Reinhold Environmental Ltd.

2007 APC Round Table & Expo Presentation

July 8-10, 2007
Chattanooga, TN
Hosted by TVA

Introduction

The addition of pollution control equipment such as Bag houses, SCRs or Scrubbers have additional pressure drop associated with the new equipment to be installed. The following is a brief introduction of the process, procedures and options associated with the decision of how to overcome this pressure drop.

Steps in the Fan Upgrade Options to obtain the additional inches of Static Pressure are……

Step 1 is to test the fans

- Establish boiler unit full load fan requirements in present condition:
- Establish existing fan MCR and TB capacities (test)
- Compare to new requirements
- Compare to initial contract data

Step 2 inspect the existing fans

- Present condition assessment

1. Foundation (stiffness / natural frequency / concrete condition / pour type)
   A. Coast down with weight on wheel
   B. Wheel impact test

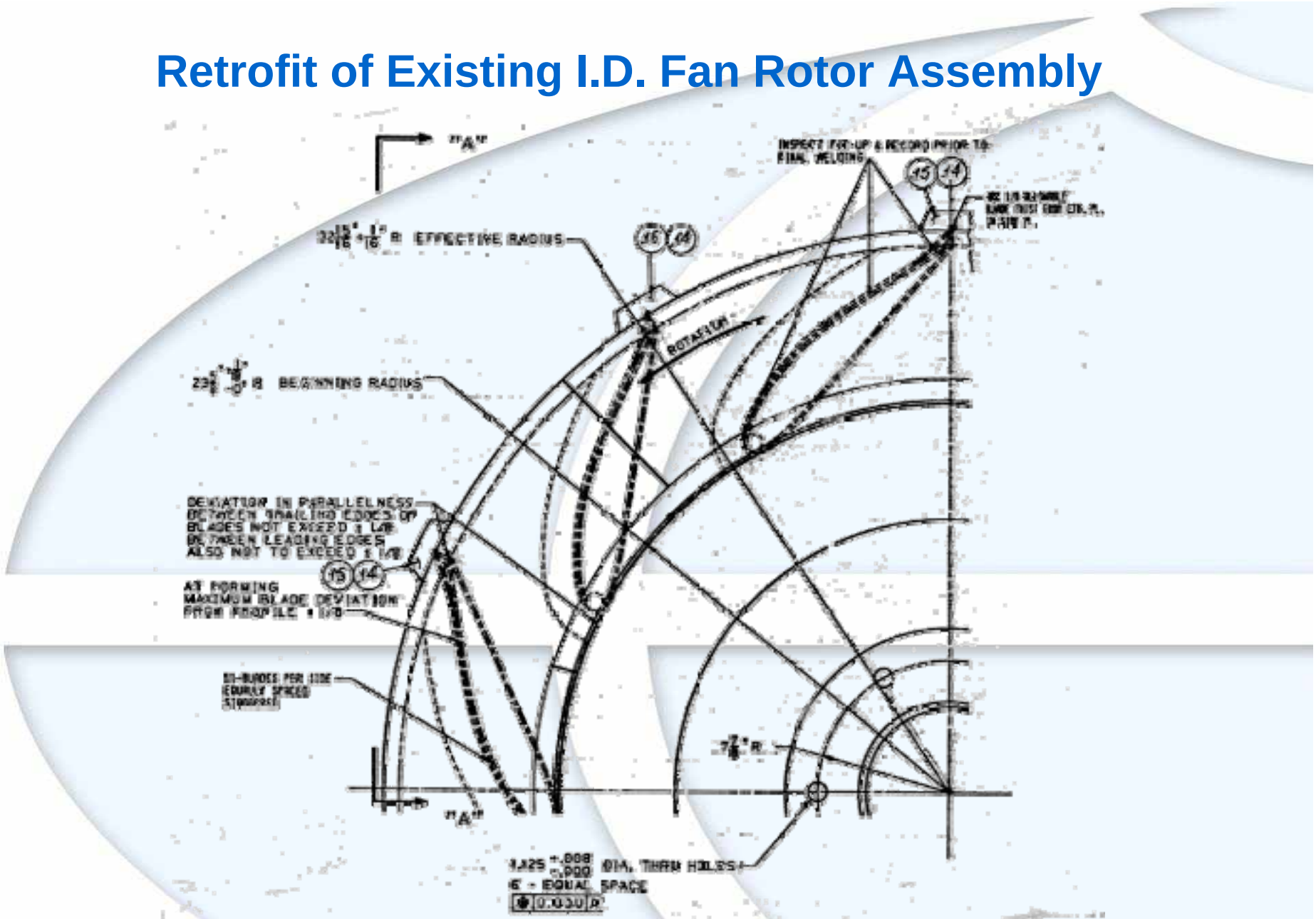
1. Condition of wheel, housing, shaft, bearings, dampers etc.

- Historical running data of current fans

Retrofit of Existing Fan

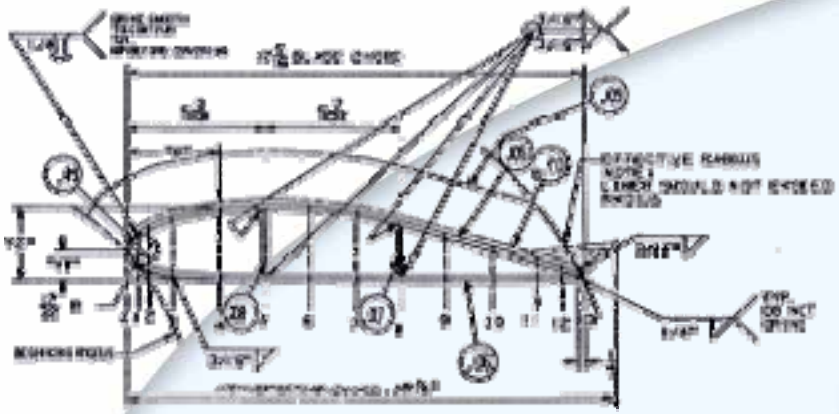
- Tip fan for 7 1/2% flow 14% pressure 23% horsepower
- Speed increase for additional performance
- New rotor in existing housing / footprint with minor adjustments

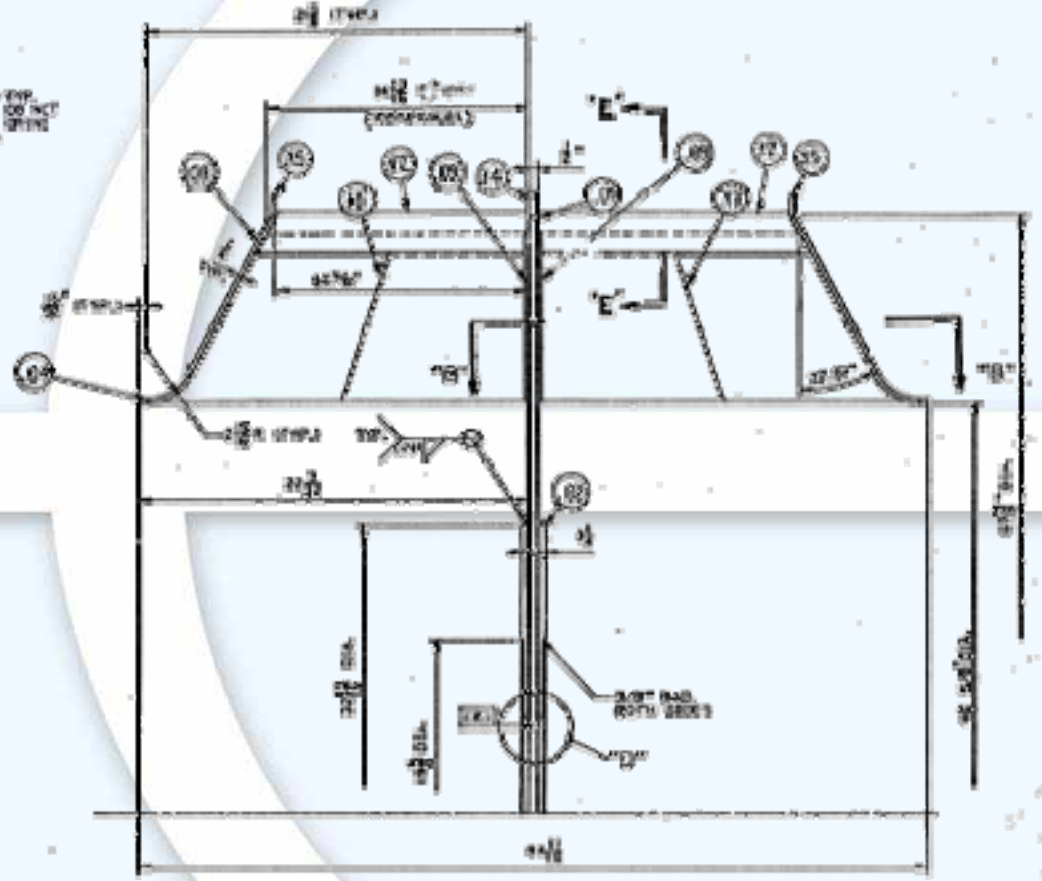
Retrofit of Existing I.D. Fan Rotor Assembly



Increase the existing diameter of a centrifugal fan by tipping the blades.

Retrofit of Existing I.D. Fan Rotor Assembly





Increase the existing diameter of a centrifugal fan by tipping the blades.

Retrofit of Existing I.D. Fan Rotor Assembly

PREDICTED PERFORMANCE

TLT-BABCOCK NUMBER: speed
Fan Size: 1904 B/2211
Speed (RPM): 782

CUSTOMER: speed increase
Cutwidth: 100. No. Inlets: 1
Flow Control Method: SPEED

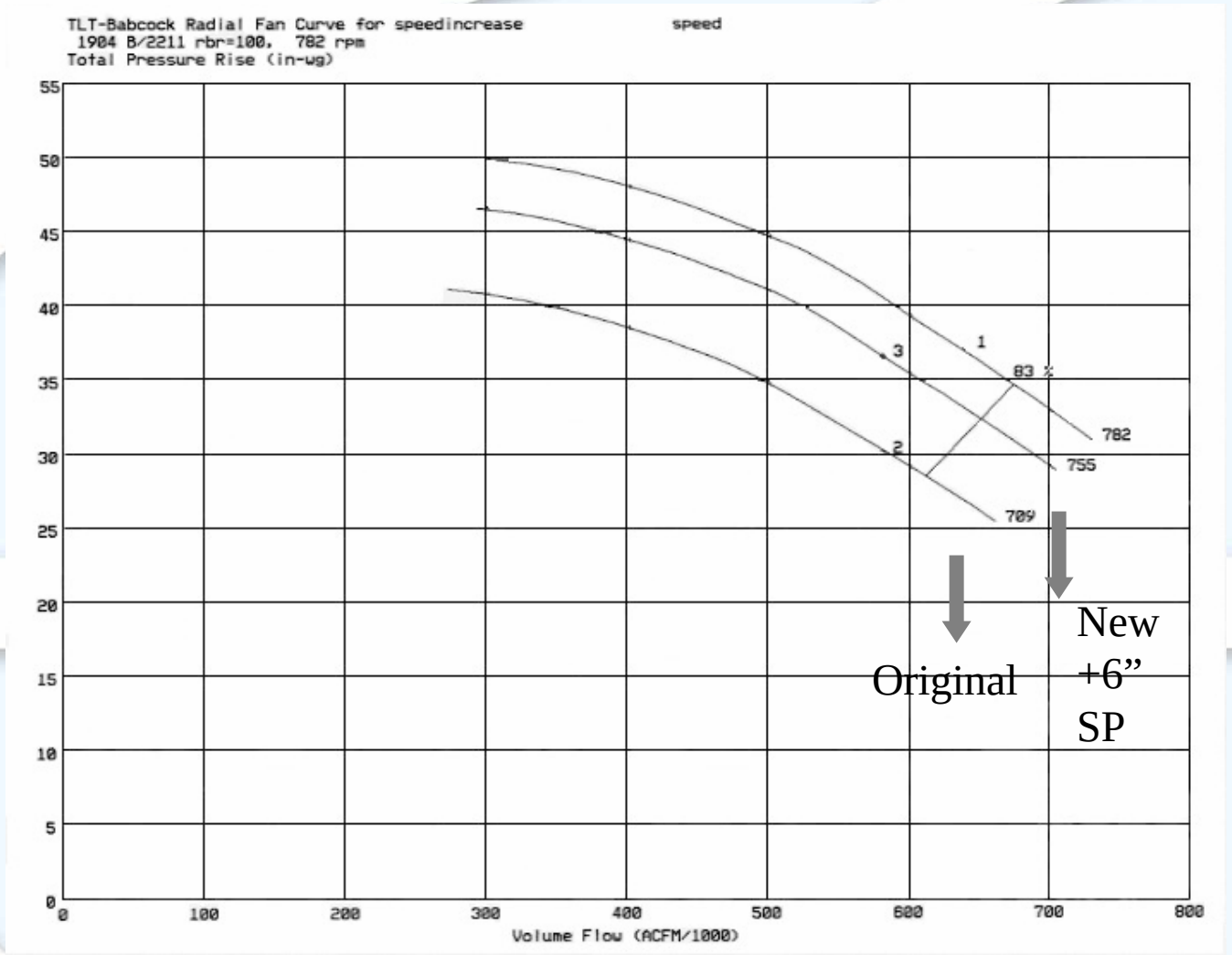
Load	sample	2	2
Flow (ACFM)	639102.	580000.	580000.
Inlet Temp. (F)	310	310	310
Inlet Density (Lbs/Ft3)	0.0472	0.0480	0.0472
Inlet press. (“WG)	-34.00	-28.00	-34.00
Static Press. Rise (“WG)	34.00	28.00	34.00
Dynamic Press Incr. (“WG)	0.51	0.43	0.42
Inlet Box loss (“WG)	1.24	1.04	1.02
IVC loss (“WG)	0.47	0.40	0.39
Inlet Damper loss (‘WG)	0.00	0.00	0.00
Outlet Damper loss (“WG)	0.00	0.00	0.00
Inlet Silencer loss (“WG)	0.00	0.00	0.00
Out. Silencer loss 9”WG)	0.00	0.00	0.00
Evase loss (“WG)	0.71	0.59	0.58
Shaft loss (“WG)	0.29	0.24	0.24
Fan Total Pressure (“WG)	37.22	30.70	36.65
Fan Total Efficiency (%)	84.69	84.39	85.52
Shaft power (BHP)	4266	3224	3777
Fan Speed (RPM)	782	710	756

Original Speed

New Speed for +6” SP

Increase the speed of the Existing Fan Rotor by Use or Modification of Fluid Drive / VFD / Gearbox / or Two Speed Motor

Retrofit of Existing I.D. Fan Rotor Assembly

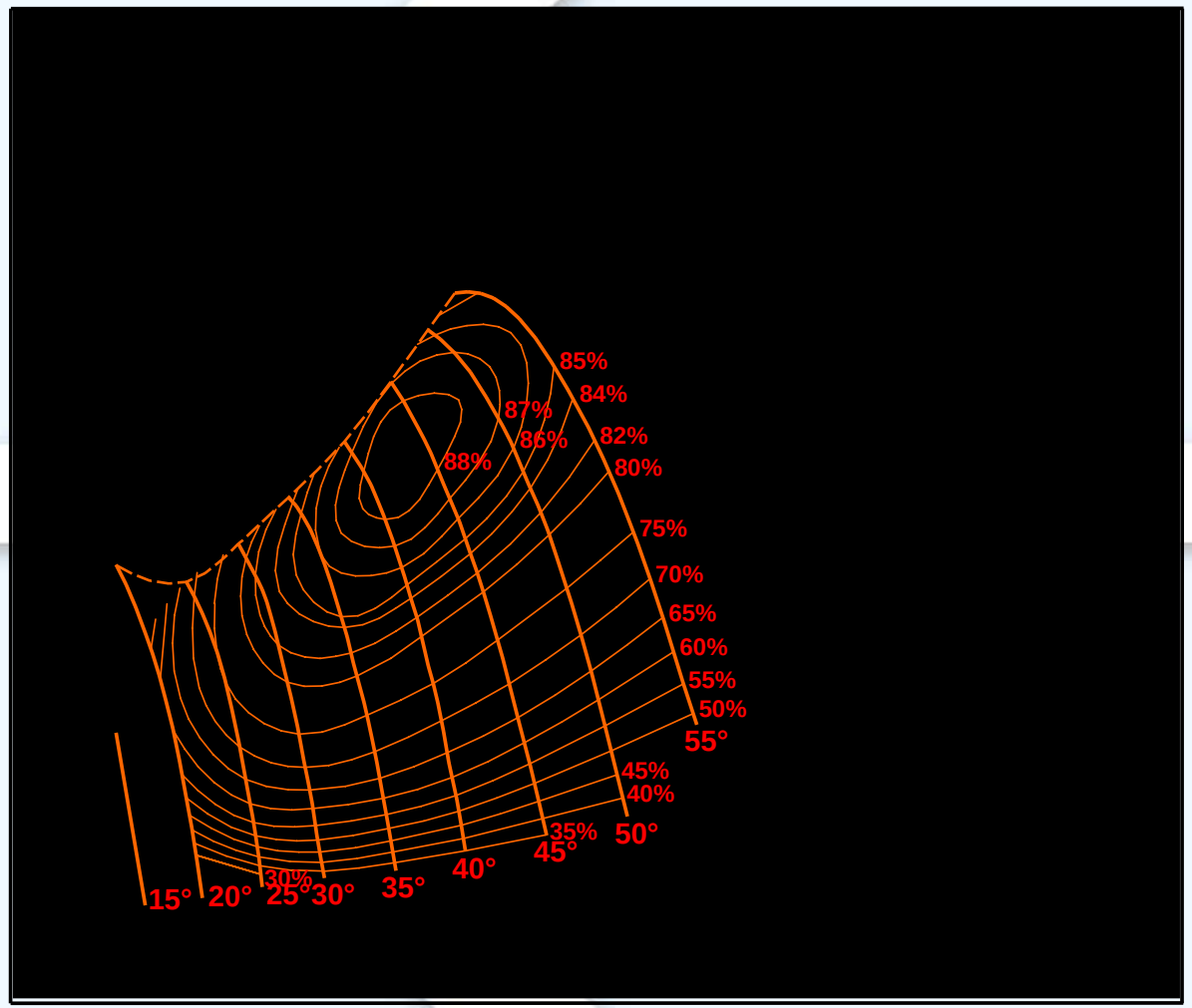


Speed Change

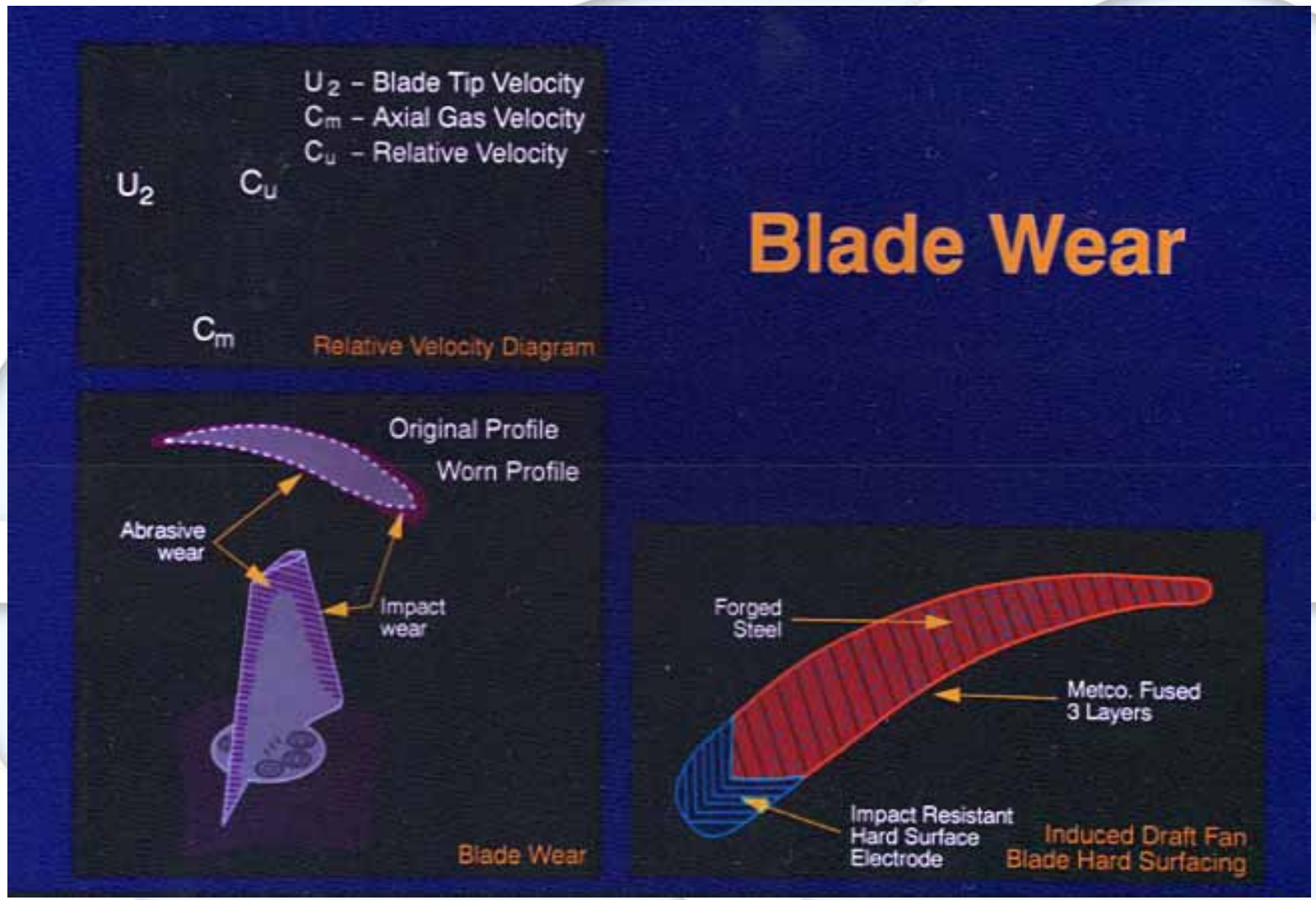
Fan Curve Showing Desired Increase

Research Result

During extensive research and development in our aerodynamic laboratory a high pressure profile has been developed giving up to 40% more volume flow and 30% more pressure



Retrofit of Existing I.D. Fan Rotor Assembly



Increase the Cord Length of Existing Blades on an Axial Fan

Consider different profile for added performance

Addition of Centrifugal I.D. Booster Fan

PREDICTED PERFORMANCE

TLT-BABCOCK NUMBER: speed
Fan Size: 14144 Z/2030
Speed (RPM): 540

CUSTOMER: speed increase
Cutwidth: 100. No. Inlets: 2
Flow Control Method: IVC

Load	1
Flow (ACFM)	580000.
Inlet Temp. (F)	310
Inlet Density (Lbs/Ft3)	0.0508
Inlet press. (“WG)	-6.00
Static Press. Rise (“WG)	6.00
Dynamic Press Incr. (“WG)	0.58
Inlet Box loss (“WG)	0.57
IVC loss (“WG)	0.21
Inlet Damper loss (‘WG)	0.00
Outlet Damper loss (“WG)	0.00
Inlet Silencer loss (“WG)	0.00
Out. Silencer loss 9”WG)	0.00
Evase loss (“WG)	0.10
Shaft loss (“WG)	0.16
Fan Total Pressure (“WG)	7.63
Fan Total Efficiency (%)	86.12
Shaft power (BHP)	802
Fan Speed (RPM)	540

Often Requires a Gearbox or Very Expensive Low Speed Motor

New I.D. Fan

Casing Splits
•Recommended on fans over 54” (1.4m) diameter for wheel removal and for shipment
•Splits flanged and bolted for wheel removal
•Shipping splits designed for field welding as standard

Flex Connections
•Recommended for use on ducted fans to reduce vibrations and to accommodate thermal expansion

Inlet Boxes
•Provided when requested
•Any air inlet angle

Centrifugal Wheel
•Six wheel types available
•Single or double inlet
•Diameter to 1800 (4.5m)

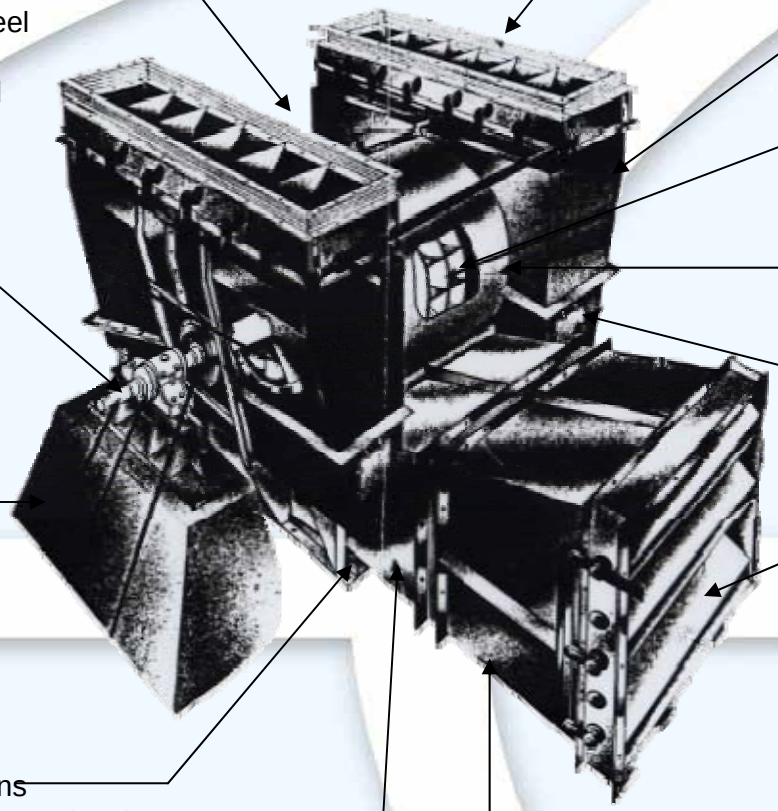
Drive Arrangements
•Direct coupled, V-bolt or variable speed drive
•Custom turning gear assemblies available for special applications

Fan Housing
•All welded construction
•Single and multi-stage designs

Access Doors
•Installed where required
•Bolted or hinged design

Bearing Pedestals
•Short pedestals for use on concrete sub-bases or full pedestals for flush mounting
•Isolated or integral designs available

Outlet Louver Dampers
•For discharge flow control and fan isolation
•Parallel bladed, zero leakage and high temperature designs available



Drain Connections
•Installed at lowest points in fan scroll and inlet boxes to allow drainage

Fan Discharge
•Any air discharge angle

Outlet Evase
•For lower air discharge velocities and improved static efficiency

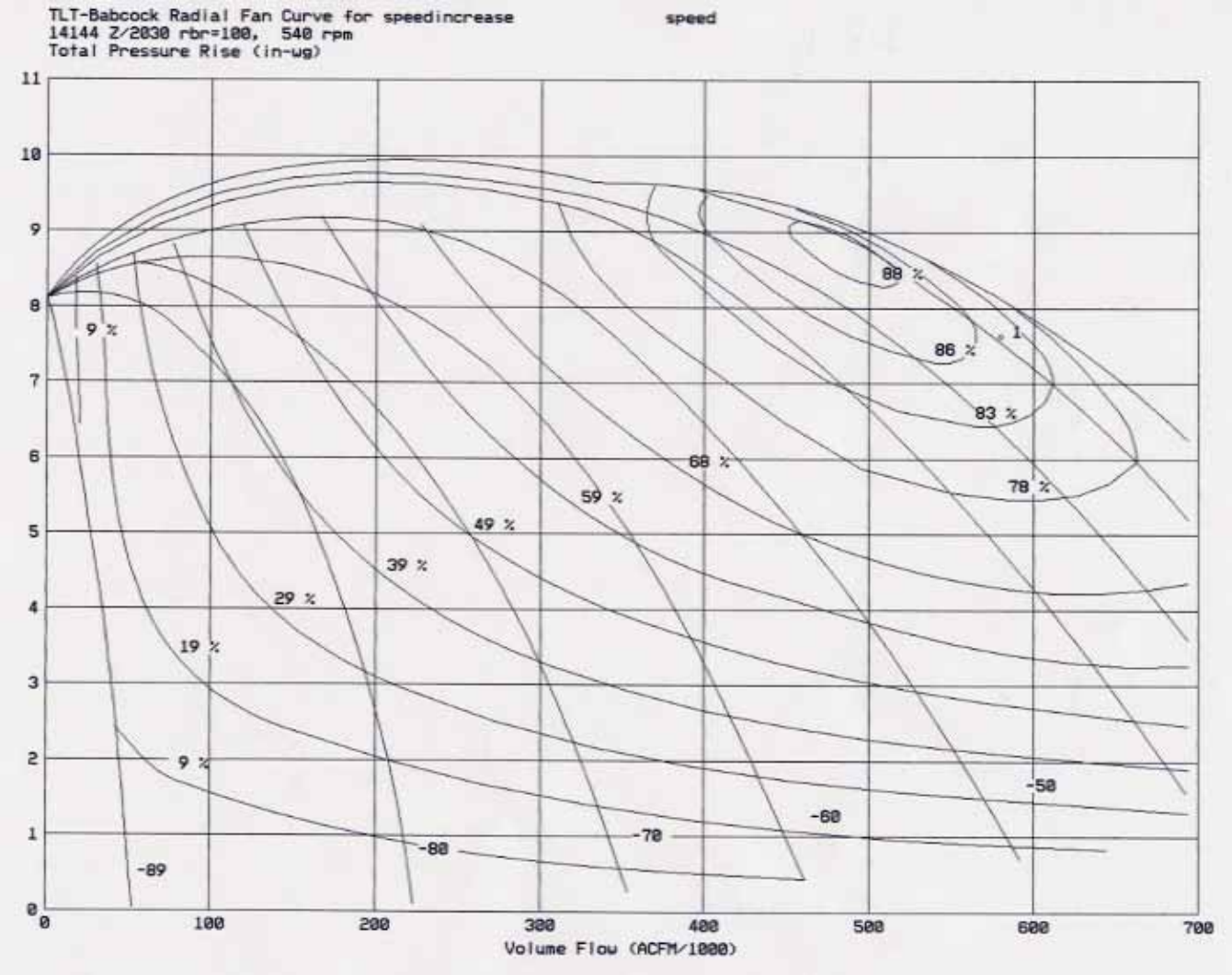
Reuse of Existing Foundation and or Other Auxiliaries Such as Dampers / Instrumentation / and Actuators.

New Foundations – Clean Sheet of Paper for Design

New fan on existing foundation

- Natural freq. concerns of foundation
- Stiffness testing / water problems investigation
- Tie in with existing duct /design
- Implosion concerns of existing components

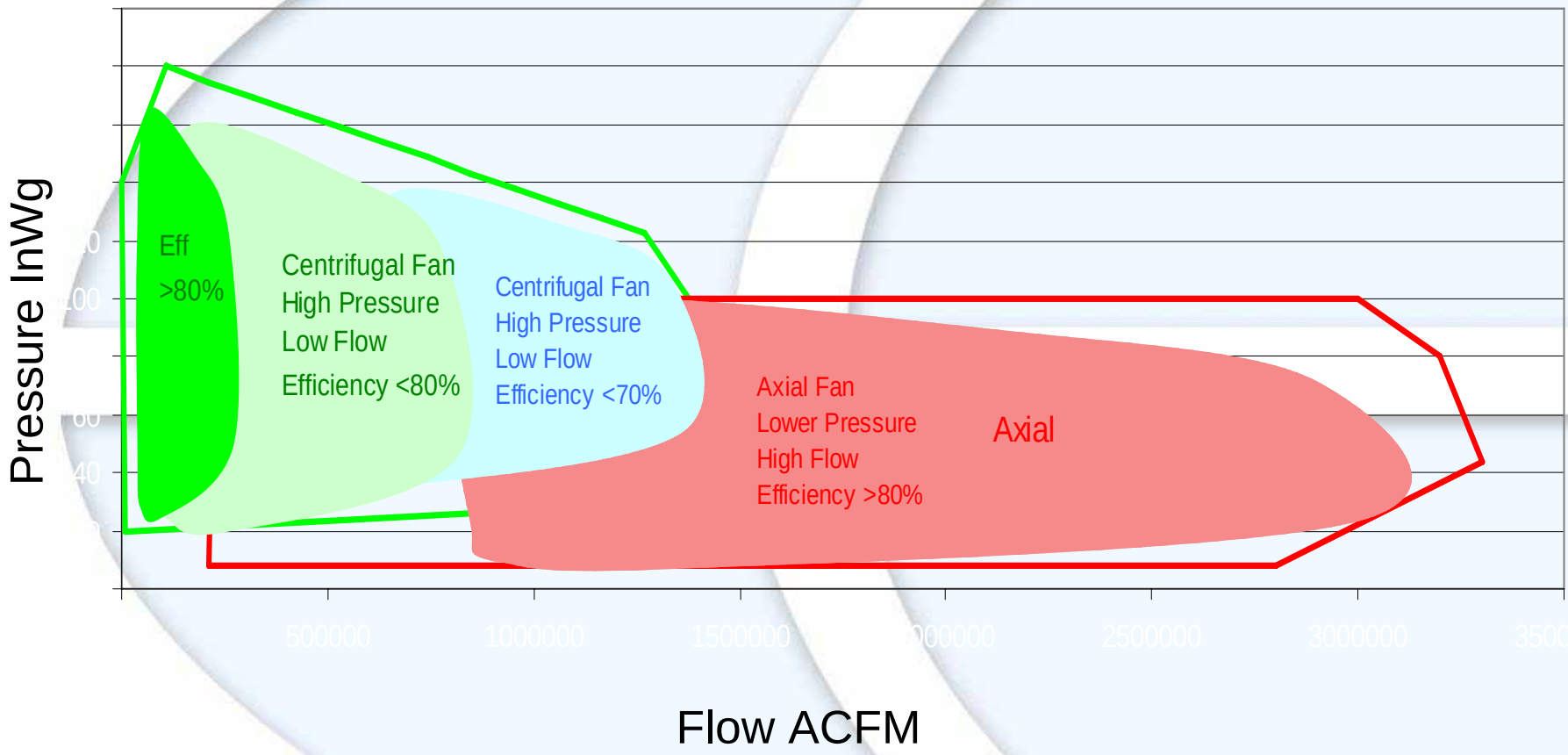
Addition of Axial I.D. Booster Fan



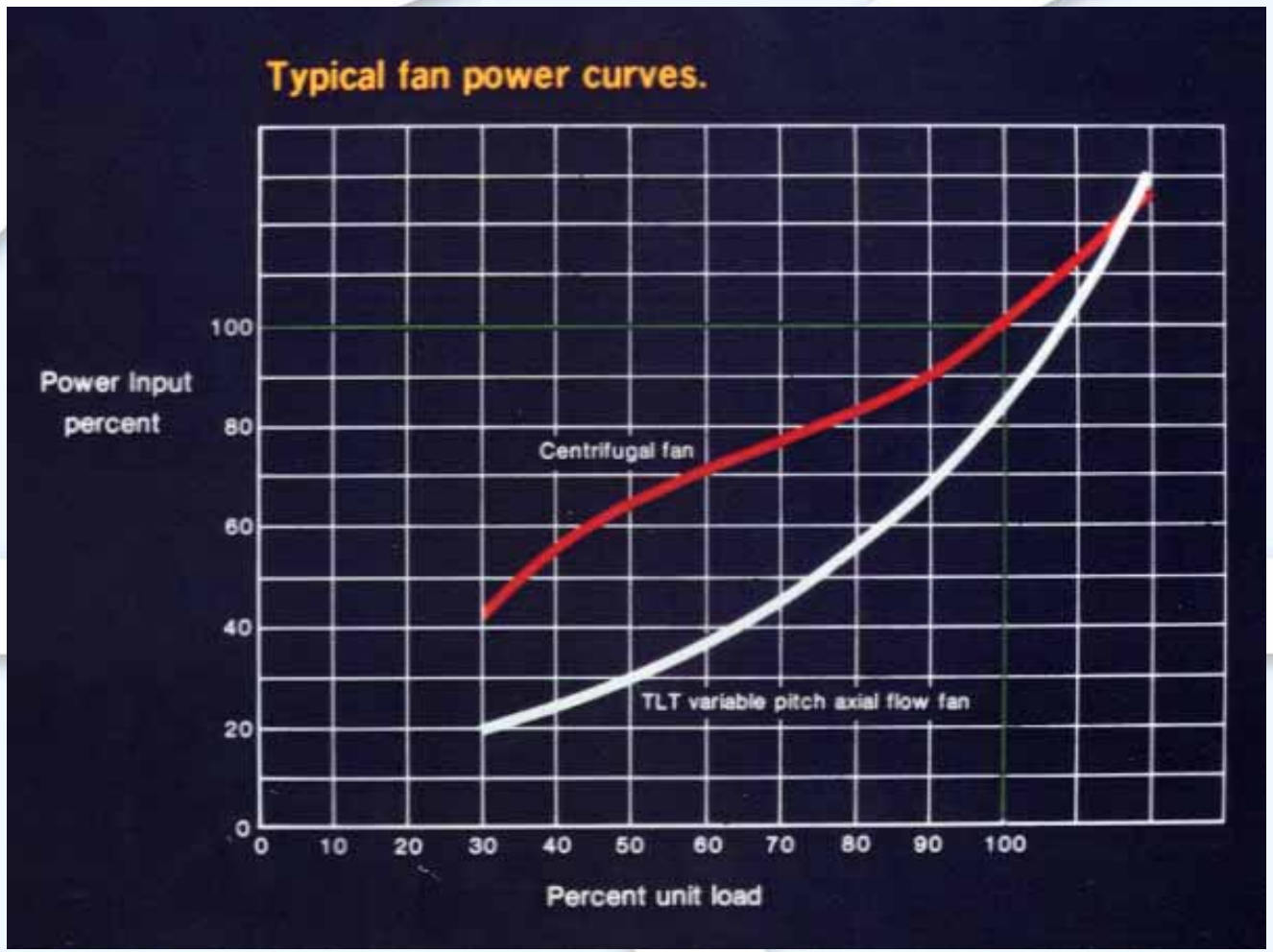
Low RPM Centrifugal Fan Booster

Fan Control Options and How They Evaluate

Comparison between Axial and Centrifugal fans



Axial vs. constant speed Centrifugal with vanes



Power Usage

variable pitch axial flow fan

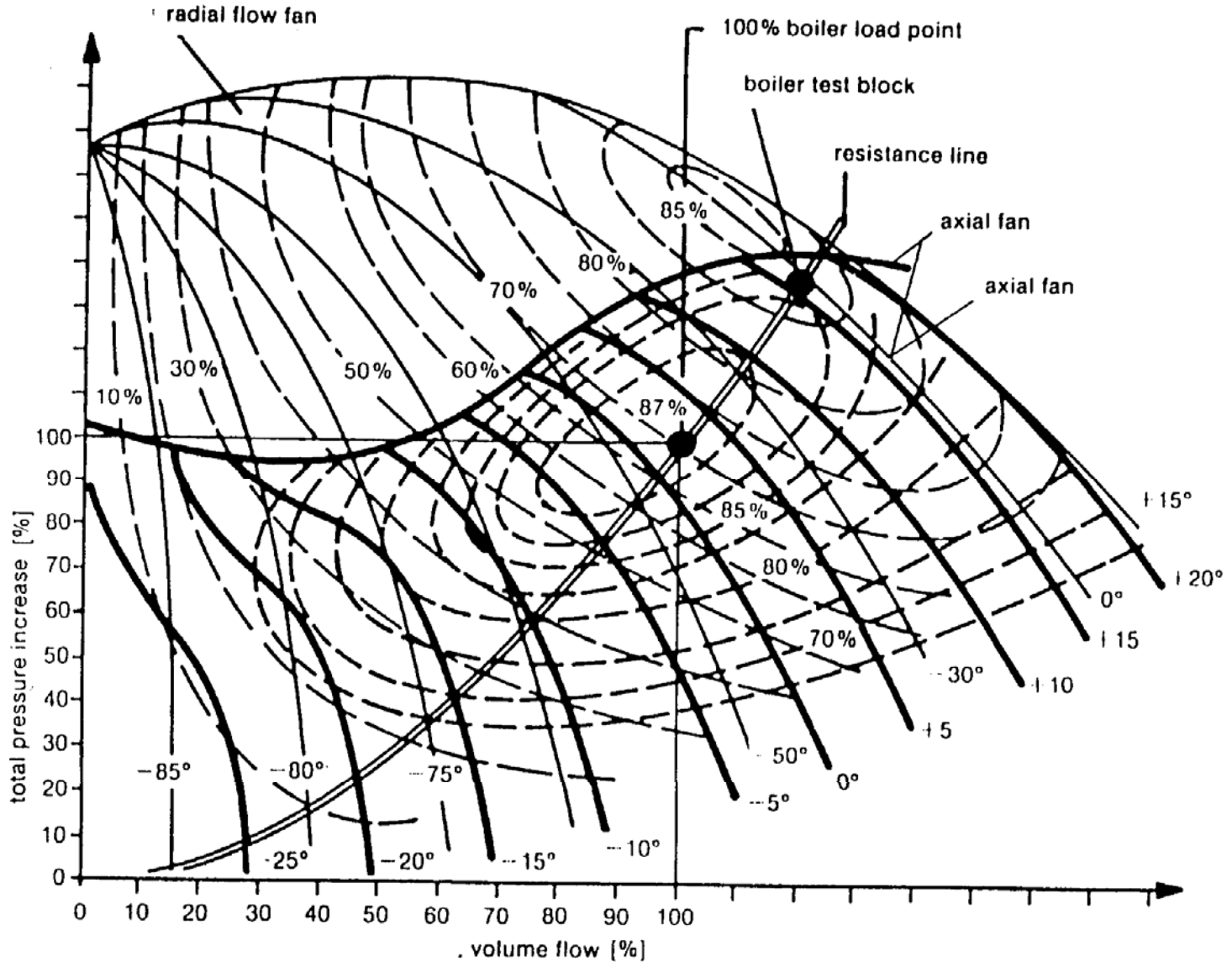


Fig. 2. Comparison between radial flow fan and axial flow fan characteristics.

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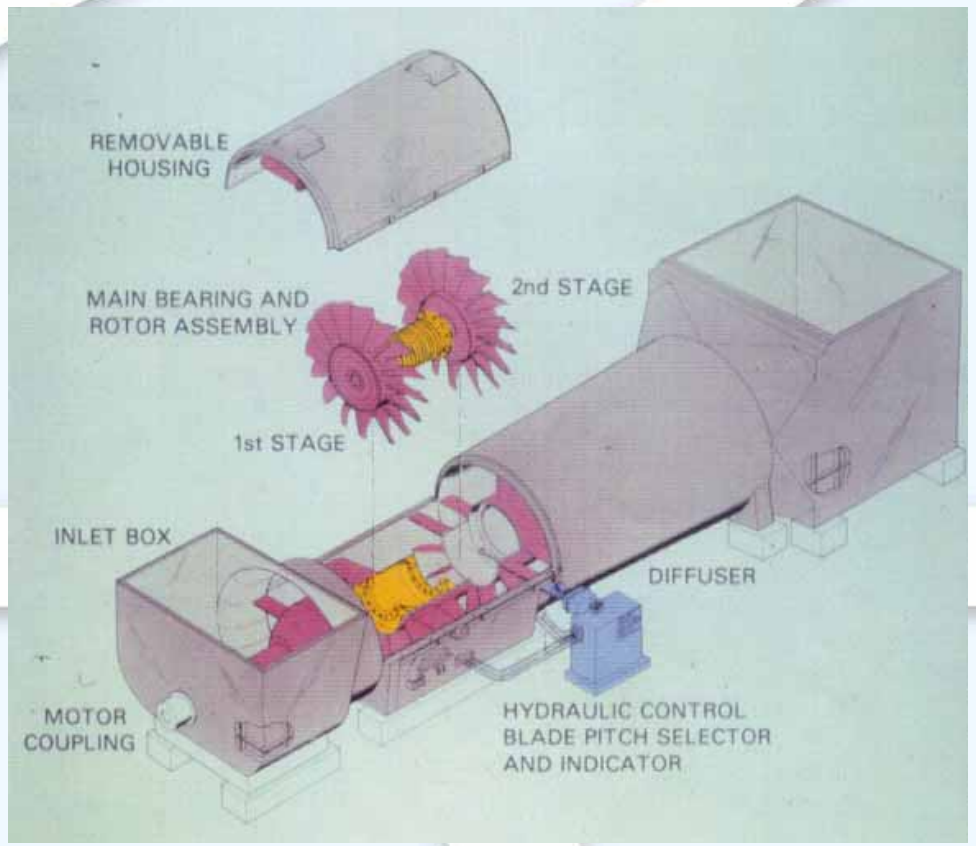
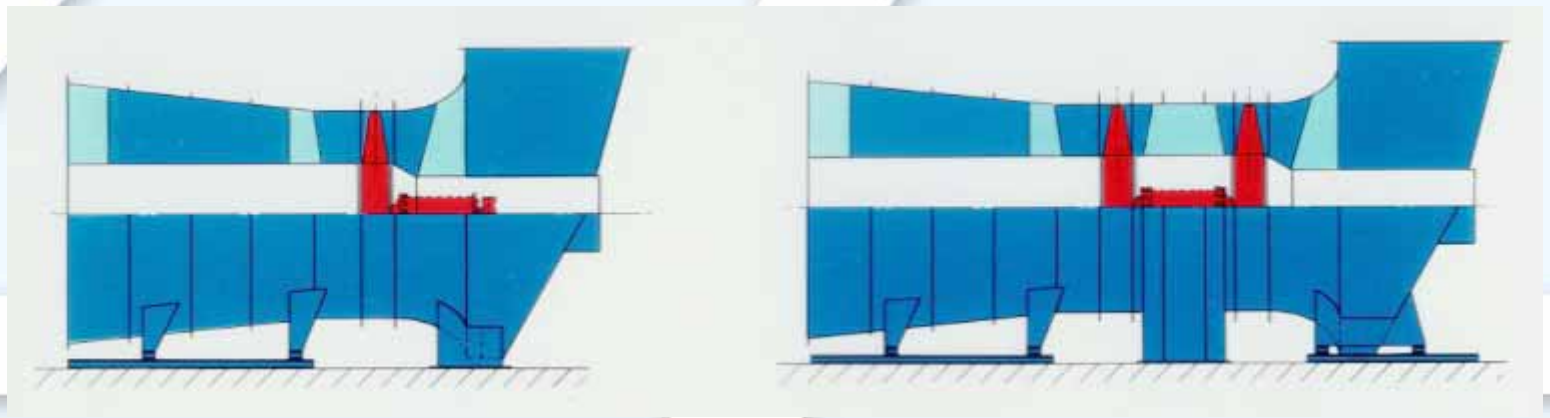
New Rotor Assembly in the Existing Fan Housing that May Need Minor Modification



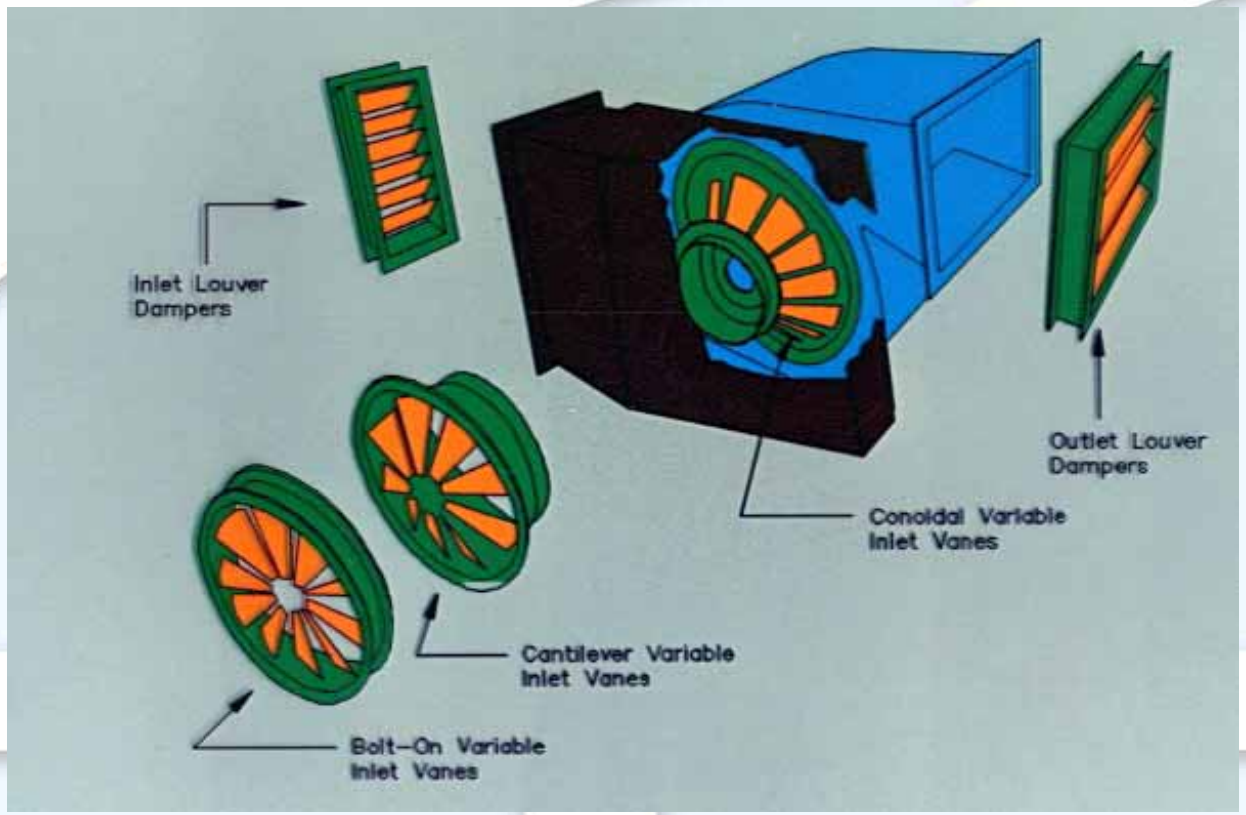
Additional Blades for an Axial fan / Re-use Inlet and Outlet Housings Only

For an Existing Axial I.D. Fan, often Requires a Single Stage Duplicate of Existing w/ Fewer Blades



Wet axial, vertical

Constant Speed Centrifugal Fans



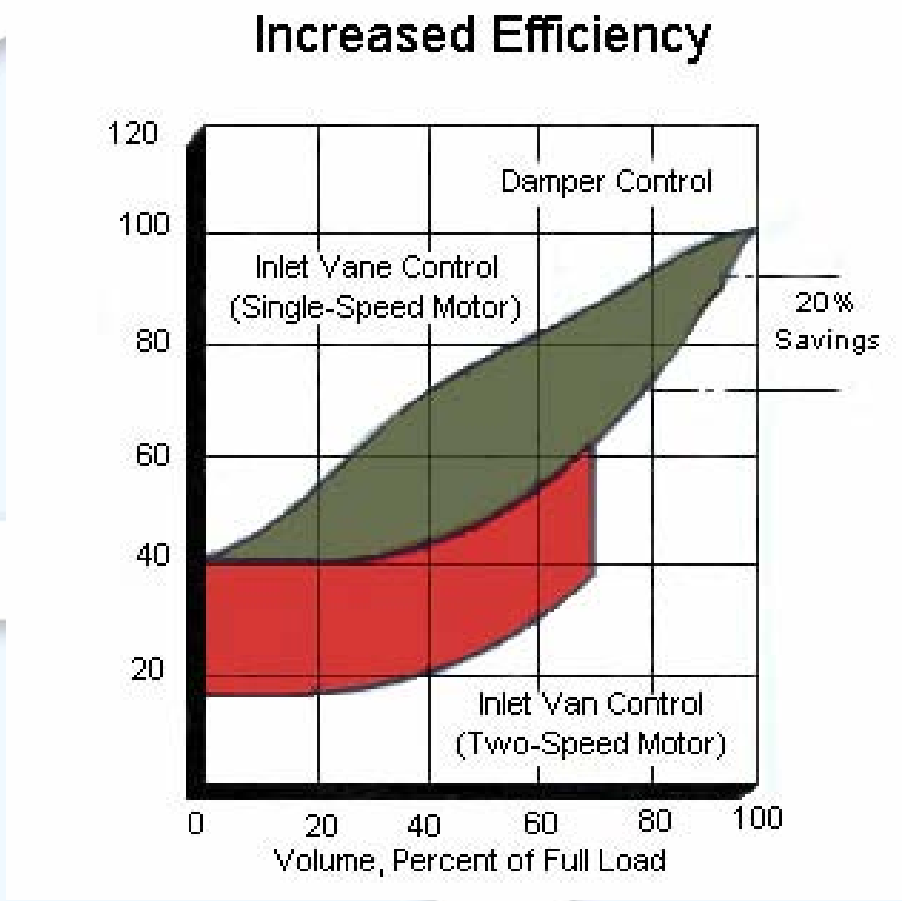
Types of Mechanical Control

Inlet Damper Control

Outlet Damper Control

Inlet Vane Control

Vane vs damper vs 2 speed w vanes Centrifugal Fans



Comparison

Power Usage Curve

2 Speed Fan Control w/ Inlet Vane Control

PREDICTED PERFORMANCE

TLT-BABCOCK NUMBER: speed
Fan Size: 1464 B/2467
Speed (RPM): 890

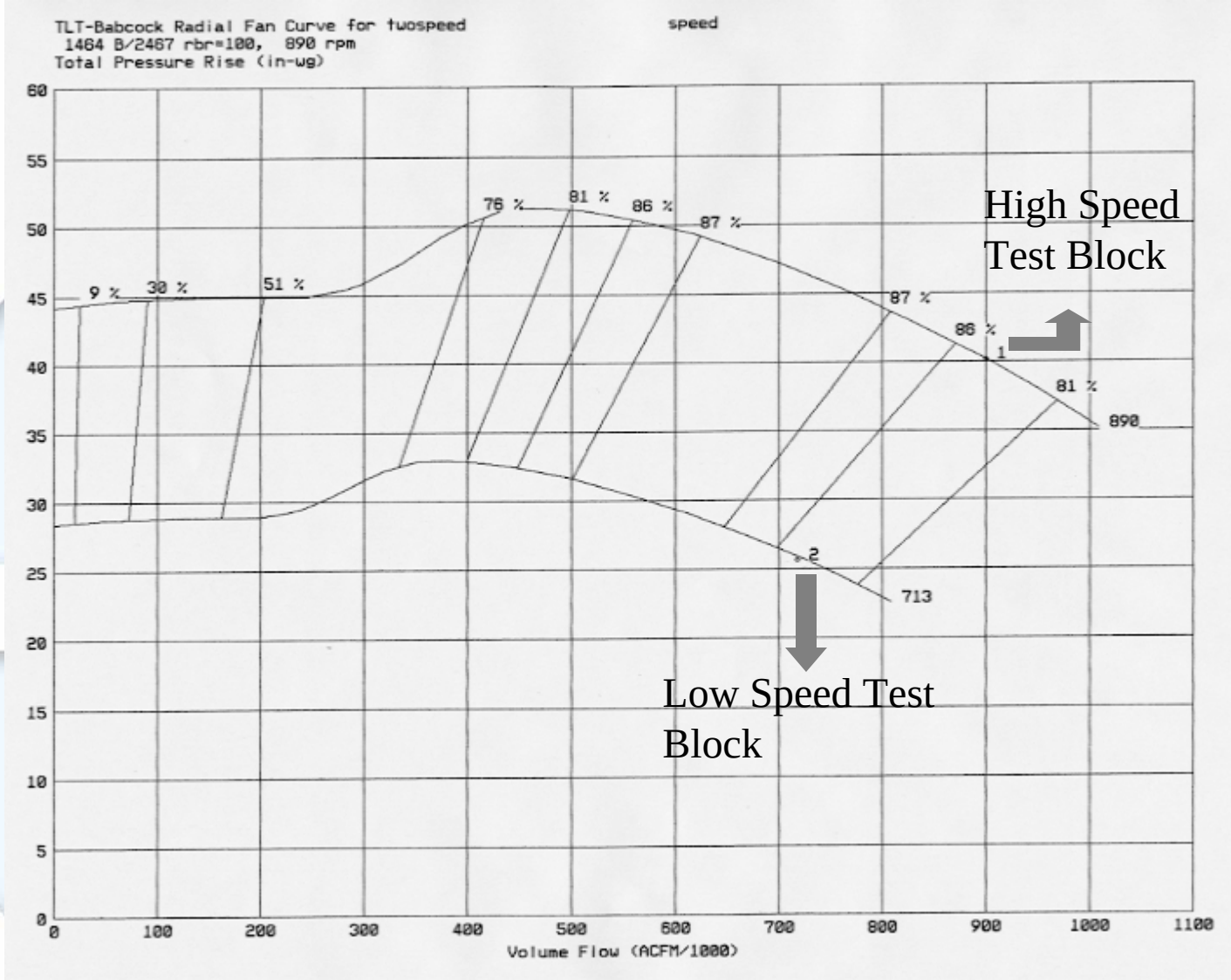
CUSTOMER: twospeed
Cutwidth: 100. No. Inlets: 1
Flow Control Method: SPEED

Load	1	2
Flow (ACFM)	900000.	717977.
Inlet Temp. (F)	310	310
Inlet Density (Lbs/Ft3)	0.0508	0.0507
Inlet press. (“WG)	-36.00	-22.91
Static Press. Rise (“WG)	36.00	22.91
Dynamic Press Incr. (“WG)	0.55	0.35
Inlet Box loss (“WG)	2.21	1.40
IVC loss (“WG)	0.40	0.26
Inlet Damper loss (‘WG)	0.00	0.00
Outlet Damper loss (“WG)	0.00	0.00
Inlet Silencer loss (“WG)	0.00	0.00
Out. Silencer loss 9”WG)	0.00	0.00
Evase loss (“WG)	0.53	0.34
Shaft loss (“WG)	0.47	0.30
Fan Total Pressure (“WG)	40.17	25.56
Fan Total Efficiency (%)	85.47	84.89
Shaft power (BHP)	6406	3320
Fan Speed (RPM)	890	714

High TB

Low TB

2 Speed Fan Control Initial Selection



2 Speed Fan Curve

2 Speed Fan Control w/ Inlet Vane Control

PREDICTED PERFORMANCE

TLT-BABCOCK NUMBER: speed
Fan Size: 1464 B/2467
Speed (RPM): 890

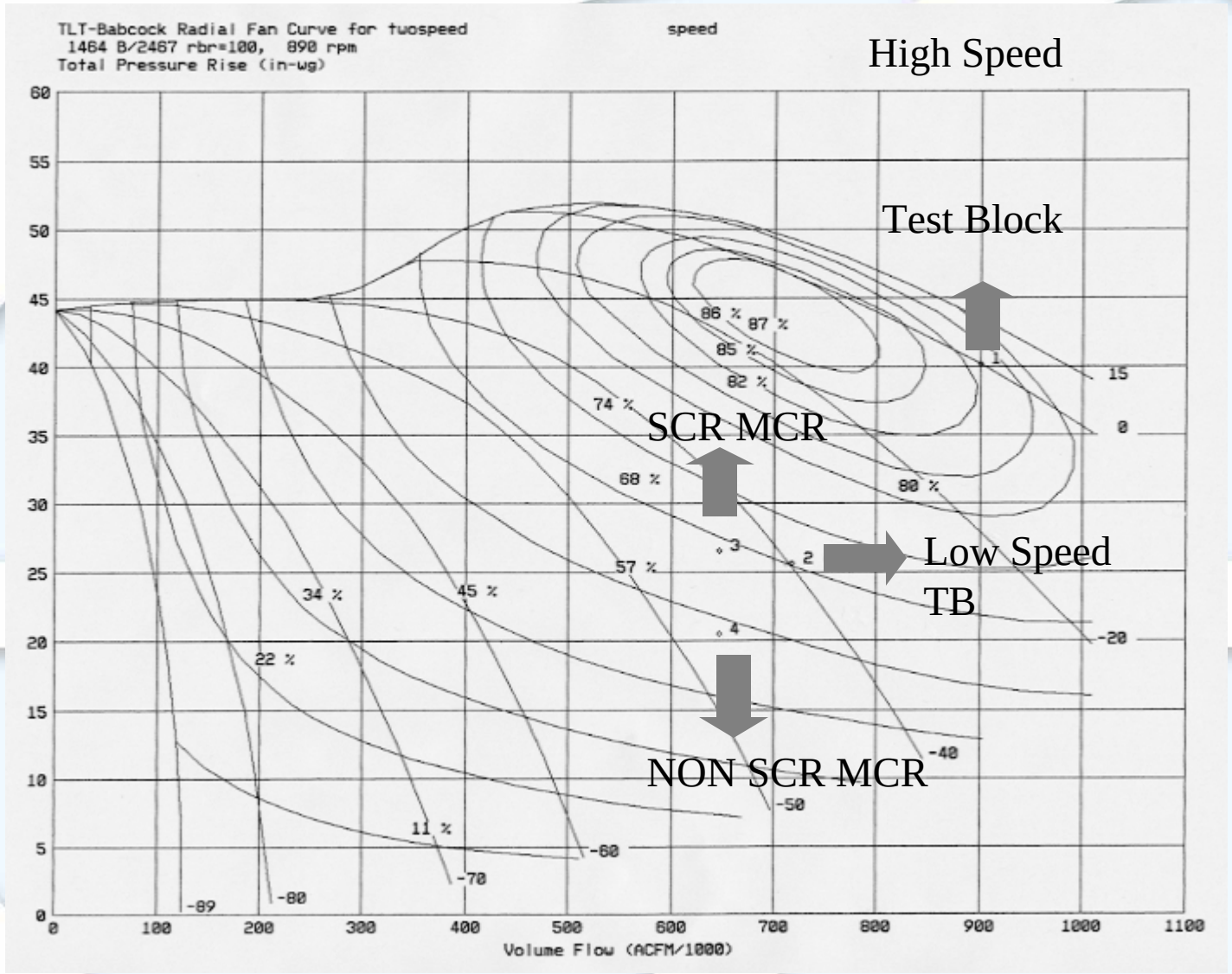
CUSTOMER: two speed
Cutwidth: 100. No. Inlets: 2
Flow Control Method: IVC

High Speed

Load	1	2	3	4
Flow (ACFM)	900000.	717977.	646179.	646179.
Inlet Temp. (F)	310	310	310	310
Inlet Density (Lbs/Ft3)	0.0508	0.0507	0.0507	0.0507
Inlet press. (“WG)	-36.00	-22.91	-24.33	-18.33
Static Press. Rise (“WG)	36.00	22.91	24.33	18.33
Dynamic Press Incr. (“WG)	0.55	0.35	0.28	0.28
Inlet Box loss (“WG)	2.21	1.40	1.14	1.14
IVC loss (“WG)	0.40	0.26	0.21	0.21
Inlet Damper loss (‘WG)	0.00	0.00	0.00	0.00
Outlet Damper loss (“WG)	0.00	0.00	0.00	0.00
Inlet Silencer loss (“WG)	0.00	0.00	0.00	0.00
Out. Silencer loss 9”WG)	0.00	0.00	0.00	0.00
Evase loss (“WG)	0.53	0.34	0.27	0.27
Shaft loss (“WG)	0.47	0.30	0.24	0.24
Fan Total Pressure (“WG)	40.17	25.56	26.48	20.48
Fan Total Efficiency (%)	85.47	69.70	67.41	55.53
Shaft power (BHP)	6406	4044	3895	3676
Fan Speed (RPM)	890	890	890	890

HIGH TB | LOW SPEED TB | SCR MCR | MCR NON SCR

2 Speed Fan Control w/ Inlet Vane Control



High Speed Fan Curve

2 Speed Fan Control w/ Inlet Vane Control

PREDICTED PERFORMANCE

TLT-BABCOCK NUMBER: speed
Fan Size: 1464 B/2467
Speed (RPM): 714

CUSTOMER: two speed
Cutwidth: 100. No. Inlets: 2
Flow Control Method: IVC

Low Speed

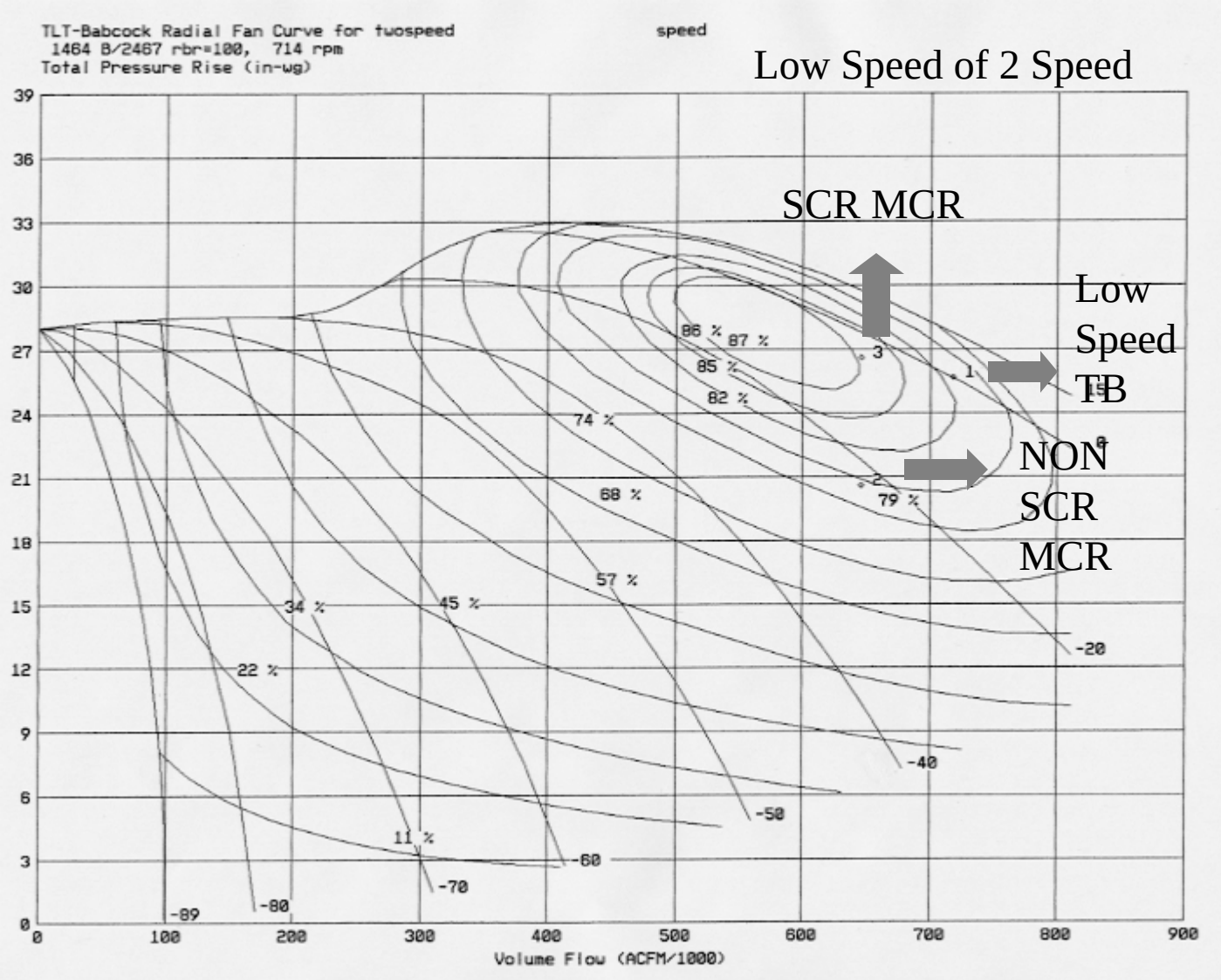
Load	1	2	3
Flow (ACFM)	717977.	646179.	646179.
Inlet Temp. (F)	310	310	310
Inlet Density (Lbs/Ft3)	0.0508	0.0507	0.0507
Inlet press. (“WG)	-22.91	-18.33	-24.33
Static Press. Rise (“WG)	22.91	18.33	24.33
Dynamic Press Incr. (“WG)	0.57	0.46	0.46
Inlet Box loss (“WG)	1.41	1.14	1.14
IVC loss (“WG)	0.25	0.20	0.20
Inlet Damper loss (‘WG)	0.00	0.00	0.00
Outlet Damper loss (“WG)	0.00	0.00	0.00
Inlet Silencer loss (“WG)	0.00	0.00	0.00
Out. Silencer loss 9”WG)	0.00	0.00	0.00
Evase loss (“WG)	0.32	0.26	0.26
Shaft loss (“WG)	0.22	0.17	0.17
Fan Total Pressure (“WG)	25.67	20.56	26.56
Fan Total Efficiency (%)	85.38	82.19	0.01
Shaft power (BHP)	3315	2494	Ø 2650
Fan Speed (RPM)	714	714	714

(Estimated)

Not Controllable

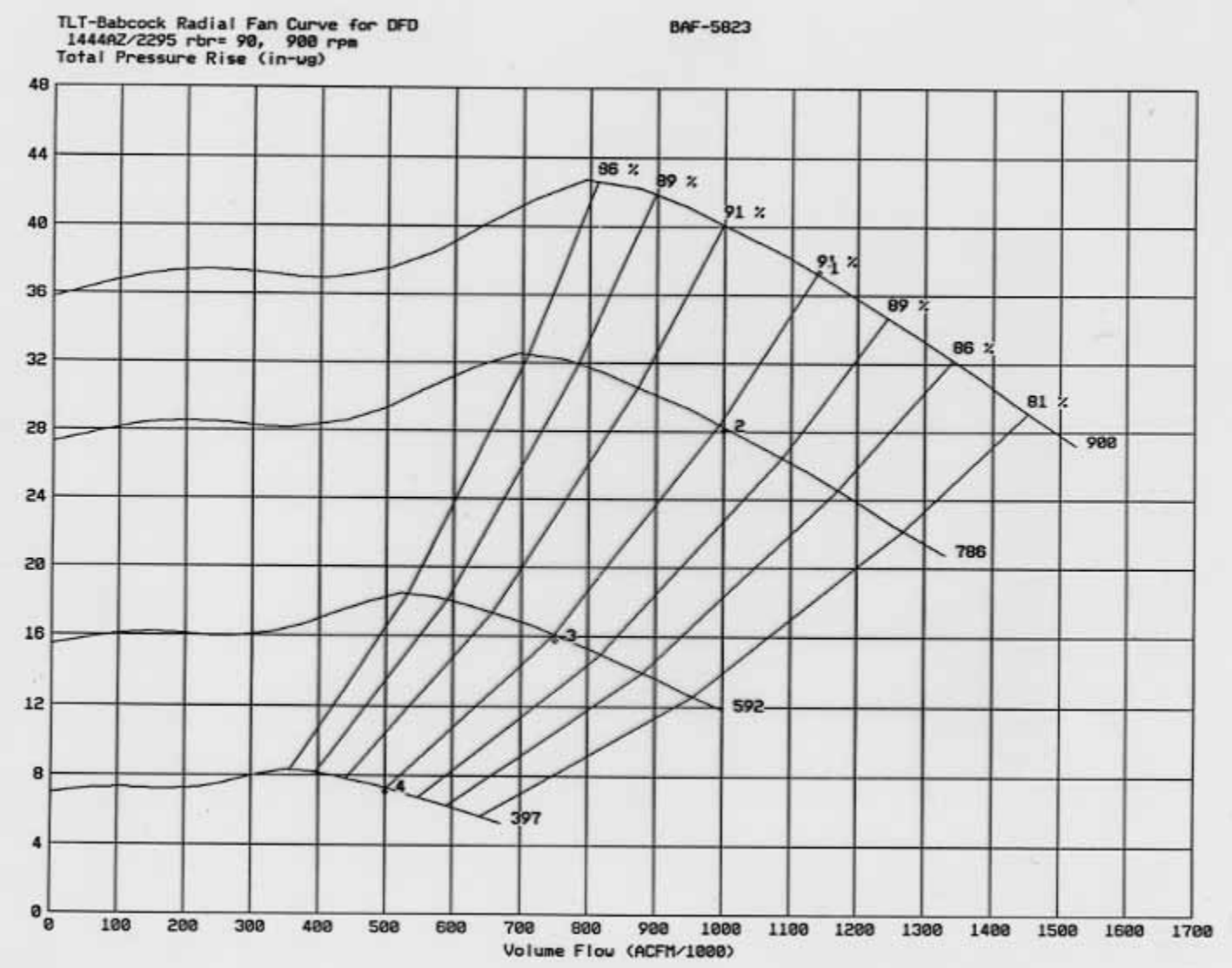
MCR NON SCR

2 Speed Fan Control w/ Inlet Vane Control



Low Speed Fan Curve

Variable Speed Control



Fan Curve