 6 feet from the ground
08	Safety gloves
09	Safety glasses
10	Sockets to be used with torque wrench or ratchet.
11	Combination wrench
12	Ruler (any completely straight instrument)
13	Inclinometer (± 0,05° accuracy)

3.2. Initial assembly

3.2.1. Coupling flange assembly

The coupling flange is designed by FanTR in accordance with the specification received from the gearbox manufacturer and it must be installed by the gearbox manufacturer following their procedure.

3.2.2. Hub assembly - Disc and ring design

Before starting the hub assembly procedure, check to see if there are protection plugs inside the holes (see **Figure 9**). Remove these plugs before beginning the assembly.

The hub's disc (part #03) and ring (part #02), as named in the **Table 1**, must be positioned in the coupling flange (part #04) after a complete cleaning of all contact surfaces. Position the hub's disc against the coupling flange to fit the position and match the holes (part #06) for the hub's bolts.

Figure 1 provides a perspective of the assembly exposing an exploded view.

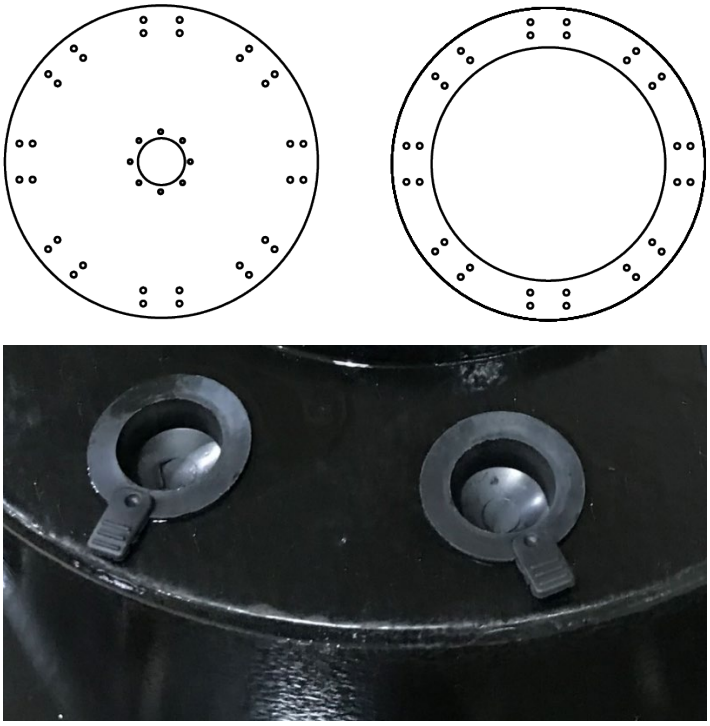

Figure 9 - Protection plugs

Once the disc is installed in the coupling flange, assemble one blade according to item **3.2.3** Blade assembly.

After that, place the ring and tighten the bolts of this installed blade to avoid the ring movement as shown **Figure 10**. **Do not apply the final torque yet.**

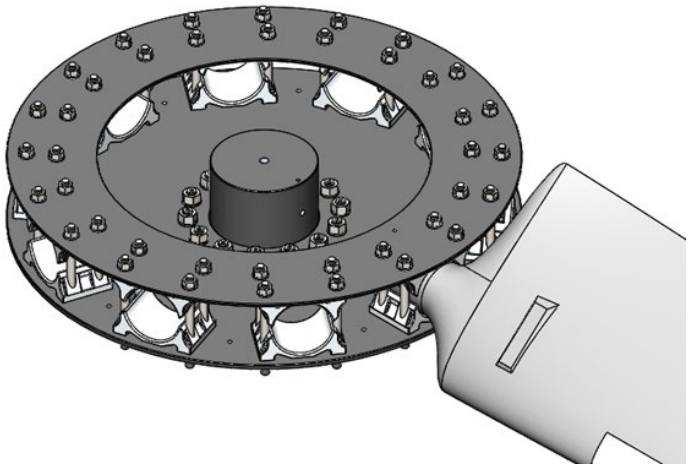

Figure 10 - Disc and ring assembly

Finally, install all blades according to item **3.2.3** Blade assembly and tighten all bolts.

3.2.3. Blade assembly

CAUTION:

BEFORE STARTING THE BLADE ASSEMBLY PROCEDURE, CHECK IF THERE ARE PROTECTION CAPS ON THE DRAIN HOLES. REMOVE THESE PLUGS BEFORE STARTING THE ASSEMBLY.

Figure 11 - Protective plugs

Insert the cylindrical root (neck) of the blade in the hub, holding it in a horizontal position and tighten the bolts hard enough to keep the blades attached to the hub while allowing the blades to rotate in their longitudinal axis for the adjustment of the pitch angle (see item **3.2.4**).

Be sure that all blades have the same tip height and that the limit bracket of the neck is facing the clamps (see **Figure 12**). To do that, one worker jigs the tip of blade until the correct accommodation of the limit bracket and blade height.

A cut view of the whole assembly is shown below:

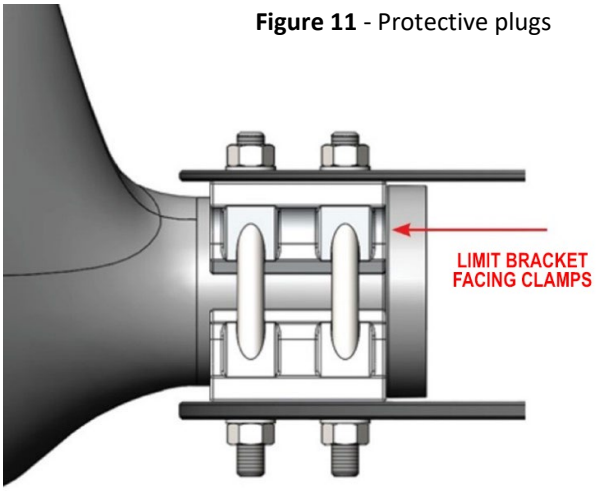

Figure 12 - Handle stop in contact with the bearing

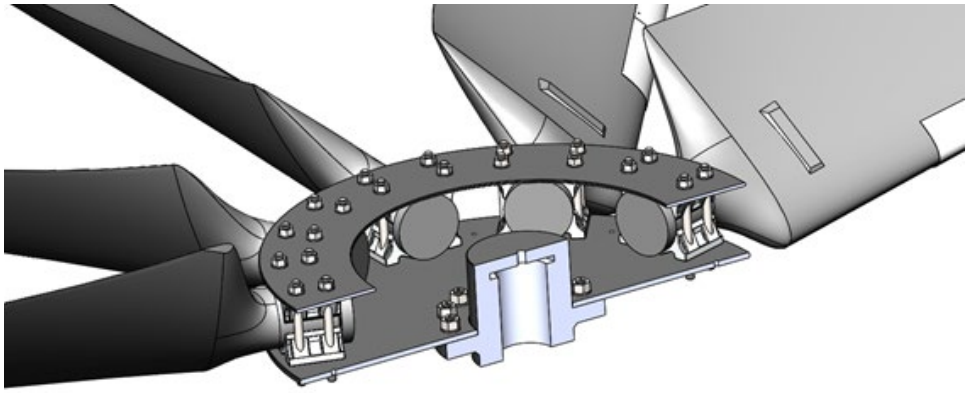

Figure 13 - Assembly cutaway view

CAUTION:

NEVER REPLACE A FANTR BLADE IN A FAN WITH ONE BLADE OF A DIFFERENT MODEL OR FROM A DIFFERENT ORDER SOURCE AS THE DIFFERENT MASS VALUE AND DISTRIBUTION CAN CAUSE STRONG VIBRATION DUE TO THE UNBALANCE. THIS MAY CAUSE SEVERE DAMAGE TO THE WHOLE EQUIPMENT.

3.2.4. Adjusting the pitch angle

The Pitch Angle is calculated for the desired operational condition in each application through FanTR Advanced Fans simulation software.

The Fan Data Sheet and the FDV indicate the operational pitch angle according to the condition for the present application.

Those documents can be obtained from our management team by providing the blade's serial number.

The pitch angle is measured with a ruler (or any instrument completely straight) and an inclinometer positioned at 50mm from the blade tip (see **Figure 14**). The pitch angle is measured with the fan in the horizontal position.

The blade pitch angle should be adjusted to the operational pitch angle value shown at FDV Drawing document with a maximum tolerance of Δ=± 0.3 degrees.

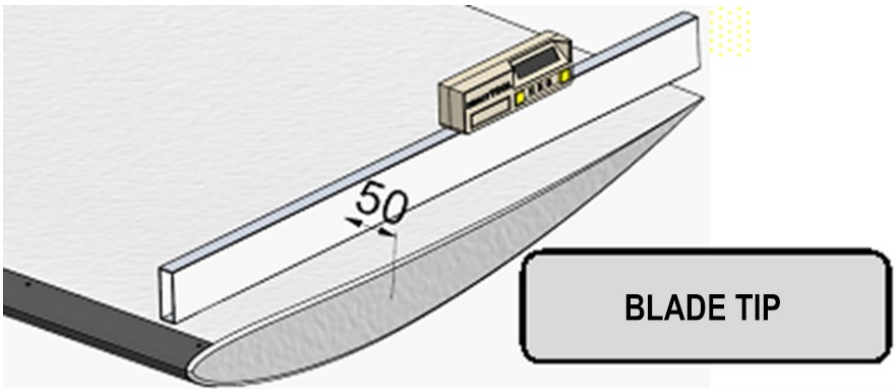

Figure 14 - Pitch angle measuring

3.2.5. Tightening the bolts

CAUTION:

FOR TORQUE VALUES THE ITEM TORQUE VALUES SHALL BE OBSERVED AND APPLIED. NOT FOLLOWING THE CORRECT TORQUE VALUES MAY LEAD TO ACCIDENT, EQUIPMENT DAMAGE/FAILURE AND LOSS OF WARRANTY.

3.2.5.1. Blade's Bolts

Before tightening the bolts, clean all the surfaces (bolt and nut) in order to be free of contaminants (oil, water, dust, etc.).

Apply lubricant with a friction coefficient (μ) steel-steel between 0.11 and 0.15 (nut factor K steel-steel between 0,15 and 0,19).

Recommendations:

A) Loctite® LB N-5000

B) Permatex® Aluminum Anti-Seize Lubricant

C) Permatex® Copper Anti-Seize Lubricant

The lubricant should always be applied on the thread of the bolt or stud. For cap bolts, the lubricant should be applied on the thread length. For studs, the lubricant should be applied on both threads, as shown in **Figure 15**.

Figure 15 - Bolt and stud threads

CAUTION:
ALL TORQUES VALUES SHALL BE APPLIED WITH LUBRICATED BOLT.

With the pitch angle adjusted and keeping the blade in the horizontal position, tighten the bolts in a cross sequence, (see **Figure 16**), with an initial torque of TORQUE A. Then, gradually increase the torque, keeping the cross sequence, up to the final torque of TORQUE B.

Please note, special care should be taken to avoid an excessive torque, which could damage the root of the blade (neck). This torque cannot exceed TORQUE B value (lubricated). It is recommended to apply the total torque in two steps. First to apply is TORQUE A, then, apply TORQUE B.

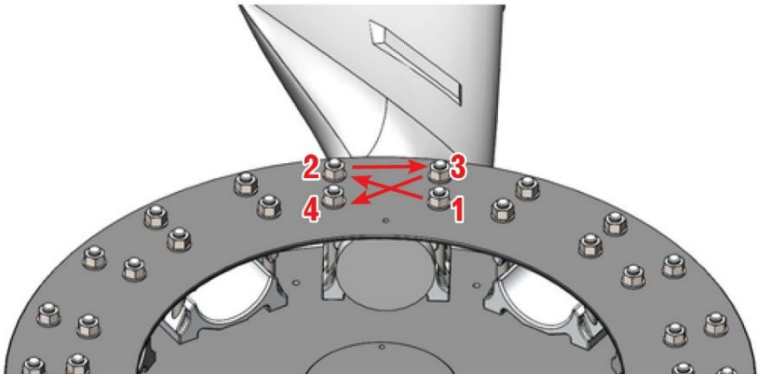

Figure 16 - Tighten cross sequence

More than one repetition of the torque to the final value operation may be required to achieve the specified torque at all bolts of blade due to laminate material accommodation (when you apply the torque on the last bolt of the joint, the first one lost some torque value). So, for each blade, apply the final torque value TORQUE B several times on all bolts until the torque wrench just snaps without rotation.

To get a perfect balance of the rotor, it is important to assure that the blade root stop is in firm contact with the metallic grip face and, therefore, there would be no large variation of the radial position (limit bracket to blade tip) maximum of 1/4" ±1/8" (6,5mm ± 3,2mm) as it is shown in **Figure 17**.

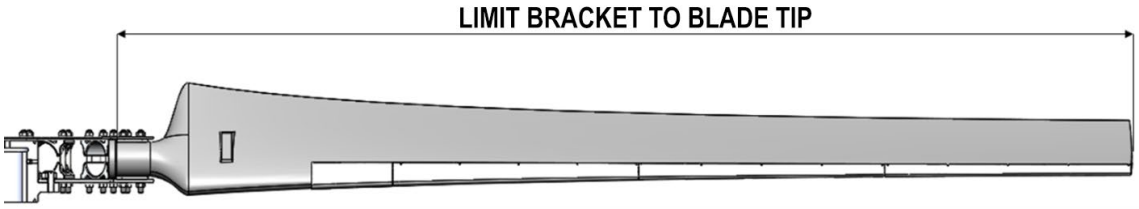

Figure 17 - Limit bracket to blade tip

The blade fastening shall also be done observing a maximum variation in the vertical position (blade tip related to the rotational plane) of ± 2 1/4" (± 57,2mm) as seen in **Figure 18**. The rotational plane is defined by a plane that contains all the trailing edge vertices. One way to verify this tolerance is by rotating the fan and marking the height of each trailing edge vertex on the fan stack at the same position and then measuring the distance between the two extremes. This distance shall not exceed 4 1/2".

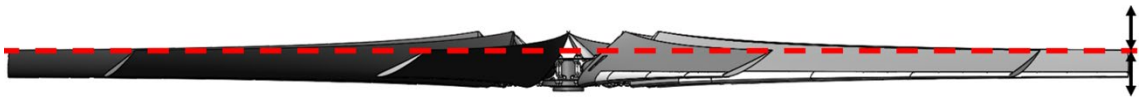

Figure 18 - Vertical variation

CAUTION:

WE STRONGLY RECOMMEND CHECKING TORQUE WRENCH CALIBRATION (OR EVEN IF THE CALIBRATION EXPIRATION DATE IS VALID) BEFORE STARTING THE BOLT TORQUE PROCEDURE.

CAUTION:

THE TORQUE MUST ALSO BE CHECKED AGAIN AFTER 24 HOURS OF INSTALLATION TO COMPENSATE POSSIBLE MATERIAL ACCOMMODATIONS, WHICH COULD REDUCE THE PRESSURE APPLIED BY THE METALLIC CLAMPS ON THE BLADE ROOT. THIS PROCEDURE IS SPECIFIED IN THE ITEM **FAN COMMISSIONING**.

3.2.5.2. Hub's Bolts

Before tightening the bolts, clean all the surfaces (bolt and nut) in order to be free of contaminants (oil, water, dust, etc.).

Apply lubricant with a friction coefficient (μ) steel-steel between 0.11 and 0.15 (nut factor K steel-steel between 0,15 and 0,19).

Recommendations:

A) Loctite® LB N-5000

B) Permatex® Aluminum Anti-Seize Lubricant

C) Permatex® Copper Anti-Seize Lubricant

After installing the bolts or studs according to FanTR drawings (FDV), apply a torque of HUB TORQUE several times on all lubricated bolts of this joint until the torque wrench just snaps without rotation.

CAUTION:

THE TORQUE MUST ALSO BE CHECKED AGAIN AFTER 24 HOURS OF INSTALLATION TO COMPENSATE POSSIBLE MATERIAL ACCOMMODATIONS. THIS PROCEDURE IS SPECIFIED IN THE ITEM **FAN COMMISSIONING**.

4. FAN COMMISSIONING

Before starting up the fan, follow these steps:

- Check that the drain holes in the blade tip are clear;
- Check pitch angle of blades according to the FDV Document;
- Check if all blades have same tip height within the tolerance of **Figure 18** - Vertical variation;
- Rotate fan by hand to be sure of free rotation and ample tip clearance;
- Check the torque of bolts in blade joints (TORQUE B) and coupling flange joints (HUB TORQUE);
- Torque check after 24 hours of installation.

CAUTION:

START THE FAN AND WAIT A MINIMUM OF 24 HOURS OF INSTALLATION, THEN STOP THE FAN AND CHECK TORQUE OF BOLTS IN BLADE JOINTS (TORQUE B) AND IN COUPLING FLANGE JOINTS (HUB TORQUE).

5. INSPECTION AND MAINTENANCE

5.1. Blades and Hubs

Periodical visual inspections are recommended to check the overall conditions of the blade (monthly for the first three months of operation and after that for every 6 months). Cleaning and removal of any deposits of dust and encrustation on the surface of the blades is a good practice during the inspections.

After a long time of operation, the surface color may change, and small and superficial cracks may appear. This does not mean that any reduction of the structural integrity has occurred. However, the existence of larger or deeper cracks may be an indication that a blade replacement is required. In this case our Technical Assistance Department should be consulted, and none repair can be done before this contact.

Special attention is recommended to preserve the blade surface layer when the blades operate in chemically aggressive environments. This will assure good protection of the laminate structure and therefore a long operation life for the equipment.

5.2. Bolts

We recommend torque checking inspections for the bolts every 6 months after the fans are placed into continuous or semi-continuous operation (from the start of commercial operation of the plant) in the first year of operation. After that, we suggest inspecting bolt torque values every 12 months. In these maintenances, all bolts must be checked (coupling flange and blade joints).

CAUTION:

DOCUMENT THESE CHECKS TO KEEP THE WARRANTY SPECIFIED IN WARRANTY TERMS LETTER. USE THE CHECKLIST FROM **INSTALLATION & COMISSIONING PERIOD TORQUE CHECK CONTROL**.

6. TROUBLESHOOTING

Trouble	What to do?
Fan presenting high vibration	Check assembly, verifying the torque of the bolts and the angle of the blades.
	Do vibration analysis and verify its spectrum, confirming or not that the vibration is in the same frequency of the fan rotation.
	Check for big encrustations on blades.
	Check items **7** and **7.1**.
Blades presenting cracks that appear during the assembly	Contact FanTR Technical Department to confirm that a repair procedure can apply.
Loosing bolts are found during the torque check	Check torque wrench calibration.
	Incorrect torque application or no use of lubricant.
Discs and coupling flange are not assembling	Confirm that procedure described in the manual.
Bolts cannot be installed due to thread problems	Tap the threads against possible dirt.

7. NOTE ON VIBRATION AND VIBRATION MEASUREMENT

Check rotation direction. Refer to drawing and instructions of other related components.

Immediately after first start-up check for smooth operation of the fan assembly. Check for irregular noise and vibrations. For allowable vibration levels of the complete installation, refer to the system manufacturer. Please refer to International Standards that may apply for the specific application, such as ANSI/AMCA 204-05 and ISO 14694.

If the vibration amplitudes measured during start up at the main shaft bearings (**Figure 19**) exceed 6.3 mm/sec RMS (acc. to ANSI/AMCA 204-05 and ISO 14694 recommendations for slow moving fan impellers flexible mounted, BV-3) proceed as follows:

- check the fastening bolts on motor, gearbox and fan
- check the alignment of the total drive
- check blade angle and fastening of blades
- check if the drain hole at the blade tip is open. Remark: The drain holes must be open to avoid dilatation of the blades by gas or water accumulation inside of them.

Evaluation for measurements (R.M.S)

- 6.3 mm/s < vibration < 11.7 mm/sec ALARM
- vibration >12.6 mm/sec SHUT DOWN

NOTE: A peak might be observed, which temporarily might reach values above START UP, at startup of the fan or due to sudden strong wind.

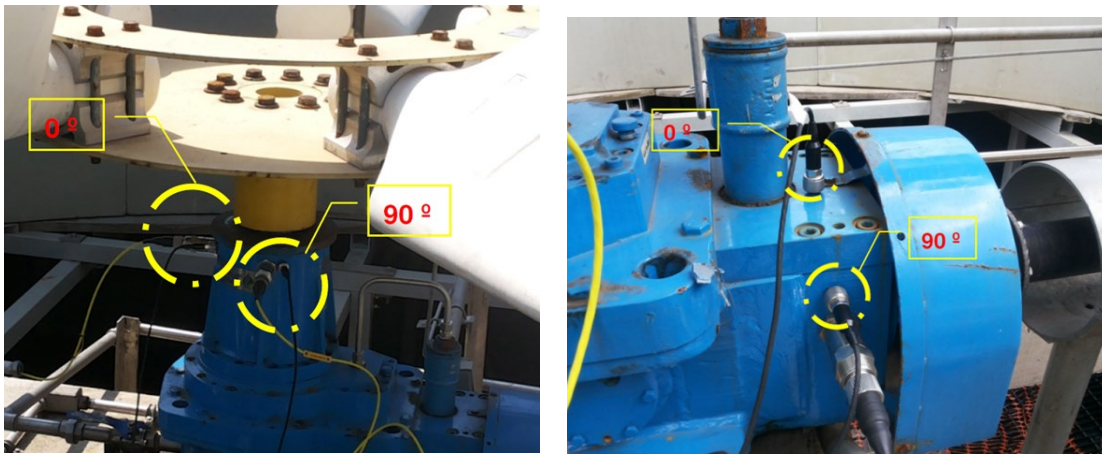

Figure 19 - Position of accelerometers for vibration data acquisition

7.1. Possible Vibration Sources

The actual causes of vibration may vary considerably. However, some of the most common are as follow:

a) Imbalance of one or more blades: the vibration caused by blade imbalance occurs on the tip path plane with a frequency equal to the rotor RPM and at an amplitude which is dependent on the degree of imbalance and the square of the rotational speed.

b) Excessive variance among blade pitch angle settings: this condition causes vibration outside the tip path plane at a frequency equal to the rotor RPM and at an amplitude which is dependent on the square of the rotational speed.

c) Blades too close to support: (Periodic aerodynamic turbulence) characterized by vibration outside the tip path plane at a frequency equal to the product of the number of rotor blades and RPM. The amplitude depends upon the extent of the aerodynamic turbulence.

d) Resonance between one of the possible forcing frequencies of the rotor and one or more of the vibrational modes of the structure on which it is installed. The main forcing frequencies generated by the rotor normally correspond to the following frequencies:

a. Rotor RPM.

b. The product of rotor RPM and the number of structural supports capable of generating aerodynamic turbulence (if they are arranged in an axial-geometric fashion).

c. Blade passing frequency (BPF): rotation x number of blades.

e) Vibration transmitted by the structure on which the rotor is installed: the frequencies of such vibration depend on both the external forcing frequencies and the resonant frequencies of the structure.

f) Resonance of the blades with one of the possible forcing frequencies: in most cases, the vibration occurs outside of the tip path plane.

g) Misalignment of the drive shaft: this generates vibration with a frequency that is one or twice the RPM.

h) Loosing of blades and/or speed reducer fixing bolts. The behavior of the rotor under these circumstances is totally unpredictable, as it depends upon the extent and location of the loosening.

i) Worn output shaft bearing: this condition generates vibration on the tip path plane at a frequency equal to the rotor RPM.

NOTE: The amplitude of the rotor vibration is determined by the rigidity of its support. Vibration that would not be critical to a rotor supported by a sufficiently rigid structure is amplified by an overly flexible support. This support rigidity may also cause unexpected variations in the resonant frequencies of the blades.

8. TORQUE VALUES

Below are the torque values that shall be applied to assemble the Disc and Ring Arrangement fan. Please, follow the notes contained in this document for the correct assembly and operation of the equipment. In addition, along with this document, the Datasheet and the FDV Drawing must also be observed, including understanding and application of this manual in its entirety.

1 - Localize the blade's model*, bolt's material, grade, and nominal Size. This information is available in the FDV document.

2 - Identify on Blade's Bolt Final Torque Reference Table which is the Final Torque for your application (Torque B → 2nd step).

3 - Then, identify which steps for torque application shall be applied on Blade's Bolt Tightening Steps Reference Table.

4 - There is no need to apply an intermediate torque step for Hub's Bolt Final Torque.

* The blade model can be found on the first FDV sheet legend ITEM number 5 or the third FDV sheet at Interference Checking Table.

CAUTION:

ALL TORQUE VALUES CONSIDER **LUBRICATED TORQUE** ACCORDING TO O&M MANUAL'S SECTION **3.2.5**.

ATTENTION:

THE TORQUE VALUES ARE VALID FOR FANS MANUFACTURED FROM 2018 ON. MODELS BEFORE 2018 CONSULT FANTR.

Blade's Bolt Final Torque Reference

	Bolt Material	Carbon Steel				Stainless Steel			
	Bolt Grade	10.9				80			
	Bolt Nominal Size	M16		M20		M16		M20	
	Unit	*kgf·m*	*lbf·ft*	*kgf·m*	*lbf·ft*	*kgf·m*	*lbf·ft*	*kgf·m*	*lbf·ft*
Blade Model	CR09 / CR12 / CR14 / CR18	10	72	-	-	10	72	-	-
	CR30	15	108	-	-	15	108	-	-
	CR36 / CR42	-	-	15	108	-	-	15	108
	NCR30	20	145	-		-	-	30	217
	NCR42	-	-	41	297	-	-	30	217
	TEP30 / TEP36	-	-	41	297	-	-	30	217

Blade's Bolt Tightening Steps Reference

Unit	*kgf·m*	*lbf·ft*	*kgf·m*	*lbf·ft*	*kgf·m*	*lbf·ft*	*kgf·m*	*lbf·ft*	*kgf·m*	*lbf·ft*
Final Torque Reference	10	72	15	108	20	145	30	217	41	297
Torque A (1st step)	5	36	8	58	10	72	15	108	20	145
Torque B (2nd step)	10	72	15	108	20	145	30	217	41	297

Hub's Bolt Final Torque Reference

- see the O&M Manual section **3.2.5** for the tightening bolts procedure
- see the FDV for Bolt's Material, Grade, Nominal Size, and Blade's Model*
- all torque values consider lubricated torque according to O&M Manual's section **3.2.5**

Bolt Material	**Carbon Steel**									
Bolt Grade	10.9									
Bolt Nominal Size	M12		M16		M20		M24		M30	
Unit	*kgf·m*	*lbf·ft*	*kgf·m*	*lbf·ft*	*kgf·m*	*lbf·ft*	*kgf·m*	*lbf·ft*	*kgf·m*	*lbf·ft*
Final Torque Reference	10	72	25	181	48	347	83	600	160	1157

Bolt Material	**Stainless Steel**									
Bolt Grade	80									
Bolt Nominal Size	M12		M16		M20		M24		M30	
Unit	*kgf·m*	*lbf·ft*	*kgf·m*	*lbf·ft*	*kgf·m*	*lbf·ft*	*kgf·m*	*lbf·ft*	*kgf·m*	*lbf·ft*
Final Torque Reference	7	51	16	116	32	231	55	398	110	796

CAUTION:

THIS DOCUMENT SHALL BE OBSERVED AND APPLIED. NOT FOLLOWING THE CORRECT TORQUE VALUES MAY LEAD TO AN ACCIDENT, EQUIPMENT DAMAGE/FAILURE AND LOSS OF WARRANTY.

On the next page, the base document for Torque Verification Control is presented. FanTR advises that equipment maintenance history is required to provide full warranty conditions. Equipment with an operation and maintenance history without traceability, these records are insufficient, unintelligible or non-existent, may have all warranty conditions compromised.

9. INSTALLATION & COMISSIONING PERIOD TORQUE CHECK CONTROL

PROJECT NAME:

FAN IDENTIFICATION - HUB SERIAL #:

MANUAL TORQUE WIRE CALIBRATION CERTIFICATE:

CALIBRATION VALID UNTIL:

Information

- Lubricant: See section "**3.2.5.1 Blade's Bolts**" for more information
- To identify each screw, use a permanent marker to number them.
- Torque check must be done for blade and mating flange bolts
- The torque values to be checked/applied must be the same as those specified in this O&M Manual

NOTE: Four or six fasteners secure the blades with a pair of bearings. To check any blade action, consider the four (or six) fasteners that hold this blade. Example: After lubricating/checking the lubrication of the four (or six) blade 1 fasteners, check blade 1 action 1.

Actions

1. The Screw/Stud must be lubricated on all threaded parts
2. Torque all fasteners until the torque wrench just clicks without rotating
3. Torque check on all fasteners before commissioning
4. Torque check after 24 hours of installation (commissioning)

Action	Blade #															Date	Responsible	Torque Applied (kgf.m)
	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15			
1																		
2																		
3*																		
4																		
Action	**Coupling Flange Bolt / Stud #**															**Date**	**Responsible**	**Torque Applied (kgf.m)**
	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15			
1																		
2																		
3*																		
4																		
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30			
1																		
2																		
3*																		
4																		

*Action 3 should be performed only if the commissioning run (24 hours of installation) does not occur within 2 days after action 2

Performed by:_____