



***ROTOR INSTALLATION,
TRACK & BALANCE
MANUAL***

SAFARI Helicopter Rotor Installation, Track and Balance
Revision 3 07/08/14

The following procedures are meant as a guide to assist you in the safe configuration of your helicopter's Main Rotor static and dynamic (running) balance and tracking. Due to the differences in balancing equipment and tracking methods available, this guide should be used along with the appropriate procedures associated with your balancer analyzer and whatever tracking method you choose to employ. Throughout this guide it is assumed that the operator is working with components (blades, attaching hardware, etc) supplied by CHR. Components supplied by CHR have undergone stringent testing and verification and are the only ones meeting with our approval. It is recommended that you read and understand all the steps related to a procedure as well as any CAUTION or WARNING statements before starting it to prevent injury or damage to components.

The following conventions are used in these procedures to identify steps or situations in which failure to follow procedures could result in injury or damage to equipment.

CAUTION

A CAUTION statement will precede any step in which failure to follow specific directions could cause damage to equipment or minor injury to the operator.

WARNING

A WARNING statement will precede any step in which failure to follow specific directions could cause catastrophic failure of equipment, serious injury or death.

All procedures listed are critical in nature and should be read and understood by the operator prior to attempting. The absence of a CAUTION or WARNING statement does not infer that injury, damage or death may not be caused by incorrect use of or failure to follow the steps listed.

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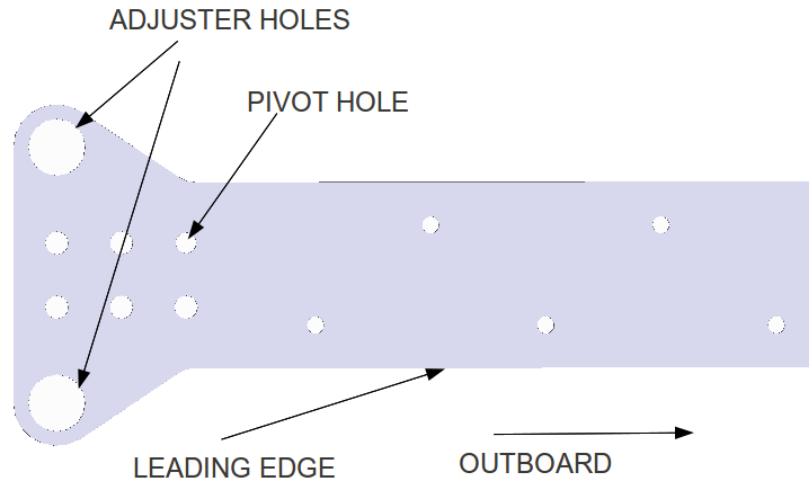
1 Revisions:

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2 Main Rotor Assembly and Static Balance

The Lead / Lag plates are slightly different than the standard blade plates. Not only do the Lead / Lag Plates have provisions for the adjusters, five of the six holes for mounting the plates to the grip are slightly larger and the remaining one is slightly smaller. The smaller hole is located on the trailing edge, outboard side of the blade and is used as a pivot point.



Picture 2.1

- (a) Ream the five 5/16" holes with a 5/16" hand ream and de-burr the holes.
- (b) Ream the Pivot Hole with a 3/8" ream and de-burr the remaining holes.
- (c) Align blade cheek plates in their respective groups noting bolt pattern for upper and lower halves.
 - i. The two long plates should be sandwiched between the two plates with a "T" support.
- (d) Using the blade bolt holes as a visual guide, align the plates as they would be installed on the blade noting the leading edge and inboard edge of the plates
 - i. All holes should be lined up
- (e) Separate the groups into top and bottom pairs.
 - i. Align the bolt holes and outline the outboard edge of the short plate onto the longer one for each pair.
 - ii. Working with one pair at a time, clean both surfaces of both plates and apply a liberal layer of 3M contact cement to the contact areas of each surface, as per instructions on the can.
 - A. Allow the adhesive to become tacky then bolt each pair of plates for alignment and press the plates together

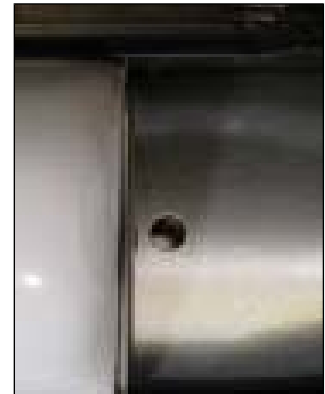
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- B. Clean any residual adhesive with a plastic scraper
- iii. Repeat steps i and ii above until all four pairs have been fastened together, keeping them in order.
- (f) Following the same order as above, unbolt and place the plates in their respective places on the blade and trace their outline. Trace the bottom of the plates where the root of the blade stops as well
- (g) Insert the adjusters into the adjuster holes making sure the 5/16" threaded hole in the center is pointing straight across to the other adjuster.
- i. You may need to use a press.
- (h) Install (4) AN4H-4A bolts and AN970-4 washers into the adjusters and tighten only finger tight.
- (i) Clean the blade plate and rotor blade contact surfaces with acetone and apply adhesive to both contact areas making sure NOT to apply any to the grip area of the plates.
- i. Repeat step d for the other pair of plates on this blade
- (j) After the adhesive has become tacky, bolt both sets of plates to the blade.
- i. Install the grip bolts as well to ensure proper alignment (do not torque)
- (k) Torque the blade bolt nuts to 20 foot pounds
- (l) Torque the adjuster attachment bolts to 70 in/lbs and safety-wire them together.
- (m) Repeat steps g through l for the other blade
- (n) Install the blades onto the Main Rotor grips with 3/8" bolts inserted and nuts just snug
- i. The trailing edge of the blade is on the same side of the grip as the pitch arm.



CAUTION

Confirm that there is clearance between the butt of the blade and the grip to provide adjustment of lead/lag.



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3 Main Rotor Lead / Lag Adjustment

The following steps must be performed in an area free of drafts and gusts as the slightest air disturbance could upset the rotor balance and cause it to strike the aircraft and/or people. It is best to have some backup system to catch the blades should they become out-of-balance.

Whenever you are performing maintenance above the clutch and cooling fan assembly, it is recommended that fan guards be installed to prevent foreign material from damaging the fan, clutch and other components.



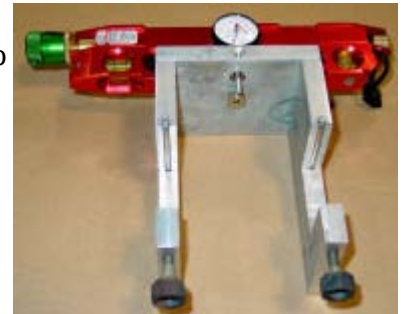
CAUTION

The following steps must be performed in an area free of drafts and gusts as the slightest air disturbance could upset the rotor balance and cause it to strike the aircraft and/or people.

When using laser tools, be sure to avoid looking into the laser to avoid possible eye or vision damage.

This procedure makes use of the SAFARI head alignment jig and a torpedo style laser level.

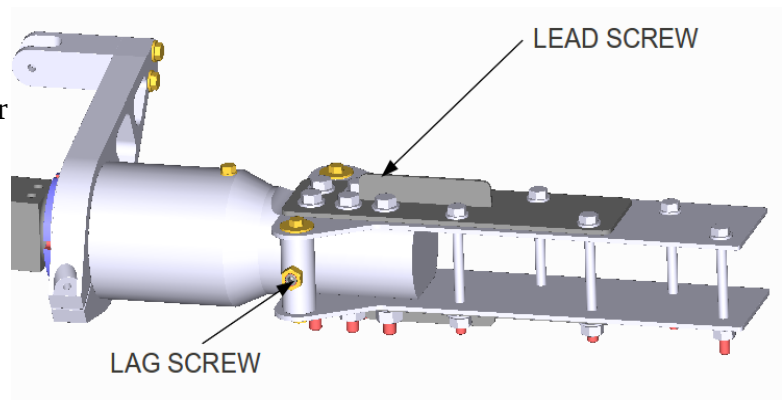
- (a) Attach the SAFARI Head alignment jig to the spindle so that the laser points down the leading edge of one blade



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Support the rotor head using either the SAFARI rotor hoisting adapter or by resting the teeter pin on two machined, level parallels

- i. The blades should be unsupported but should close to some means of support in the event of an unintended tilting of the head
- (b) Establish the rotor head in a level position and brace it to maintain that orientation
- (c) Place a level across the blade being measured and secure the pitch arm to obtain a level reading on the blade
- (d) Mark two locations on the blade's leading edge
 - i. One tip point inboard of the blade tip about 1/4"
 - ii. One root point outboard of the blade plates about 24"
- (e) Measure the distance of the laser beam at these two points
 - i. If the tip reading is larger than the root reading, the blade is lagging
 - ii. If the tip reading is smaller than the root reading, the blade is leading
- (f) Loosen the jamnuts on the lead / lag adjuster screws
 - i. If necessary, loosen the blade plate grip (3/8") nuts
- (g) Tighten the screw on the leading edge to lag the blade or the screw on the trailing edge to lead it
 - i. Loosen the opposing screw before tightening
 - ii. Repeat until the root and tip readings are as close to each other as possible
 - A. Try to get below 1/16"
 - iii. It may be helpful to rotate the blade grip bolts in their holes to a spot where they move more freely
- (h) When you are satisfied with the adjustment, torque the blade grip bolt nuts to 39 ft/lbs
- (i) Torque the adjustment screws to 72 in/lbs
 - i. Start with the loosest screw first.
- (j) Torque the jamnuts to 72 in/lbs
- (k) Repeat steps a thru j for the other blade



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4 Main Rotor Head Installation

- a. Put a thin film of grease in the yoke caps and install on the head pins in the same side they were removed from.
 - i. Use cap bolts to assist with alignment, tighten the bolts and install caps on yoke.
 - ii. You may have to tap with a rubber mallet to seat the caps properly
 1. Be aware of alignment problems and do not force them on mis-aligned
- b. Remove the cap bolts and install the angle plates on the yoke caps with 5/16 12 point cap bolts.
 - i. Torque to 160 inch pounds and safety wire.
 1. Old bolts (hex head) are torqued to 10 foot pounds
 - a. It is recommended that you contact the factory to replace these bolts.
- c. Install angle plate cross bolt
 - i. Note the force required to pivot the blades up and down.
 - ii. Tighten the cross bolt until the head has just a little drag when pivoting.
 1. Cotter pin the nut.
- d. If necessary, install the head pin jacking bolts in the head box



CAUTION

Too much torque applied to the jacking bolts can cause them to mushroom out at the end causing difficulty adjusting the head position in the future. To assist moving the head, you can loosen one bolt, tighten the opposite bolt, and then, using a small propane torch, heat the head box slightly. You will likely hear a popping sound and will be able to observe the head movement on the dial indicator. The popping sound is the stress giving way as the metal of the head box expands around the pin and allows the box to slide.

4.1 Main Rotor Head Centering

- a. Install the SAFARI Head Alignment jig with the centering attachment on the spindle
- b. Ensure the centering attachment is centered on the shaft by tilting the head one way or the other
- c. Using a feeler gauge, determine the amount of space between the jig and the main shaft
 - i. Only one person should use the feeler gauge so the drag felt on the gauge will be consistent
- d. Install the jig on the other side of the spindle and measure again
 - i. Subtract the lower number from the larger number and divide by two
 - ii. This is the amount to move the farther side to get it equal to the closer side

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- e. Adjust the head jacking bolts until the measurements are equal on both sides
- f. When you are satisfied with the adjustments, safety wire the head jacking bolts together.

4.2 Main Rotor Pre-Track Adjustments

Note: When installing pitch rods note that one rod end is left hand threaded and the other is right hand (normal) threaded. It is best if the left hand end is installed at the swash plate and the other is installed in the pitch arm to prevent damage to the threads. Using this method, you can use your right hand to determine rod rotation and direction of movement. With your palm facing the rod and your fingers pointed in the direction of rotation, your thumb indicates the direction in which the pitch arm will be moved.

- a. Lock the collective full down then position and lock the cyclic stick to level the swash plate.

Note: If the cyclic lock does not center the stick so that the swash plate is level in relation to the Main Rotor pylon mount, you may wish to modify it so that it does.

- b. Install the pitch rods in the pitch arms and swashplate and cotter pin the nuts.
 - i. Bolt heads should be on the inboard side of the pitch arm
 1. The Original SAFARI Rotor Head, the SAFARI 400 Series 1 (long pitch arms) and Series 2 (short pitch arms) all use different lengths of pitch rods. Make sure you have the right rods to go with your head
 - ii. Torque the nuts to 60 in/lbs and tighten to the next cotter pin hole
- c. Rotate the head to place one blade directly over the nose
- d. Place a machinist's ruler and protractor on edge across the grip at the end of the blade plates on the blade over the nose.
 - i. Be sure it is flat against the grip and not riding on the radius cut of the grip.
- e. Loosen pitch link jam nuts on both ends and adjust rods to obtain the proper pre-track measurement
 - i. Use the main rotor pylon as a level reference and measure across the blade plates
 1. Original Safari Head: 2 degrees negative pitch
 2. 400 Series 1: 2.2 degrees negative pitch
 3. 400 Series 2: 2.2 degrees negative pitch
- f. Rotate the head so that the other blade is directly over the nose and repeat steps d & e



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- i. When both blades are adjusted properly, ensure the pitch rod ends are centered in the ears and torque the rod end jam nuts to 100 in/lbs

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5 Main Rotor Tracking (Strobe / Tip Light Method)

- a. If installed, make sure balancer/analyzer wiring is routed so that it will not interfere with flight controls, Main Rotor, or Tail Rotor output shaft rotation.
- b. If installed, make sure balancer/analyzer pickup will not interfere with Main Rotor or Tail Rotor output shaft rotation.

CAUTION

At approximately 400 RPM (Rotor speed) there is a resonance range during clutch engagement in which the helicopter will vibrate excessively. **DO NOT PAUSE** in this range. The vibration is greatly exaggerated when the Main Rotor head has not been dynamically balanced. Pulling a slight amount of collective upon reaching it will ease the transition through the range. To minimize the effects of this resonant range, it is recommended that initial balancing be done on soft ground (grass) as a hard surface will amplify the vibration.

If vibration is excessive, it may be necessary to start measurements at lower speeds and work your way up to 500 RPM (Rotor)

- c. Ensure your aircraft is ready for flight and that the area is free from hazards and loose debris which might get blown into the rotors.
- d. Review procedures with all crew members and ensure any non-essential personnel remain clear of the aircraft.
- e. Ensure a qualified operator is at the controls of the helicopter at all times during operation.
- f. Ensure the operator maintains visual contact with all ground crew members during operations.
- g. Ensure tip targets (red on target blade, white on non-target) or lights are installed.
 - i. Having the Sun close to the aircraft's six o'clock position is helpful
- h. Bring Rotor RPM to 500 if possible at flat pitch and light on the skids (17 inches of manifold pressure).
- i. Draw an imaginary line from the rotor pickup to the blade tip through the Main Rotor shaft.
- j. Point the strobe at about mid blade along that line. It may be necessary to hunt left or right a bit. Once the blade is acquired, move the strobe along the blade toward the edge of the rotor arc until the targets can be seen. If using tip lights, observe lights at aircraft's 12:00 position. (straight off the nose)
 - i. Record the lowest blade and estimate the distance to the higher blade.
- k. Shutdown the helicopter
 - i. If needed, adjust track by lengthening the pitch link of the higher blade.
 1. One full turn on the pitch link translates to 2 inches of blade tip travel.
 - ii. If adjustments were made, ensure the rod end jam nuts are tight.

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1. Repeat steps h through k until you are satisfied that the blades are flying level to each other.

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6 Main Rotor Balance

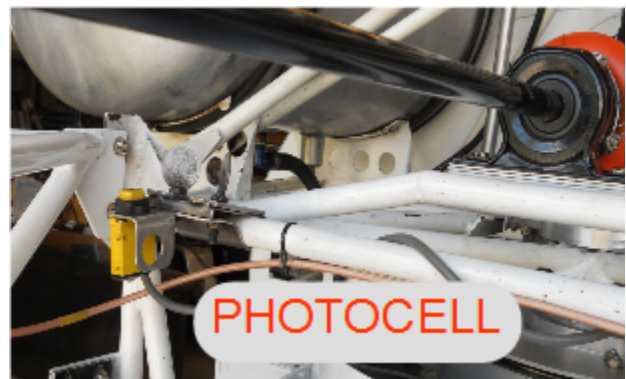
Note:

The Safari Main Rotor system has four basic adjustments:

- A. Pitch links – Adjust blade track and autorotation rotor speed.
Lengthening a pitch link by one turn will lower the blade tip 2 inches.
Lengthening both pitch links equally will increase autorotation RPM.
Adjusting blade track will move lateral vibrations along the 1:30 to 7:30 axis.
- B. Grip weights – Weight should only be installed on one blade and should be installed on the most outboard bolt of the plate on the blade. Do not place weight under the existing nut, but on top of it using a second nut to secure it. If you need to add weight to a blade for dynamic balancing and there is weight installed on the other blade, remove the appropriate amount from the blade that already has weight installed. If enough weights cannot be removed, add the remainder to the blade that initially had none. Adjusting grip weight will move lateral vibrations along the 4:50 – 10:50 axis
- C. Head Shift – Adjusted with the head jacking bolts. .002” adjustment nulls approximately .1 IPS on the 400 heads and .2 IPS on the Original heads. Any adjustment should be made in very small increments (.002”-.004”).If head shift exceeds .003” from initial center adjustment, blade sweep and head box centering should be checked. Head shift adjustments are for fine tuning ONLY and should be kept to a minimum. Adjustments to Head Shift will move lateral vibrations along the 2:10 – 8:10 axis.
- D. Lead/Lag (Blade Sweep) – Adjusted by loosening the six grip plate bolts and moving the blade fore/aft. (See Section 3) This aligns the CG of both blades so that it runs through the center of rotation of the head box. It is preferred to have the blade's CG lag slightly and SAFARI blades have this engineered into them. Do not set the blades to lag or lead, but rather align them parallel to the spindle. This should have been done in Section 3. Blades that are out of alignment will cause a condition that can be corrected by shifting the head box. See “Adjustment of rotational center” diagram in Section 8 Attachments.

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- a. Install balancer/analyzer if you haven't already done so.
 - i. The lateral vibration transducer is mounted directly to the Main Rotor Pylon mount on the forward, right corner.
 - ii. The vertical vibration transducer is mounted below the instrument pod between the vertical and angled support rods
 - iii. Reflective target about 2" square is installed one blade where it meets the grip plates at the center of the plates.
 1. This is now the "Target" blade.
 2. This target patch will remain on the helicopter and should never be painted or clear coated to prevent loss of reflective properties.
 - iv. The optical pickup (photo cell) gets mounted on the front of the tailboom to the port side of the Tail Rotor output shaft, aiming upwards at the reflective target.
- b. Ensure cables and pickups will not interfere with flight control movement or Main Rotor shaft, swashplate, and Tail Rotor output shaft rotation.



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Note: When making hover balance runs, the aircraft Center of Gravity (CG) should be as close to center as possible. If needed, place shot bags in the cabin to obtain center CG

If vibration feels excessive enough to prevent safe operation at 500 RPM, start measurements at 450 RPM and work your way up to 500 RPM as the helicopter's vibrations are adjusted out.

We have found that using tracking and grip weight adjustments as the primary method of balancing achieves the best results. Also, utilizing both lateral and vertical measurements gives a better indication of aircraft dynamic conditions. Measurements for lateral and vertical vibrations should remain on the same side of the chart in that a tracking adjustment to lower lateral vibrations should not increase vertical vibrations. If this is not the case, it may indicate worn bushings in the swashplate, loose flight controls in the cabin or worn rodends and should be addressed.

Adjustments made to Head Shift should ONLY be a last resort and should be measured by zeroing a dial indicator to the head box and measuring the amount shifted by adjusting the jacking bolts. (See Section 13) No more than 0.002" - 0.004" per run and no more than 0.003" in one direction total. It is recommended that you record Head shift as positive (+) when adjusting toward the target pitch arm and negative (-) when adjusting away from the target pitch arm. Always record actual amount moved if it is different from intended amount moved. The adjustments should be added and a running total kept to determine if blade sweep is required.

- c. Ensure your aircraft is ready for flight and that the area is free from hazards and loose debris which might get blown into the rotors.
- d. Review procedures with all crew members and ensure any non-essential personnel remain clear of the aircraft.
- e. Ensure a qualified operator is at the controls of the helicopter at all times during operation.
- f. Ensure the operator maintains visual contact with all ground crew members during operations whenever possible.

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- g. Run the helicopter to 500 RPM (or max safe speed) flat pitch.
 - i. If this is your first run, verify calibration of aircraft Tachometer with analyzer reading
- h. Lift the aircraft gently into a stable hover 3-5 Feet AGL.
 - i. Initiate balance run on analyzer for lateral vibrations
 - ii. Initiate balance run on analyzer for vertical vibrations
- i. Return the aircraft safely to the ground and return to idle
 - i. After the cylinders have cooled sufficiently and the battery has charged, shut down the aircraft
- j. Record IPS readings and clock (phase) angle on charts.
 - i. Plot readings on Polar chart and label with run #.
- k. Using the above guidelines, determine what adjustment needs to be made and annotate the proposed change on the chart for the next run.
 - i. Make only one change per run
- l. Make changes as required
- m. Ensure all hardware is tightened and the helicopter is safe for flight.
- n. Repeat steps g through k until IPS reading is at least less than .2 ips
 - i. A reading of less than .1 ips vertical and lateral will give the best results if possible
- o. Safety wire head jacking bolts.
- p. Remove balancer/analyzer sensors and cables from aircraft.

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7 Tail Rotor Balance Procedures

NOTE: Your tail rotor assembly may have been dynamically balanced at the factory. If this is the case, it will usually be good until the next overhaul. Check the paperwork that was shipped with your tail rotor

SAFARI offers dynamic bench balancing of the entire tail rotor assembly at the factory that is far superior to an “on aircraft” balance.

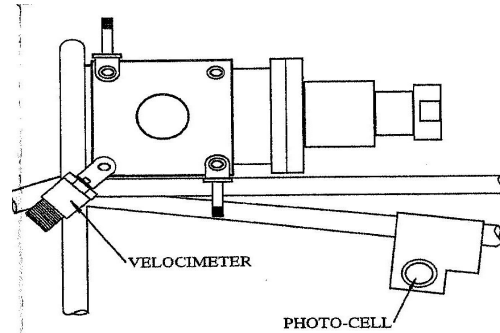
The Safari Tail Rotor system has one basic adjustment:

Balance weight: Weight is added to the tail rotor bump stop ring to counter forces that may cause vibrations. The ring is graduated at 30° increments to correspond to clock angles generated by some balancing equipment with 0° (12:00) being on or just to the left of the target blade when viewed from the front of the ring. Weight is typically added opposite to the perceived source of vibration. For example, A vibration at 8:00 would be countered by weight added to the 2:00 position on the ring.

1. Balancing the Tail Rotor can be very difficult and multiple attempts or strategies may be required. Sometimes it may be as simple as applying weight opposite the indicated clock angle and other times may require a “hunt and peck” method. Typically, 1 gram of weight will counter .1 ips. Ideally, you want the least amount of weight possible and in one position however this may not always be the case. No more than two bolts should be used to balance the rotor. If the calculated weight does not lower vibrations as expected, move one clock angle up or down from the starting point until the desired effect is achieved.
2. The goal in selecting weight and position is to make the vibration “jump the clock” and read 180° from the initial reading. Weight is then reduced or moved to another clock position to fine tune. Only one change at a time should be done to provide an “undo” element.
3. If less than 5 grams of weight is required at a location, it may be possible to add 5 grams directly opposite the desired location then, add the necessary weight PLUS 5 grams at the desired location.
 - Example:
 - Vibration of .39 IPS @ 4:00
 - Place short bolt and nut (5 grams) @ 4:00
 - Place medium short bolt plus 2 washers (approx. 8.5 grams) @ 10:00

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- a. Install balancer/analyzer if you haven't already done so.
 - i. Using the bottom rear bolt from the tail rotor gearbox, mount the vibration transducer so that it is 90° to the output shaft.
 1. It is not necessary to cotter pin this bolt until the transducer is removed.
 - ii. A reflective target about 2" square is installed on one blade where it meets the grip at the center of the blade.
 1. This is now the "Target" blade.
 2. This target patch will remain on the helicopter and should never be painted or clear coated to prevent loss of reflective properties.
 - iii. The optical pickup (photo cell) gets mounted on the port side of the tailboom, aiming out at the reflective target.
- b. Ensure cables and pickups will not interfere with flight control movement, Tail Rotor Blades, or Tail Rotor shaft rotation.
- c. Ensure your aircraft is ready for flight and that the area is free from hazards and loose debris which might get blown into the rotors.
- d. Review procedures with all crew members and ensure any non-essential personnel remain clear of the aircraft.
- e. Ensure a qualified operator is at the controls of the helicopter at all times during operation.
- f. Ensure the operator maintains visual contact with all ground crew members during operations whenever possible.
- g. Run the helicopter to 500 RPM flat pitch.
 - i. Initiate balance run on analyzer
 - ii. Record IPS reading and clock (phase) angle on chart.
 - iii. Plot reading on Polar chart and label with run #.



CAUTION

Use only self locking type nuts to secure weight to the Bump Stop Ring. Ensure the locking feature of the nut is functioning properly.

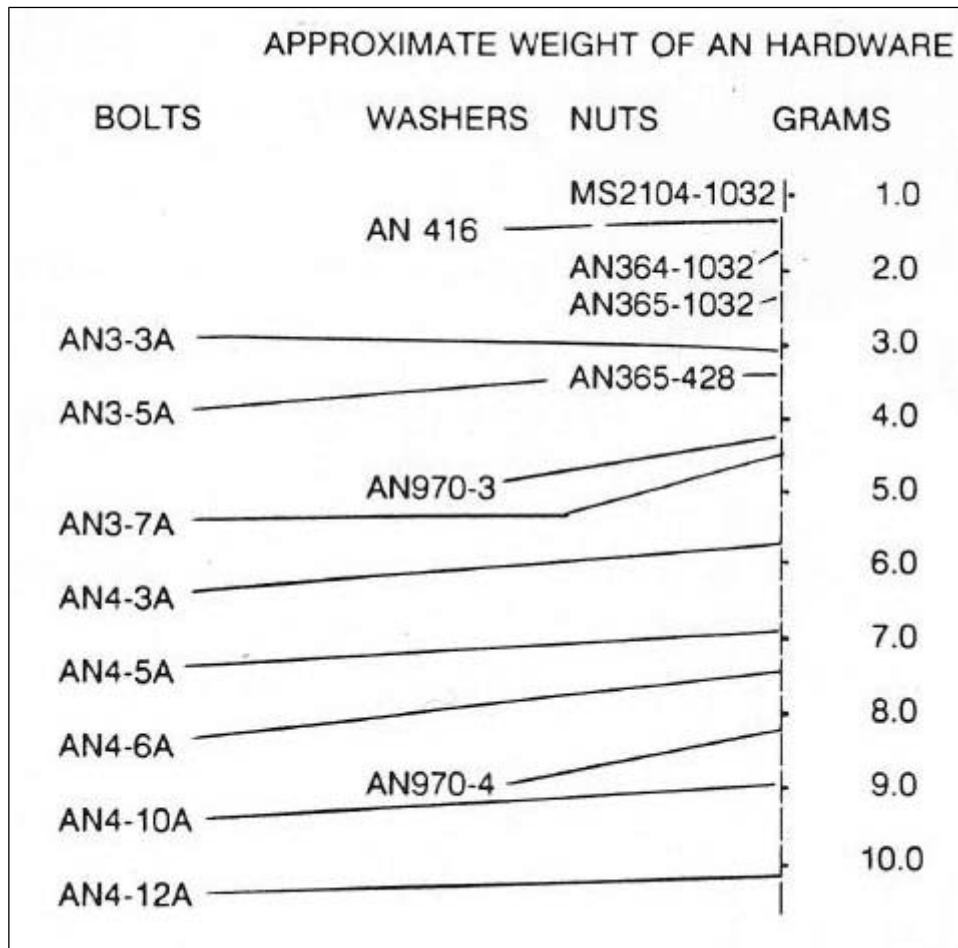
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- h. Using the above guidelines, determine what adjustment needs to be made and annotate the proposed change on the chart for the next run.
 - i. Make only one change per run
 - ii. Apply the desired weight
 1. Opposite the indicated vibration.
 2. Approximately 1 gram / .1 ips.
 3. Ensure hardware does not interfere with the blade grips.
- i. Ensure all hardware is tightened and the helicopter is safe for flight.
- j. Repeat steps g through i until IPS reading is less than .2 ips
- k. Remove balancer/analyzer sensors and cables from aircraft.
- l. Tighten and cotter pin the lower rear bolt on the tail rotor gearbox.

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8 Attachments

8.1 Approximate Weights of AN Hardware



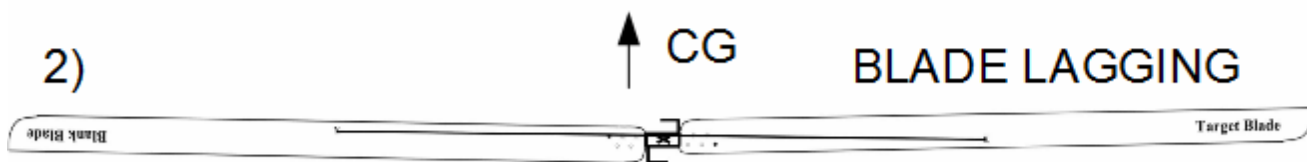
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8.2 Adjustment of Rotational Center

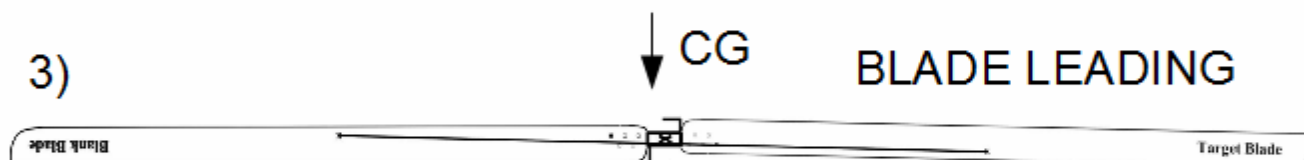
1) PROPERLY ALIGNED



2) BLADE LAGGING



3) BLADE LEADING



IN EXAMPLE 1) THE BLADES ARE PROPERLY ALIGNED AND CG INTERSECTS THE CENTER OF ROTATION.

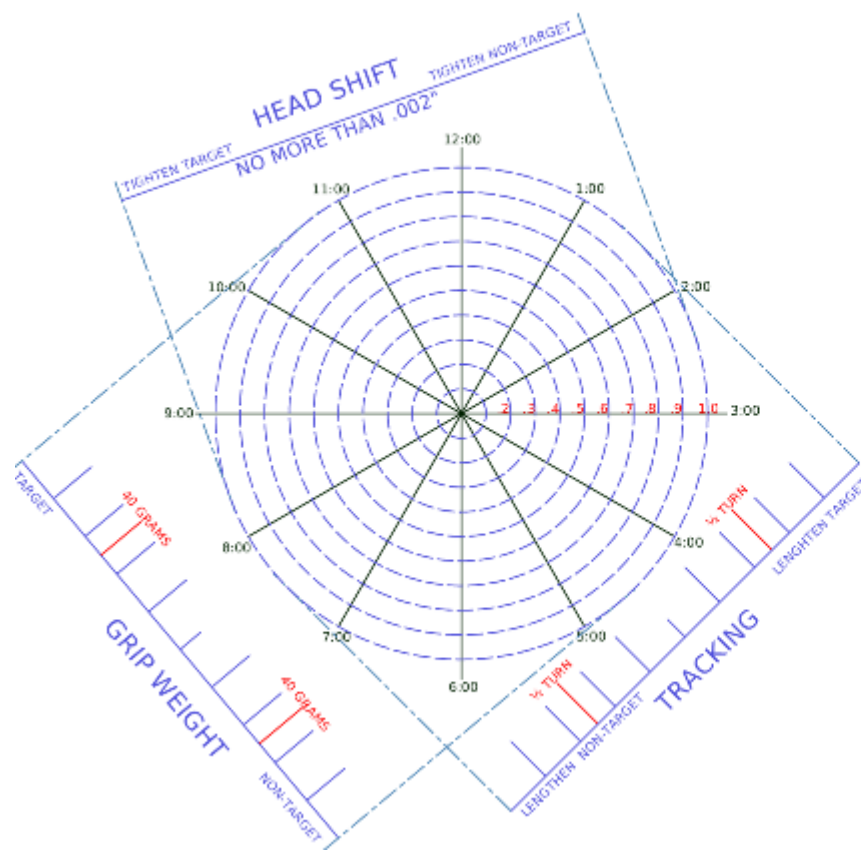
IN EXAMPLE 2) THE TARGET BLADE IS LAGGING AND CG IS OFF CENTER. EITHER TIGHTENING THE BOLT CLOSEST TO THE TARGET PITCH ARM OR LAGGING THE OTHER BLADE EQUALLY WILL CORRECT IT.

IN EXAMPLE 3) THE TARGET BLADE IS LEADING AND CG IS OFF CENTER. THIS BLADE SHOULD BE LAGGED TO CORRECT IT.

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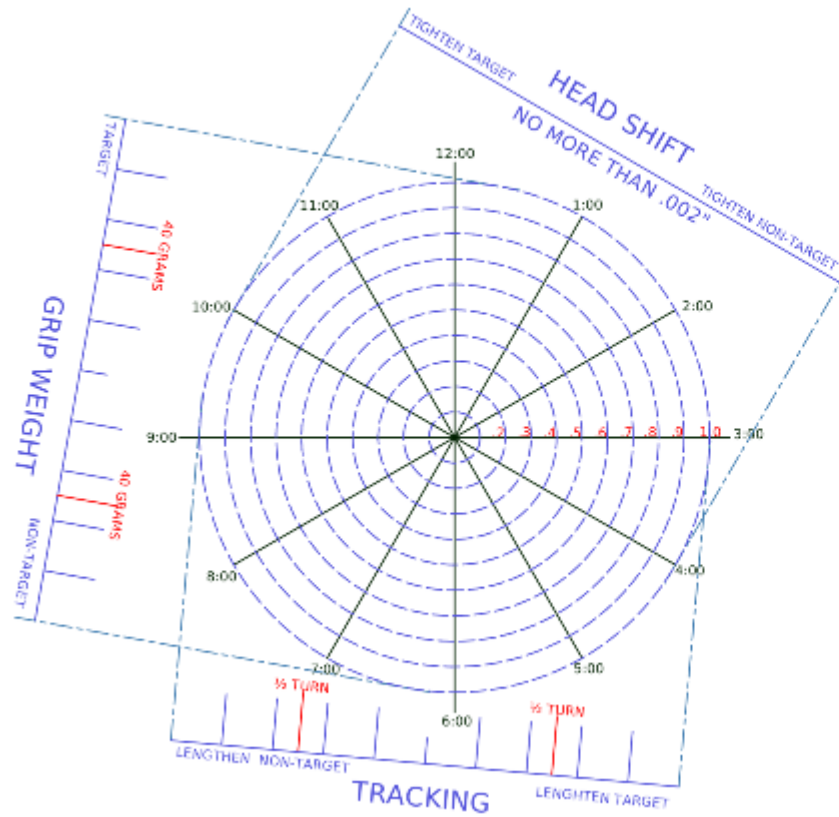
8.3 CHARTS

LATERAL HOVER



RUN #	CHANGES	IPS	ANGLE
1			
2			
3			
4			
5			
6			
7			
8			
9			

VERTICAL HOVER

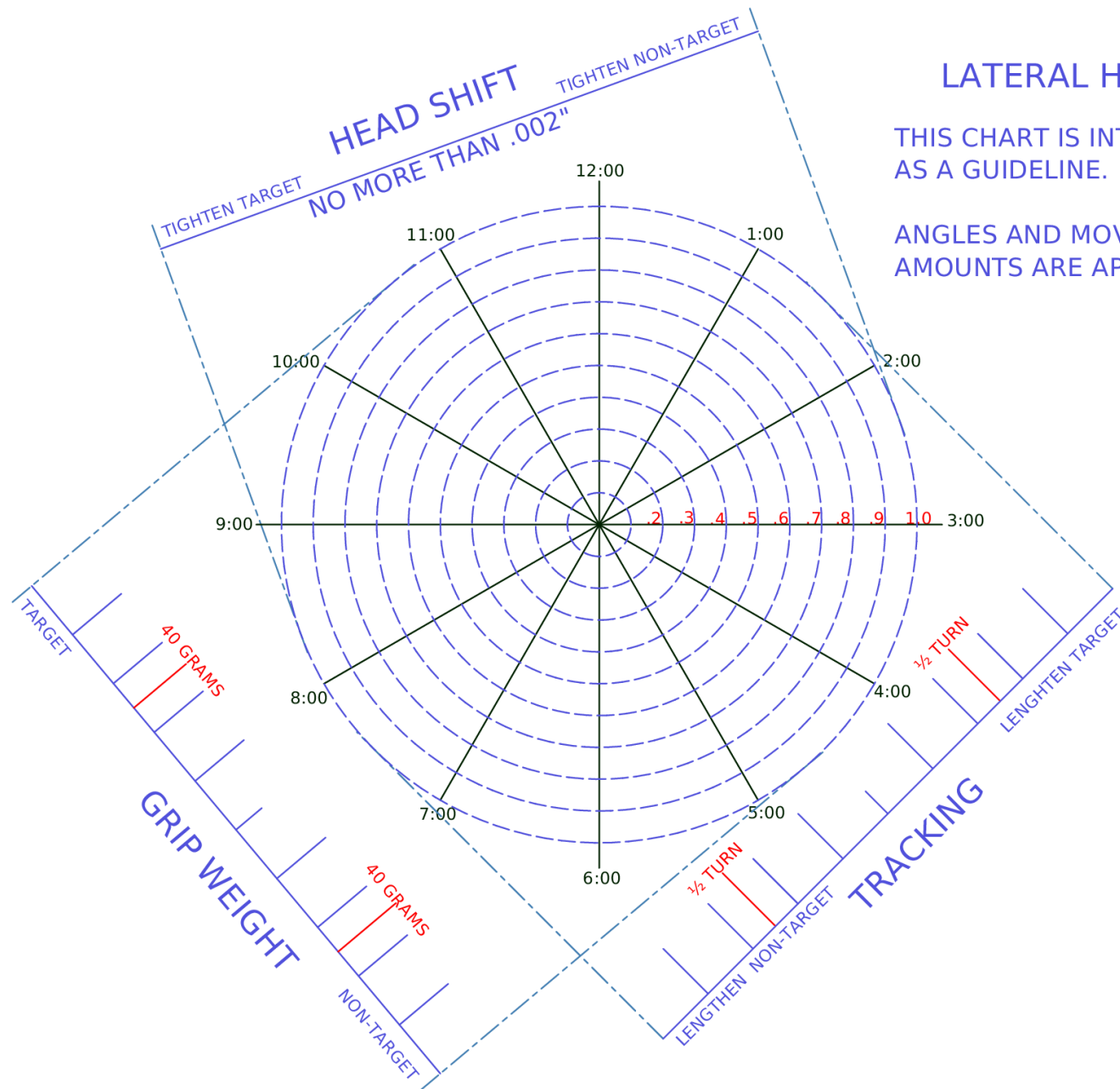


RUN #	CHANGES	IPS	ANGLE
1			
2			
3			
4			
5			
6			
7			
8			
9			

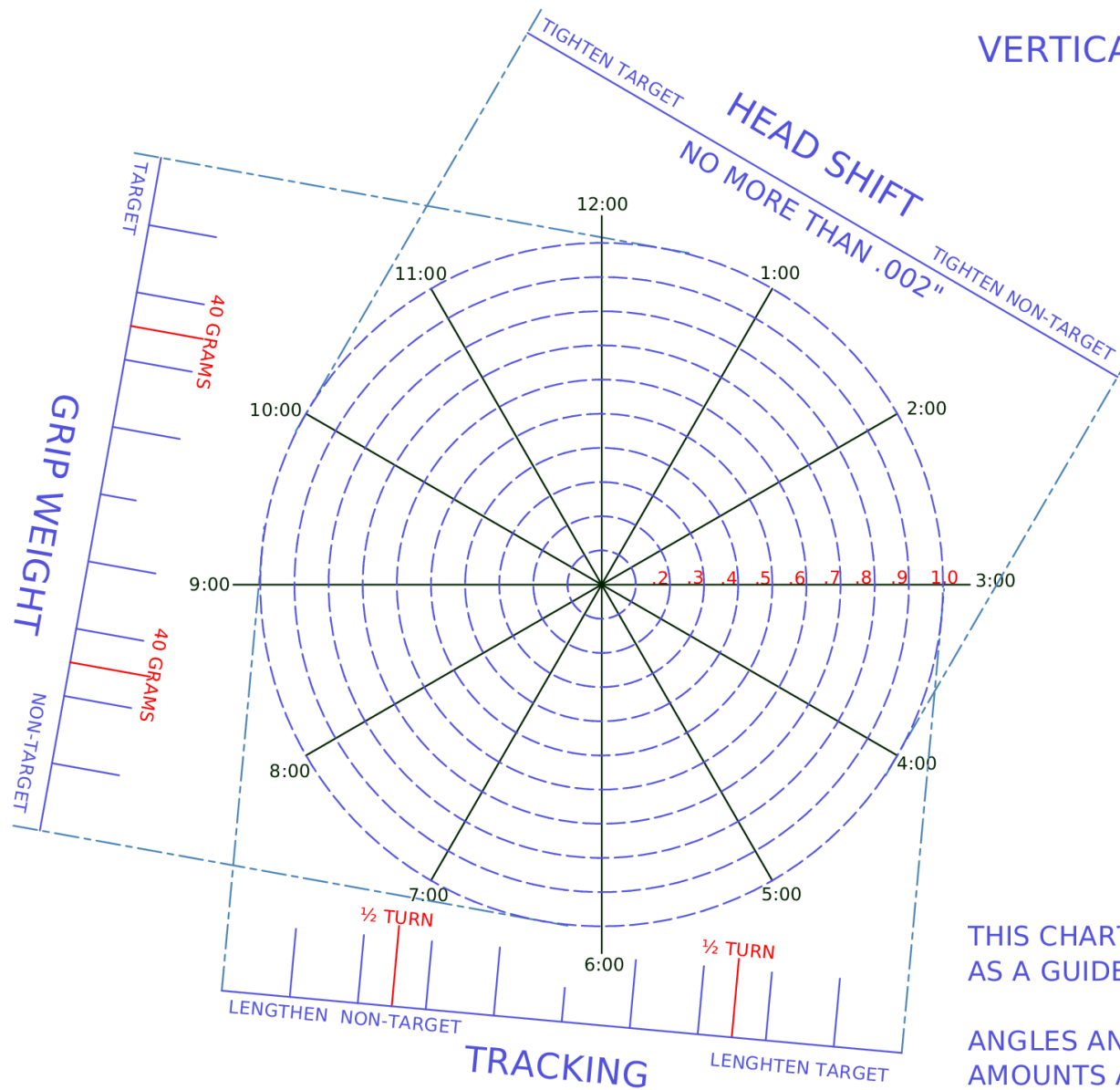
LATERAL HOVER

THIS CHART IS INTENDED
AS A GUIDELINE.

ANGLES AND MOVEMENT
AMOUNTS ARE APPROXIMATE.



VERTICAL HOVER



THIS CHART IS INTENDED
AS A GUIDELINE.

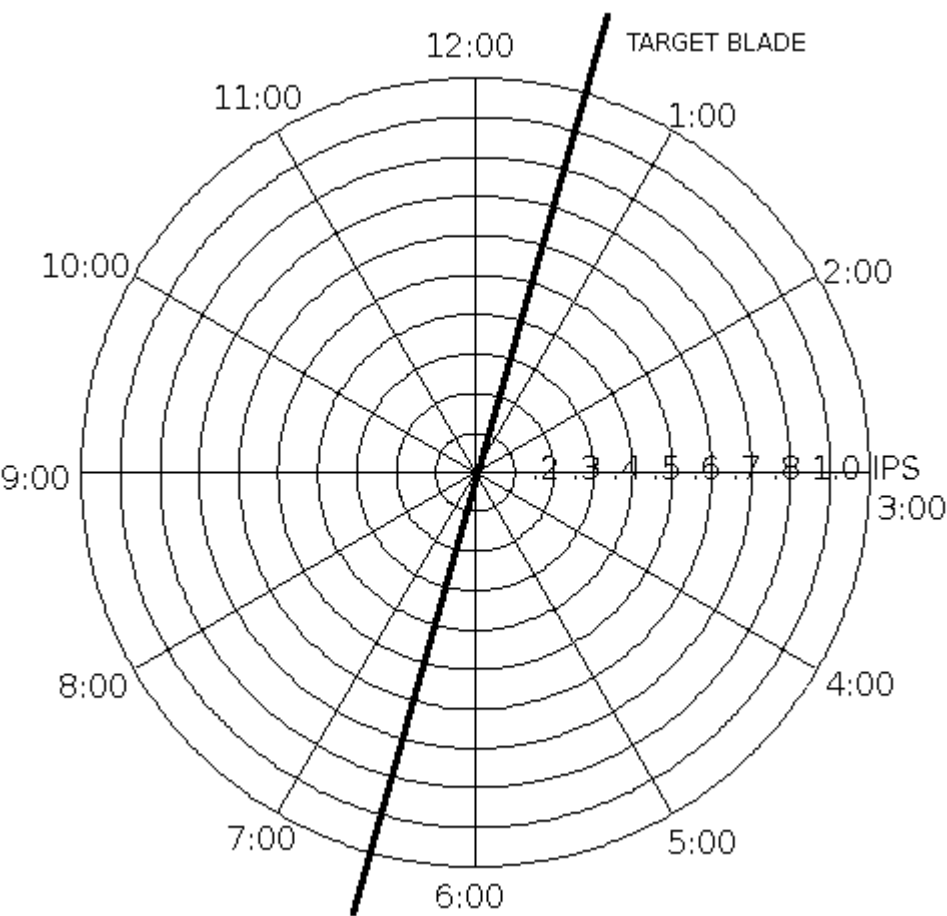
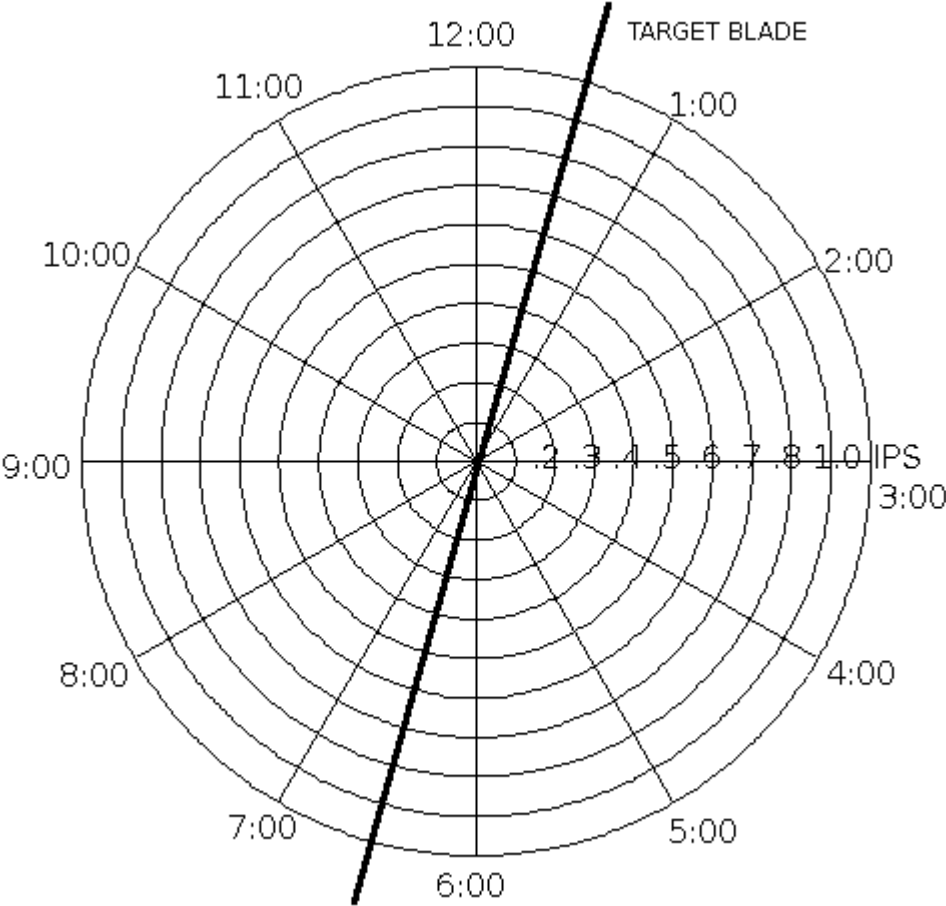
ANGLES AND MOVEMENT
AMOUNTS ARE APPROXIMATE.

Tail Rotor Chart

ACCOMPLISHED BY _____

DATE _____ TAIL # _____

RUN #	CHANGE MADE	IPS	CLOCK ANGLE	RUN #	CHANGE MADE	IPS	CLOCK ANGLE



8.4 NOTES

[illegible]

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9 Addendum:

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