ES-24.74	HUDSON PRODUCTS CORPORATION ***Fan Engineering Standards*** **Hudson Fan Assembly Balancing Specification** ***For General Release***	**Page 1 of 4**

Introduction

The Hudson fan design, manufacturing, and balancing scheme has historically followed the same plan. Hub assemblies and seal-discs are independently balanced as a sub-assembly in the factory and the fan blades are individually moment-balanced at the factory.

The rationale in this plan is the idea that the best of all worlds are combined: the hub inner rotating parts are balanced in a trained, controlled environment at the factory and the moment balancing of the blades promotes interchangeability of blades both in the original installation and later as replacements.

Shipment and handling of complete fan assemblies dynamic balanced at the factory is an extra-cost option with Series CX but it not normally necessary for good Tuf-Lite performance in typical field applications. Note that once a fan is dynamic balanced, it must continue to be dynamic balanced, removing the blade replacement interchangeability feature.

Procedures

1. Hubs for S1000 & S3000H (6 ft – 14 ft diameter)(Tuf-Lite II)

    a. The entire hub assembly is assembled with the clamp and bolt assemblies intact
    b. The hub assembly is *dynamically balanced* on a *Stewart-Warner 2410 Spin-Balance System*
    c. Standard cast iron balancing weights are bolted near the outer perimeter of the hub as instructed by the 2410 system
    d. Final unbalance residual must comply with values shown in Table A

2. Hubs for S3000B (5 ft –16 ft diameter)(Tuf-Lite)

    a. The entire hub assembly is assembled with the clamp and bolt assemblies intact
    b. The hub assembly is mounted on a horizontal shaft *static balance* machine
    c. Standard cast iron balancing weights are bolted near the outer perimeter of the hub until a stable balance is achieved about the shaft centerline
    d. Final unbalance residual must comply with values shown in Table A

3. Hubs for CX Series, S4000, S5000, & S6000 (15 ft – 32.81 ft) (Tuf-Lite II & Tuf-Lite III)

    a. The entire hub assembly is assembled with the clamp and bolt assemblies intact
    b. The hub assembly is mounted on a horizontal shaft *static balance* machine
    c. Standard cast iron balancing weights are bolted near the outer perimeter of the hub until a stable balance is achieved about the shaft centerline
    d. Final unbalance residual has been calculated to comply within the range shown in Table A

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4. Hubs for S7000 & S8000 (34 ft – 40 ft) (Tuf-Lite II)

    a. The entire hub assembly is assembled as a "short" hub (no clamps and no clamp bolts)
    b. The hub assembly is mounted on a horizontal shaft *static balance* machine
    c. Standard cast iron balancing weights are bolted near the outer perimeter of the hub until a stable balance is achieved about the shaft centerline
    d. Final unbalance residual has been calculated to comply within the range shown in Table A

5. Tuf-Lite II and Tuf-Lite III Fan Blades
    a. After the last blade processing, every fan blade is *individually moment balanced*
    b. A *micro-processor* controls the balancing machine, instructing the operator as to the quantity of balancing resin needed to be added to the blade tip
    c. The balance resin is allowed to set
    d. Blade tip drain holes are re-drilled after each balance resin addition
    e. Steps b-d above are repeated until the moment balance compliance
    f. A valid *blade serial number sticker* is not printed until until the blade meets the tolerance
    g. The *tolerance is a narrow*, commensurate with the size and influence of the blade (see Table B)
    h. The moment balancing machine *keeps track of all blade weight and moment balancing data*
    i. All production moment balance *data is up-loaded to the server* database for future production statistics & quality program monitoring

6. Tuf-Lite (aka Tuf-Lite I) Fan Blades

    a. Procedure is the same as in Tuf-Lite II and Tuf-Lite III above except the balancing process is *manually controlled* (like a balance scale) and *records are manual logged*

7. Series CX (*Ultra-Low-Noise*) Fan Blades

    a. Procedure is moment balanced in two X-Y planes against a MB blade size standard
    b. Balancing process is *controlled by two digital scales*
    c. Resin is introduced through *balancing ports* at the indicated positions
    d. Balance *resin ports are sealed* with plastic caps
    e. Records are manual logged

6. Seal-Discs (all types & sizes)

    a. The seal-disc is assembled according to factory procedures
    b. The seal-disc assembly mounted on a horizontal shaft *static balance* machine
    c. Standard metal balancing weights are bolted near the outer perimeter of the hub until a stable balance is achieved about the shaft centerline
    d. Section match marks are made

e. Seal-disc is dis-assembled and re-packaged for shipment

6. Series CX Dynamically Balanced Fan Assemblies (price & delivery optional)

f. The hubs are mounted on to a spring-supported dynamic balance test stand
g. Blades are installed at each position and set to the specified blade pitch
h. An accelerometer is installed at the fan bearing position
i. A Schenk vibration/balance analyzer is used to determine the amount of imbalance
j. Weights are placed onto the hub plate periphery or additional balance resin is placed into the blades as indicated by the instrument

Discussion

1. Standard Hub Assembly and Individual Fan Blade Balance Level

The balance procedures as explained above result in the hub assembly and individual blade moment balance standard schedule as summarized in Tables A & B below.

Table A: Hub Assembly Balance Tolerances

Fan Series Hub	*Residual Un-Balance (in-oz)*	*Dynamic Balance RPM*
S1000 (AV)	2.5	600
S3000 (AP)	2.0	690
S4000 & Seriex CX	8.5	-
S5000	15.0	-
S6000 (10m)	50.0	-
S8000	51.0	-

Table B: Individual Blade Moment Balance Tolerances

Fan Size	*Band Width*
Small Diameter (5-10)	1.2 % - 1.7 %
Medium Diameter (11-20)	0.6 % - 0.7 %
Large Diameter (22-40)	0.14 % - 0.56 %

2. Total Fan Assembly Balance Level vs. ISO-1940/1

Results of a parametric modeling study has resulted in the following ISO-1940/1 (International Standards Organization) vibration level categories for given fan configurations shown in Table C below. These example configurations were analyzed for various degrees of component assembly quality taking into consideration random positioning of parts within drawing tolerance ranges and a range of assembly

technician expertise/training/diligence rating from 0.5 to 1.0. Ten fan assemblies were used in the typical production run and standard hub balance level ranges and standard blade moment balance level ranges were used as shown in Tables A & B above. These results are based on a single plane analysis:

Table C: Examples of Total Fan Assembly Balance Levels re: ISO-1940/1 Rating System

Fan Model	*Tip Speed (fpm)*	*ISO G Level -Minimum*	*ISO G Level -Maximum*
S3000-APT-8H-4	**10,000**	**G4**	**G66**
S3000-APT-14H-6	**8,500**	**G1**	**G35**
S4000-APT-20H-6	**10,000**	**G1**	**G30**
S5000-APT-24H-8	**12,000**	**G2**	**G24**
S5000-APT-30H-10	**12,000**	**G1**	**G33**
S6000-APT-32.81H-10	**12,000**	**G1**	**G20**
S8000-APT-40H-10	**12,000**	**G0.5**	**G7**

Note that field dynamic balancing done by qualified personnel on Hudson fans, all other installation details permitting, generally results in final vibration levels in the G5 to G10 levels, depending on fan size.

3. In-Field Vibration Levels vs. API & CTI

When called to the field, Hudson service people expect to see fan vibration levels within the maximum vibration levels as specified in API-661 (American Petroleum Institute) which is 6.0 mils peak-to-peak (or equivalent velocity) average value as measured on the machinery mount of a heat exchanger. For cooling towers, we would expect to find vibration levels on Hudson fans as measured on the gearbox within similar acceptable vibrations levels as specified by CTI (Cooling Tower Institute) , namely 3 to 12 mils peak-to-peak over the fan speed range of 100 – 200 rpm. Sometimes there are installation conditions beyond Hudson's control which prevent achieving such balance levels; in this event, our service personnel will report on such conditions and try to make recommendations for corrective action wherever possible.

REV.	DESCRIPTION OF REVISION	DATE	APPROVED
0	Initial release	10/1 /04	LRS
1	Added balance model data.	1/19/05	LRS
2	Updated, corrected, added S7000 & Series CX	3/13/08	LRS