Avoiding Impacts of System Design and Fan Accessories on Fan Performance

Geoff Sheard, DSc, AGS Consulting LLC

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- You must be present for the entire session and complete a post-course online evaluation.
- Credit cannot be issued to anyone who does not complete the evaluation.
- A link to the evaluation will be provided at the end of the session and e-mailed in the weeks following the 2024 AHR Expo.

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Attendance for the entire presentation
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Dr. Geoff Sheard

Consultant, AMCA Member Company

- Over 40 years experience in the aerodynamic and mechanical design of rotating equipment
- International expert in fan technology and development of high efficiency fans for commercial and industrial application
- Holds a BEng in mechanical engineering, a DPhil in aerodynamics plus a DSc awarded for the application of aerospace design techniques in commercial and industrial fan design.
- Past President of AMCA and Chairman of the FAN 2012, 2015, 2018, 2022 & Fan 2025 conference organizing committee.

Purpose and Learning Objectives

The purpose of this presentation is to give you an insight into how fan performance is derived and how fan accessories and the system into which they are fitted diminish fan performance.

At the end of this presentation, you will:

1. Be aware of forthcoming regulation that will likely impact system design and fan accessories in the future.
2. Understand the derivation of fan performance and the factors that can diminish it, particularly the influence of fan accessories and the systems within which they are integrated.
3. Have a clear understanding of fan accessories and system design features, based on AMCA Publication 201, and the impact they have on a fans performance characteristic.
4. Have an insight into the impact of accessories and system design features on fan power consumption.
5. Be able to apply practical strategies for avoiding losses due to accessories and system design features, minimizing power consumption, and therefore the system operating cost.

Agenda

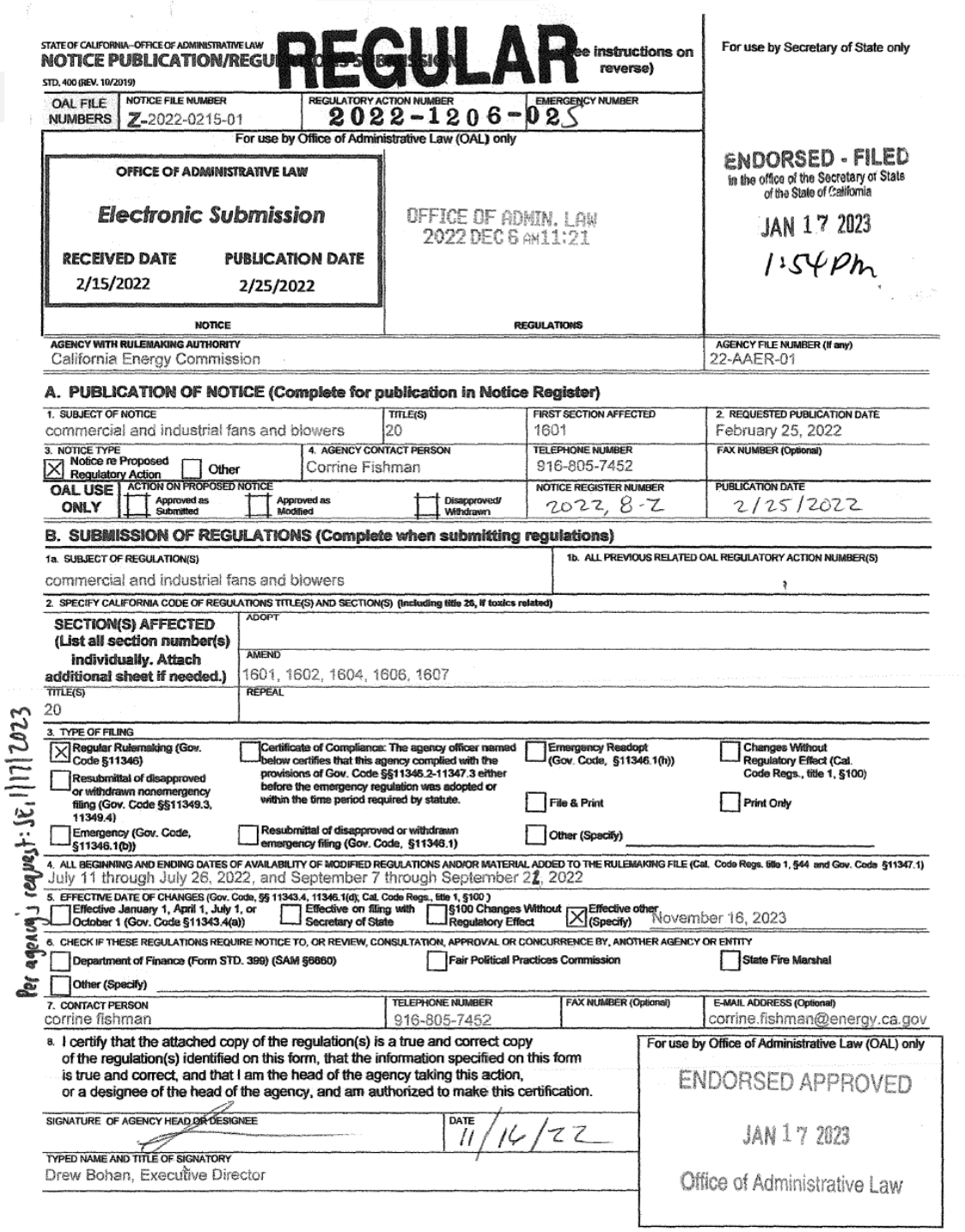
- Regulation of the Air Movement Fan Industry
- System Effect
- Fan Accessories
- Troubleshooting in the Field
- Summary and Conclusions

Regulation

- Air movement fan industry is being regulated in the USA.
- Regulation is specifically aimed at regulating inefficient fans off the market.
- The objective of regulating inefficient fans off the market is to reduce the energy consumed by air movement fans.
- Experience in Europe is that minimum allowable efficiency levels are periodically increased, in an ongoing quest to reduce the energy consumed by air movement fans.

Regulation

- On January 17, 2023, the state of California announced its intension to regulate air movement fans.
- The regulation mandated minimum fan efficiency levels fans sold into California must meet if sold into California after November 16, 2023.



STATE OF CALIFORNIA–OFFICE OF ADMINISTRATIVE LAW
NOTICE PUBLICATION/REGULATIONS SUBMISSION — REGULAR — (See instructions on reverse)
For use by Secretary of State only
STD. 400 (REV. 10/2019)

OAL FILE NUMBERS: NOTICE FILE NUMBER Z-2022-0215-01; REGULATORY ACTION NUMBER 2022-1206-02S; EMERGENCY NUMBER

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OFFICE OF ADMINISTRATIVE LAW
Electronic Submission
RECEIVED DATE 2/15/2022
PUBLICATION DATE 2/25/2022
NOTICE

OFFICE OF ADMIN. LAW
2022 DEC 6 AM 11:21
REGULATIONS

ENDORSED - FILED
In the office of the Secretary of State of the State of California
JAN 17 2023
1:54 PM

AGENCY WITH RULEMAKING AUTHORITY: California Energy Commission
AGENCY FILE NUMBER (If any): 22-AAER-01

A. PUBLICATION OF NOTICE (Complete for publication in Notice Register)

1. SUBJECT OF NOTICE: commercial and industrial fans and blowers
TITLE(S): 20
FIRST SECTION AFFECTED: 1601
2. REQUESTED PUBLICATION DATE: February 25, 2022
3. NOTICE TYPE: [X] Notice re Proposed Regulatory Action [ ] Other
4. AGENCY CONTACT PERSON: Corrine Fishman
TELEPHONE NUMBER: 916-805-7452
FAX NUMBER (Optional):
OAL USE ONLY — ACTION ON PROPOSED NOTICE: [ ] Approved as Submitted [ ] Approved as Modified [ ] Disapproved/ Withdrawn
NOTICE REGISTER NUMBER: 2022, 8-Z
PUBLICATION DATE: 2/25/2022

B. SUBMISSION OF REGULATIONS (Complete when submitting regulations)

1a. SUBJECT OF REGULATION(S): commercial and industrial fans and blowers
1b. ALL PREVIOUS RELATED OAL REGULATORY ACTION NUMBER(S):
2. SPECIFY CALIFORNIA CODE OF REGULATIONS TITLE(S) AND SECTION(S) (Including title 26, if toxics related)
SECTION(S) AFFECTED (List all section number(s) individually. Attach additional sheet if needed.)
TITLE(S): 20
ADOPT:
AMEND: 1601, 1602, 1604, 1606, 1607
REPEAL:
3. TYPE OF FILING
[X] Regular Rulemaking (Gov. Code §11346)
[ ] Certificate of Compliance: The agency officer named below certifies that this agency complied with the provisions of Gov. Code §§11346.2-11347.3 either before the emergency regulation was adopted or within the time period required by statute.
[ ] Emergency Readopt (Gov. Code, §11346.1(h))
[ ] Changes Without Regulatory Effect (Cal. Code Regs., title 1, §100)
[ ] Resubmittal of disapproved or withdrawn nonemergency filing (Gov. Code §§11349.3, 11349.4)
[ ] File & Print
[ ] Print Only
[ ] Emergency (Gov. Code, §11346.1(b))
[ ] Resubmittal of disapproved or withdrawn emergency filing (Gov. Code, §11346.1)
[ ] Other (Specify)
Per agency's request: 1/17/2023
4. ALL BEGINNING AND ENDING DATES OF AVAILABILITY OF MODIFIED REGULATIONS AND/OR MATERIAL ADDED TO THE RULEMAKING FILE (Cal. Code Regs. title 1, §44 and Gov. Code §11347.1)
July 11 through July 26, 2022, and September 7 through September 22, 2022
5. EFFECTIVE DATE OF CHANGES (Gov. Code, §§ 11343.4, 11346.1(d); Cal. Code Regs., title 1, §100)
[ ] Effective January 1, April 1, July 1, or October 1 (Gov. Code §11343.4(a))
[ ] Effective on filing with Secretary of State
[ ] §100 Changes Without Regulatory Effect
[X] Effective other (Specify) November 16, 2023
6. CHECK IF THESE REGULATIONS REQUIRE NOTICE TO, OR REVIEW, CONSULTATION, APPROVAL OR CONCURRENCE BY, ANOTHER AGENCY OR ENTITY
[ ] Department of Finance (Form STD. 399) (SAM §6660)
[ ] Fair Political Practices Commission
[ ] State Fire Marshal
[ ] Other (Specify)
7. CONTACT PERSON: corrine fishman
TELEPHONE NUMBER: 916-805-7452
FAX NUMBER (Optional):
E-MAIL ADDRESS (Optional): corrine.fishman@energy.ca.gov
8. I certify that the attached copy of the regulation(s) is a true and correct copy of the regulation(s) identified on this form, that the information specified on this form is true and correct, and that I am the head of the agency taking this action, or a designee of the head of the agency, and am authorized to make this certification.
SIGNATURE OF AGENCY HEAD OR DESIGNEE
DATE: 11/16/22
TYPED NAME AND TITLE OF SIGNATORY: Drew Bohan, Executive Director

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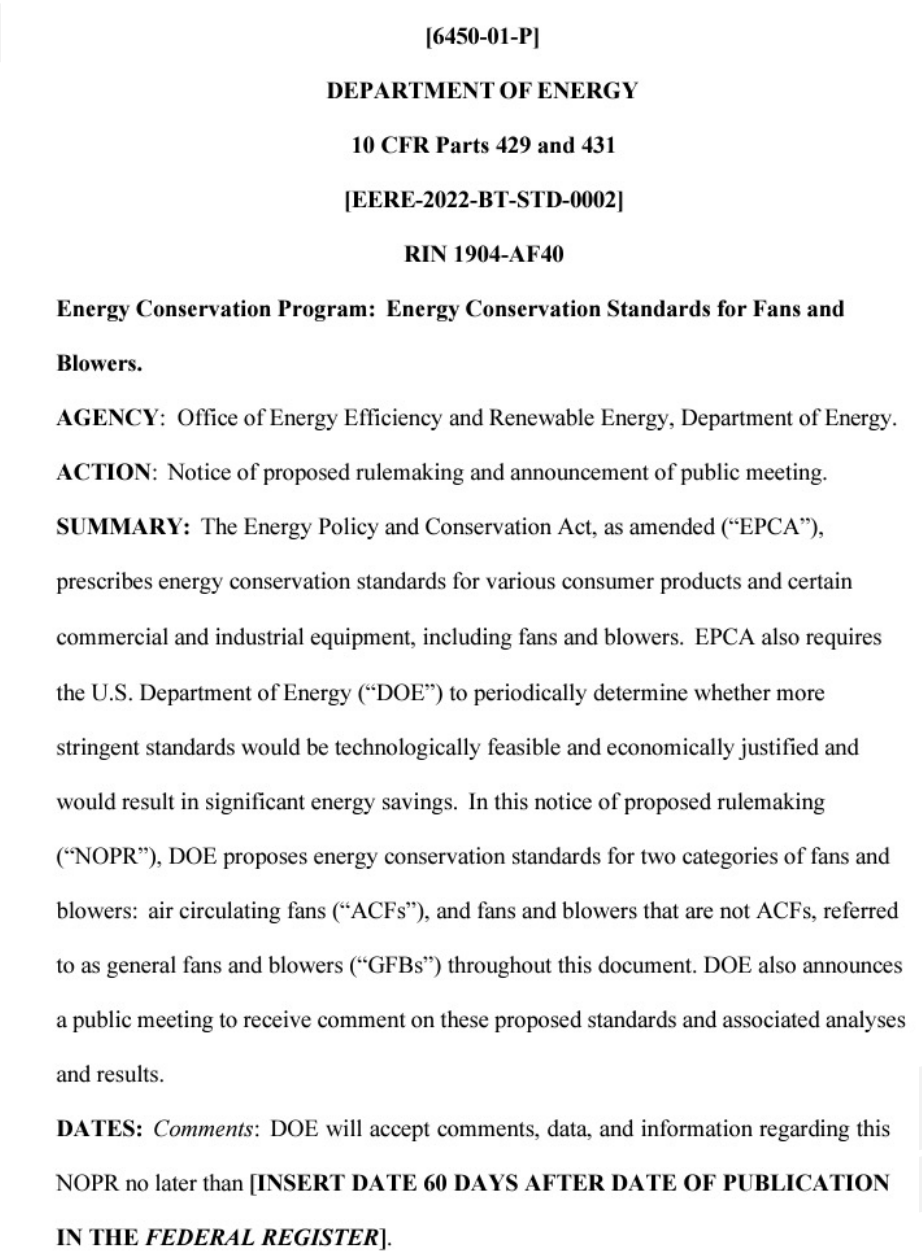
ENDORSED APPROVED
JAN 17 2023
Office of Administrative Law

Regulation

- The U.S. Department of Energy (DOE) has issued a pre-publication Federal Register notice of proposed rulemaking (NOPR) pertaining to energy conservation standards for fans and blowers.
- The Energy Policy and Conservation Act (EPCA) requires DOE to periodically determine whether more stringent standards would be technologically feasible and economically justified and would result in significant energy savings.
- In this NOPR, DOE proposes standards for two categories of fans and blowers: air circulating fans (ACFs), and fans and blowers that are not ACFs, referred to as general fans and blowers (GFBs) throughout the NOPR.



[6450-01-P]

DEPARTMENT OF ENERGY

10 CFR Parts 429 and 431

[EERE-2022-BT-STD-0002]

RIN 1904-AF40

Energy Conservation Program: Energy Conservation Standards for Fans and Blowers.

AGENCY: Office of Energy Efficiency and Renewable Energy, Department of Energy.

ACTION: Notice of proposed rulemaking and announcement of public meeting.

SUMMARY: The Energy Policy and Conservation Act, as amended ("EPCA"), prescribes energy conservation standards for various consumer products and certain commercial and industrial equipment, including fans and blowers. EPCA also requires the U.S. Department of Energy ("DOE") to periodically determine whether more stringent standards would be technologically feasible and economically justified and would result in significant energy savings. In this notice of proposed rulemaking ("NOPR"), DOE proposes energy conservation standards for two categories of fans and blowers: air circulating fans ("ACFs"), and fans and blowers that are not ACFs, referred to as general fans and blowers ("GFBs") throughout this document. DOE also announces a public meeting to receive comment on these proposed standards and associated analyses and results.

DATES: *Comments*: DOE will accept comments, data, and information regarding this NOPR no later than **[INSERT DATE 60 DAYS AFTER DATE OF PUBLICATION IN THE *FEDERAL REGISTER*]**.

1

Regulation

- The DOE NOPR was issued on December 29, 2023.
- The NOPR is 471 pages long, and its content is still being studied.
- However, fan efficiency targets are aggressive, and will drive a significant proportion of fans currently sold off the market.
- This indicates the importance the DOE place on energy efficiency.

Table 1 to § 431.175 - Energy Conservation Standards for Fans and Blowers Other than Air Circulating Fans

Equipment Class	With or Without Motor Controller	Fan Energy Index (FEI)*
Axial Inline	Without	1.18 * A
Axial Panel	Without	1.48 * A
Axial Power Roof Ventilator	Without	0.85 * A
Centrifugal Housed	Without	1.31 * A
Centrifugal Unhoused	Without	1.35 * A
Centrifugal Inline	Without	1.28 * A
Radial Housed	Without	1.17 * A
Centrifugal Power Roof Ventilator - Exhaust	Without	1.00 * A
Centrifugal Power Roof Ventilator - Supply	Without	1.19 * A
Axial Inline	With	1.18 * A* B
Axial Panel	With	1.48 * A* B
Axial Power Roof Ventilator	With	0.85 * A* B
Centrifugal Housed	With	1.31 * A* B
Centrifugal Unhoused	With	1.35 * A* B
Centrifugal Inline	With	1.28 * A* B
Radial Housed	With	1.17 * A* B
Centrifugal Power Roof Ventilator - Exhaust	With	1.00 * A* B
Centrifugal Power Roof Ventilator - Supply	With	1.19 * A* B

*A is a constant representing an adjustment in FEI for motor hp, which can be found in table 2 of this section. B is a constant representing an adjustment in FEI for motor controllers, which can be found in table 2 of this section.

Regulation

- The impact of regulation on the air movement fan industry is still being evaluated.
- It is likely that some fans sold today will be replaced by larger and lower speed fans that are more efficient and meet required efficiency targets.
- It is also likely that some types of fans applied into some applications will be regulated off the market, being replaced by other more efficient types off fans.
- As the size and type of fan used changes, there is a consequential impact on the system into which it is applied and the accessories used.
- As the impact of regulation on the fan industry is evaluated, the implications for system design and fan accessories will clarify.

Agenda

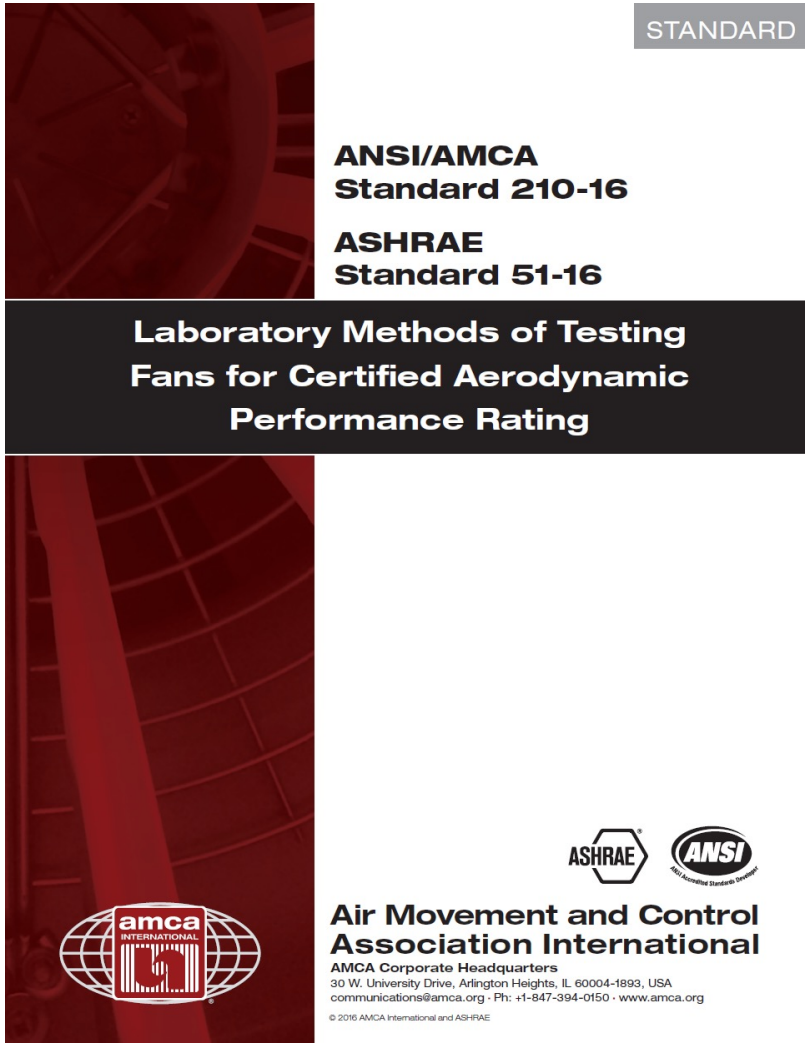
- Regulation of the Air Movement Fan Industry
- System Effect
- Fan Accessories
- Troubleshooting in the Field
- Summary and Conclusions

System Effect

- Before discussing system effect, we must consider how fan performance is measured without the system within which it is embedded impacting its performance.
- The fan community has collaborated with both Air Movement and Control Association (AMCA) and the International Organization for Standardization (ISO) to write standards defining how a fan should be laboratory tested.
- These standards define best practices when testing different types of fans in a laboratory.
- The standards are intended to ensure that fan performance measured in different laboratories is comparable such that fans from different manufactures can be compared on a like for like basis.

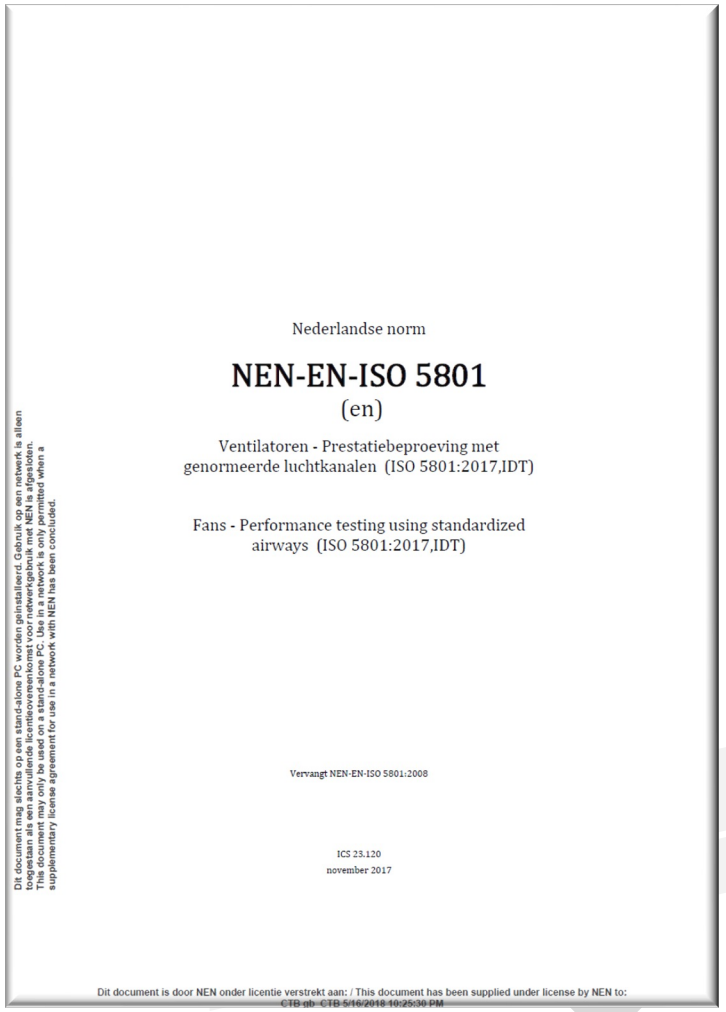
AMCA 210

- The standard AMCA 210, *Laboratory Methods of Testing Fan for Certified Aerodynamic Performance Rating*, defines how fans should be laboratory tested.
- Within the USA, reputable fan manufacturers test their fans in accordance with one of the test methods defined in AMCA 210.



ISO 5801

- The standard ISO 5801, *Fans – Performance Testing in Standardized Airways*, is an international standard.
- Outside the USA, reputable fan manufacturers test their fans in accordance with one of the test methods defined in ISO 5801.
- AMCA staff have harmonized the requirements of AMCA 210 and ISO 5801. Hence, when specifying fans, you may specify they are tested in accordance with AMCA 210 or ISO 5801.



Nederlandse norm

NEN-EN-ISO 5801
(en)

Ventilatoren - Prestatiebeproeving met genormeerde luchtkanalen (ISO 5801:2017,IDT)

Fans - Performance testing using standardized airways (ISO 5801:2017,IDT)

Vervangt NEN-EN-ISO 5801:2008

ICS 23.120
november 2017

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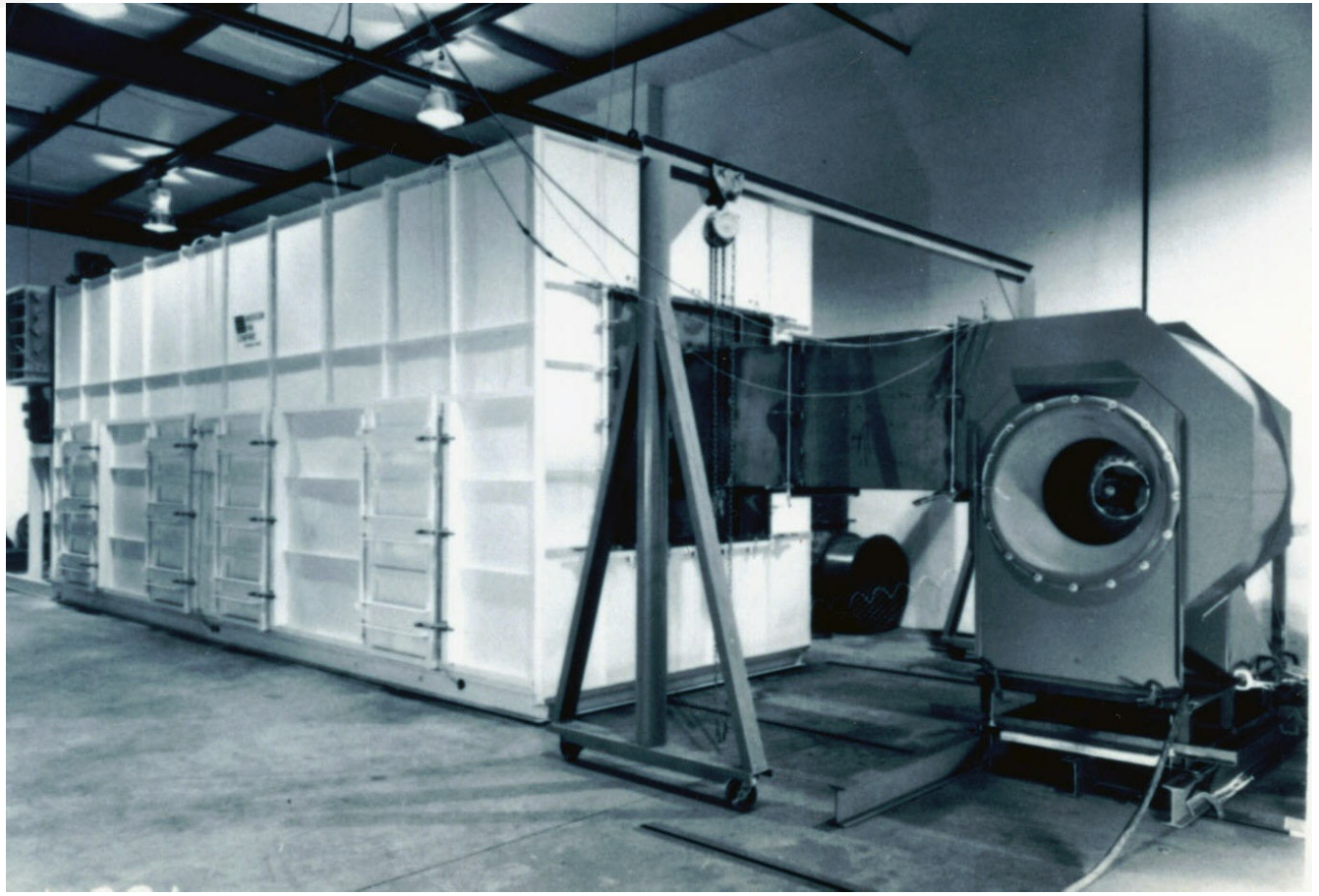
AMCA Chamber



AMCA Installation Type B: Free Inlet, Ducted Outlet

AMCA Chamber

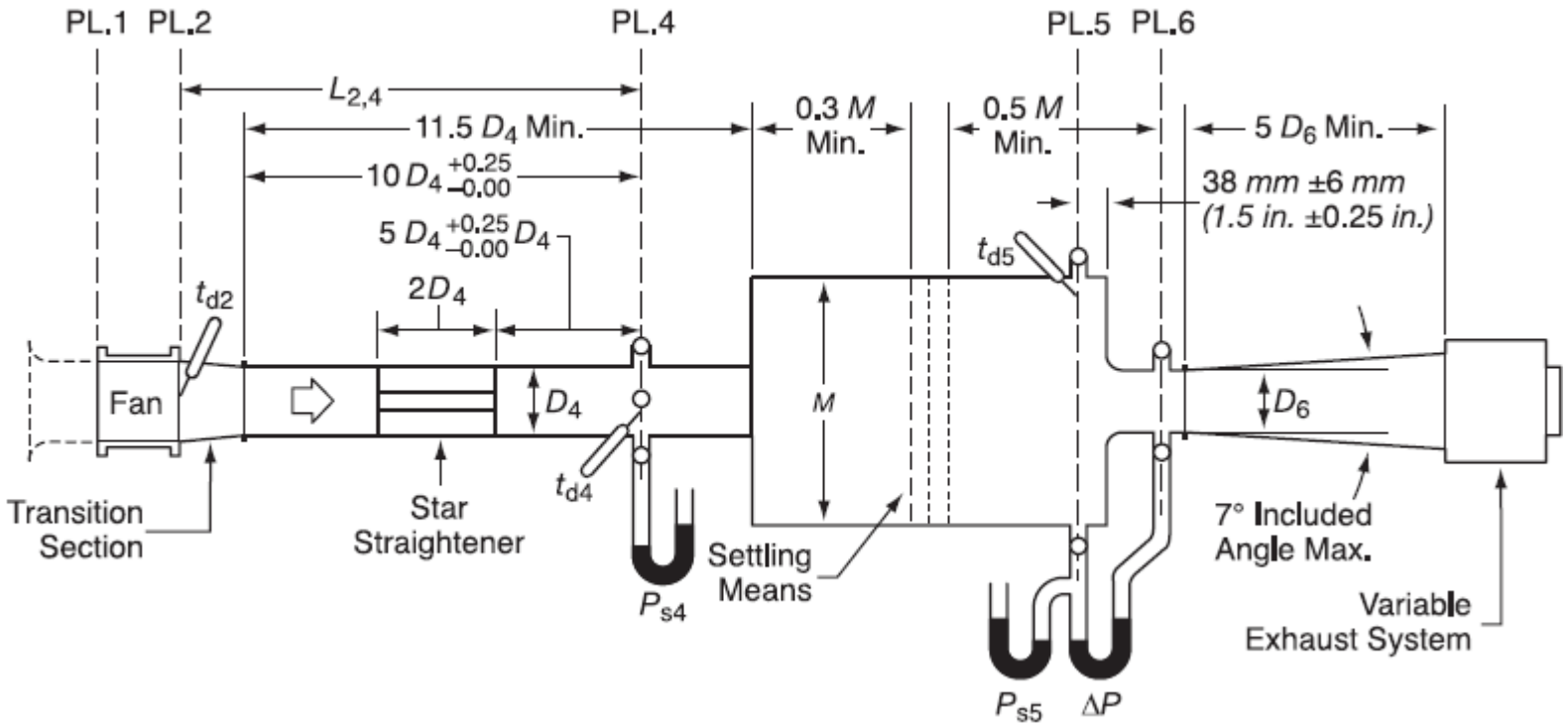
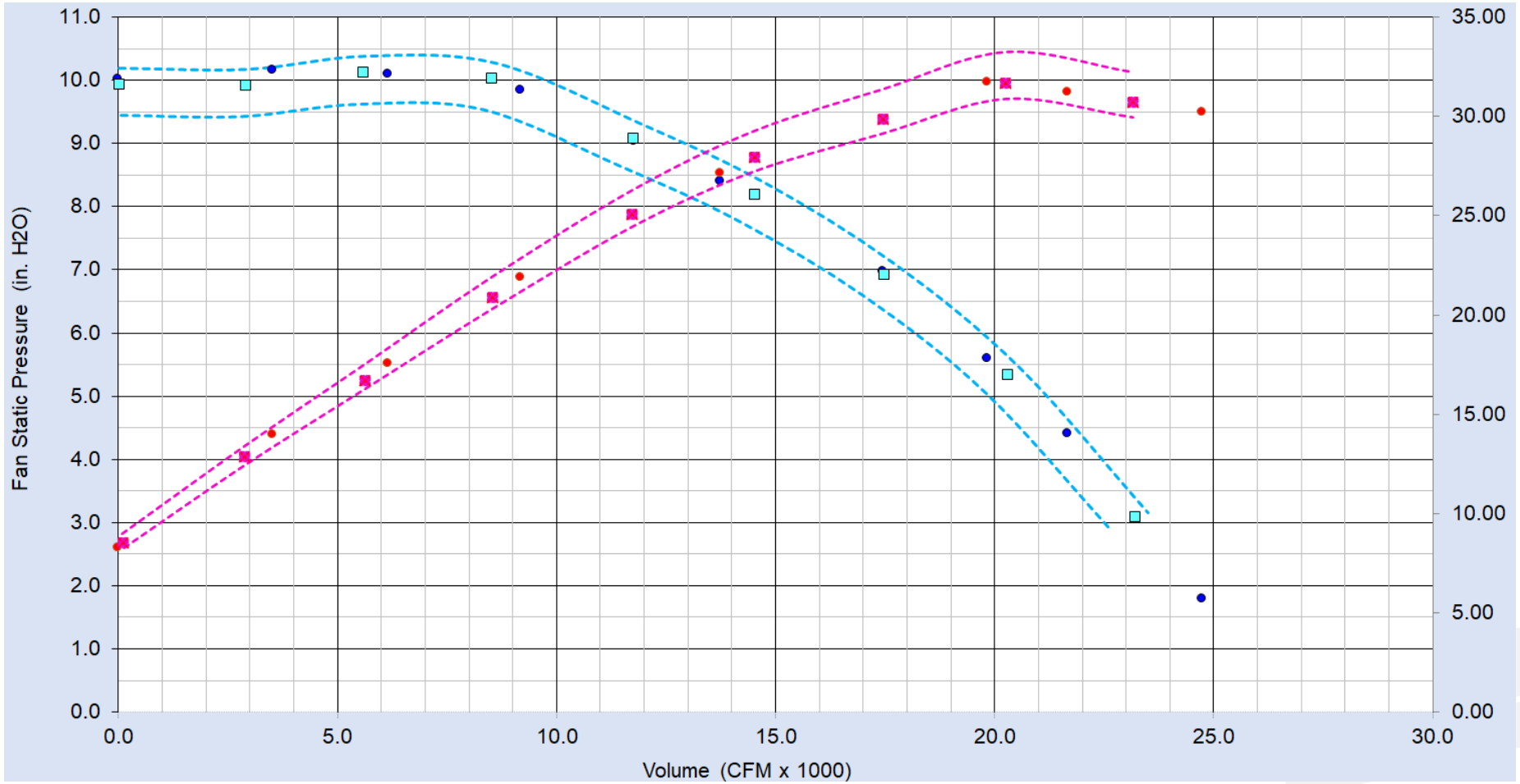


Figure 9B
Outlet Duct Setup — Nozzle On End of Chamber with Star Straightener

Example Laboratory Measured Data



System Effect

- Conditions that alter the aerodynamic characteristics of the air flowing through the fan such that the fan's full airflow potential, as tested in the laboratory and catalogued, is not likely to be realized.

AMCA 201-02 (R2011)

System Effect Factor (SEF)

- A System Effect Factor is a value that accounts for the effect of conditions adversely influencing fan performance when installed in the air system.

AMCA 201-02 (R2011)

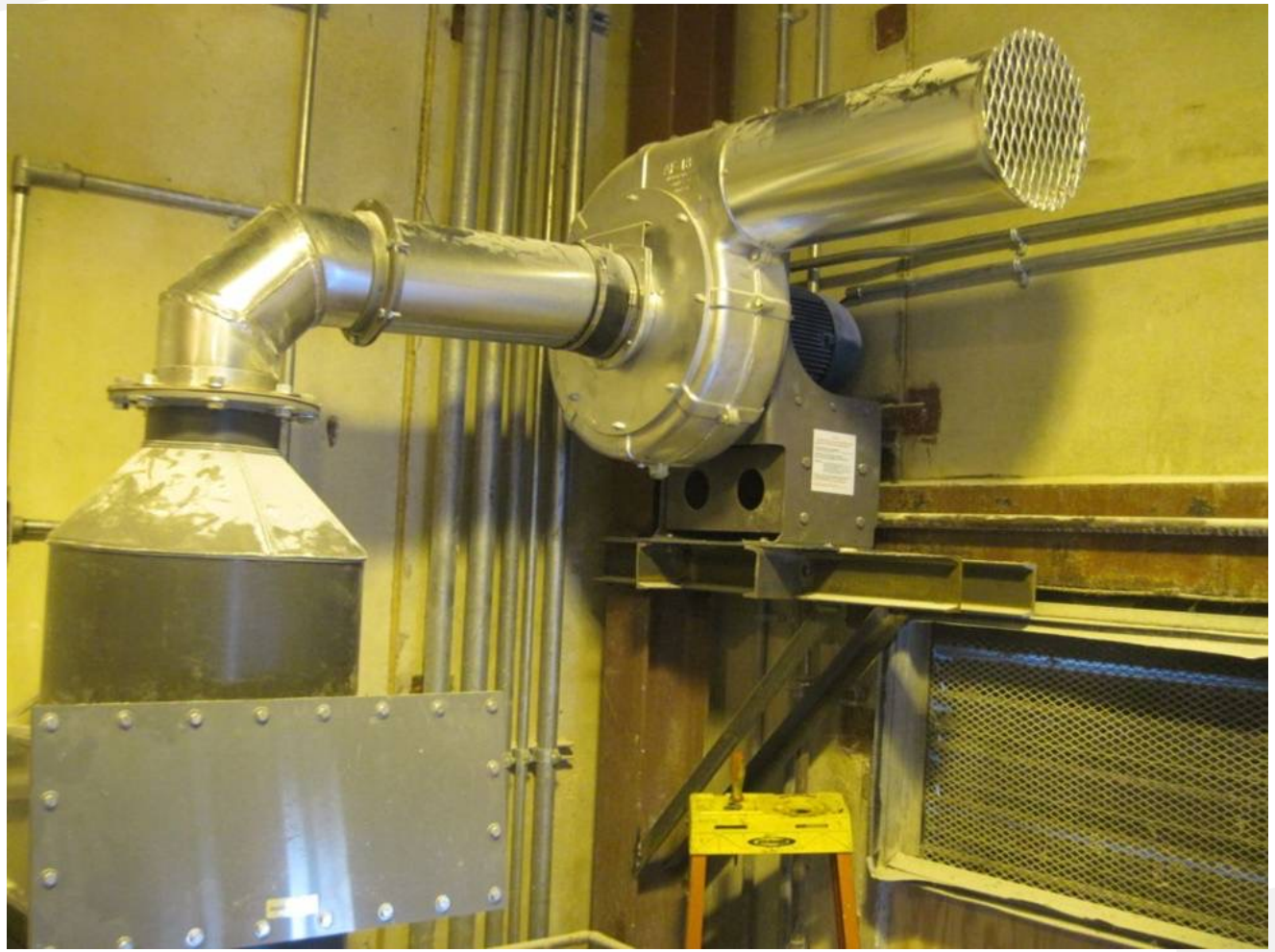
Common System Effect Causes

- Elbows too close to the inlet/outlet
- Airflow obstructions
- Poorly designed inlet/outlet transitions
- Inlet too close to the wall
- Outlet elbow orientation
- Inlet Vane Damper installed backwards
- Corrugated hose

Good Installation

Good Installation

Good Installation



Good Installation

Good Installation

Good Installation

Good Installation

Good Installation

Good or Poor Installation?

Truism

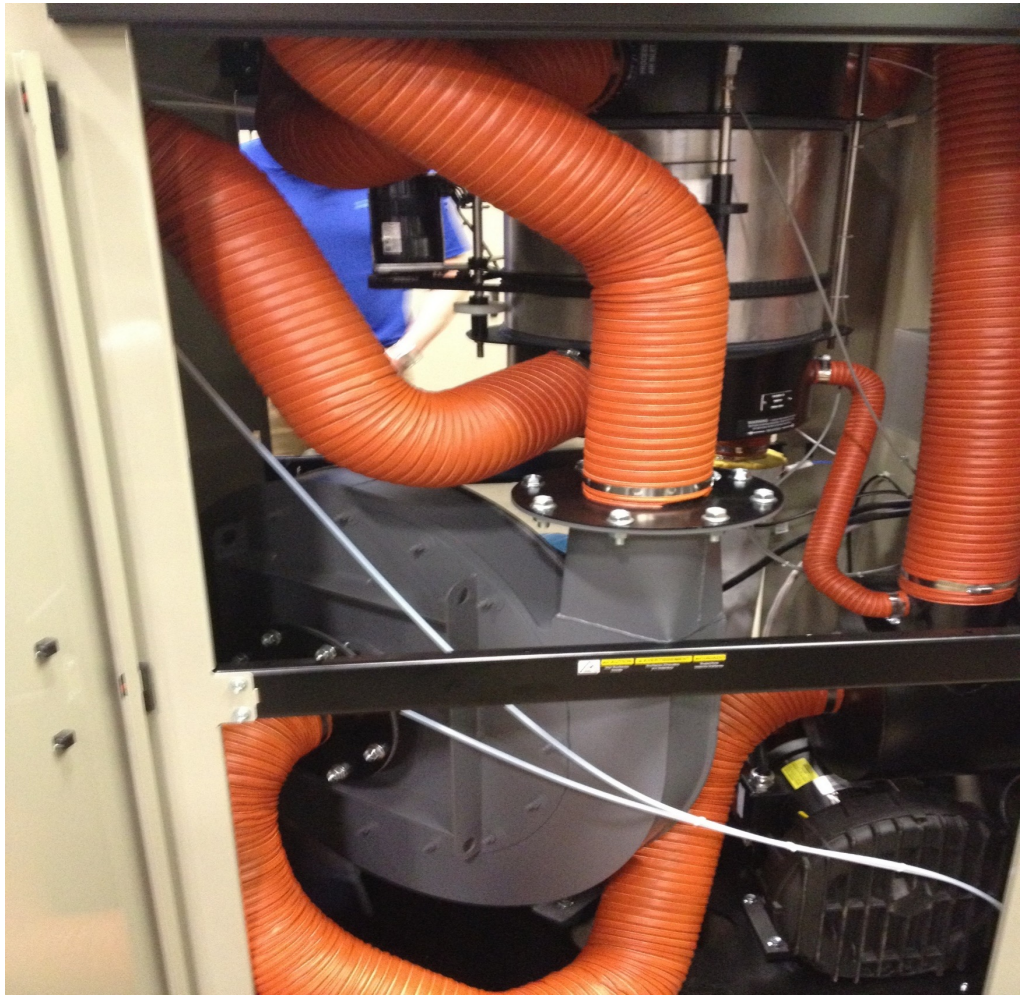
How fans are installed can have an adverse effect on how they perform.

Good or Poor Installation?

Good or Poor Installation?

Good or Poor Installation?

Poor Installation



Poor Installation

Poor Installation

Poor Installation

Poor Installation

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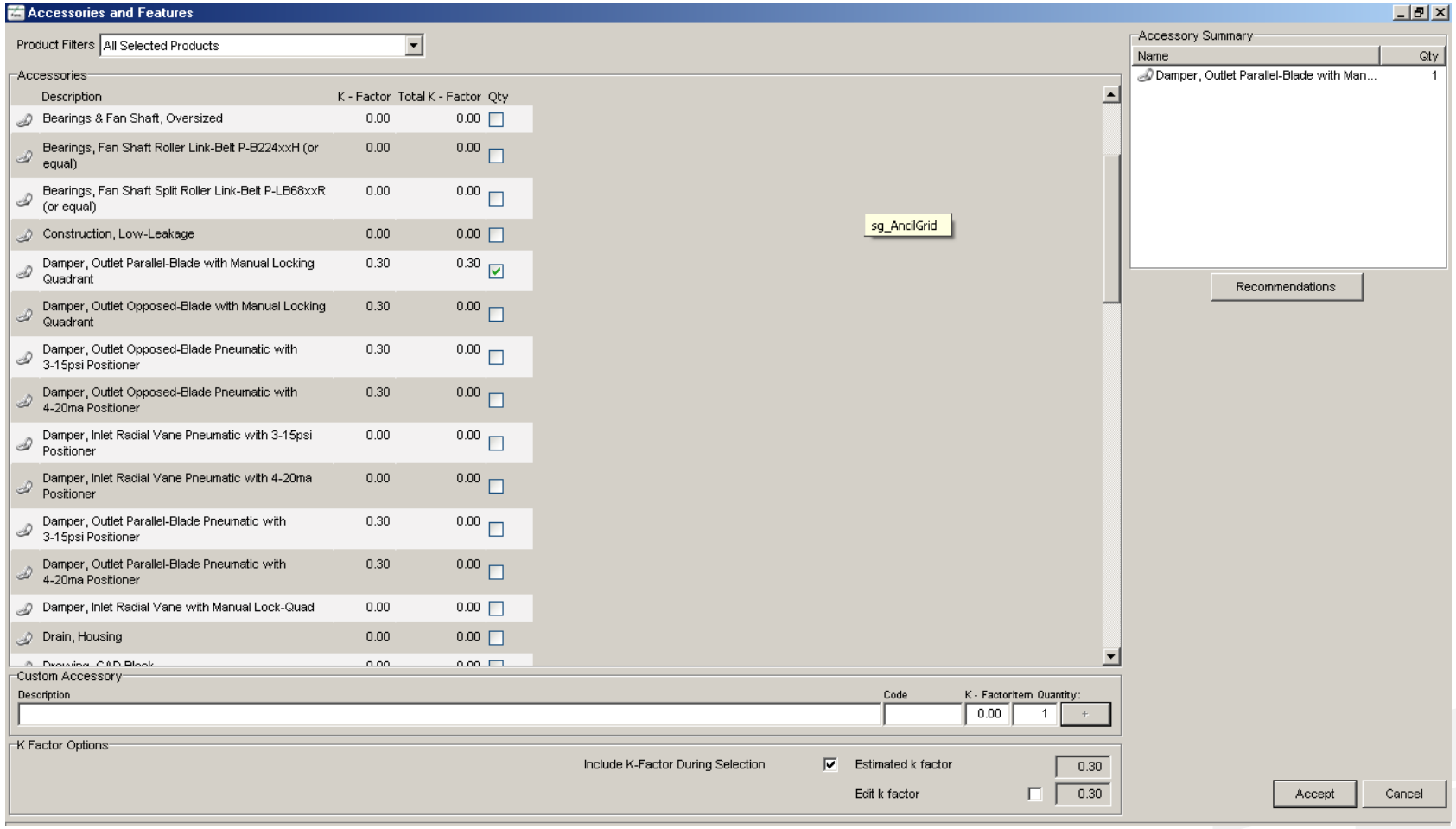
Fan Accessories May Affect Performance

- Dampers – multi-louver, radial vane, wafer, cutoff
- Screens and Guards
- Inlet Filters and Silencers
- Inlet Boxes

Typical SP Losses

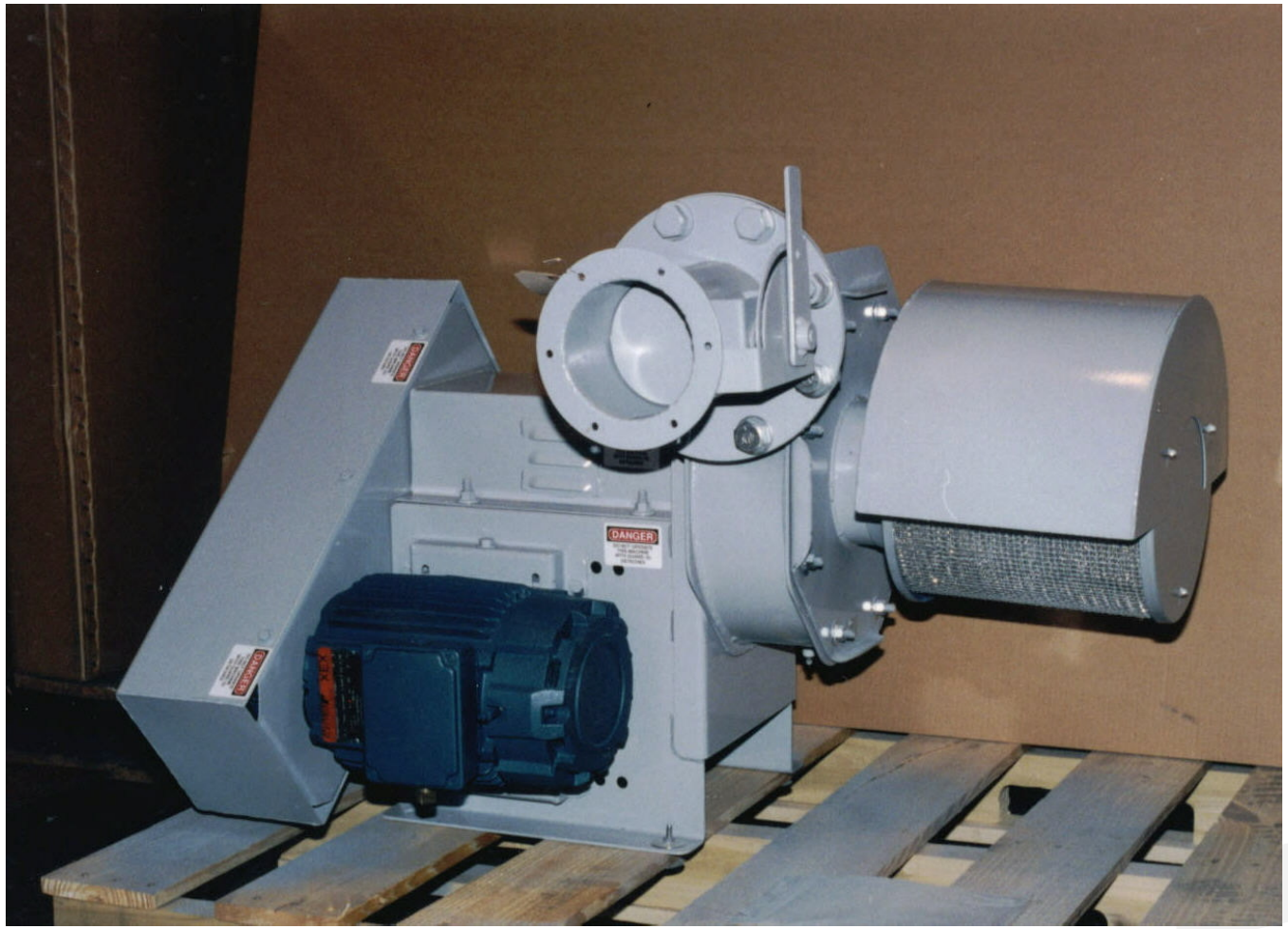
- Wire mesh inlet filter = ¼” (when clean)
- Inlet screen (wire mesh) = 0.7” @ 3000 ft/min velocity
- Inlet guard (expanded metal) = 1.4” @ 3000 ft/min
- Inlet silencer = varies from ¼” to 1.5”
- Inlet box = 1 velocity pressure
- Louver damper = 2” @ 3000 ft/min (fully open position)

Fan Selector K Factor

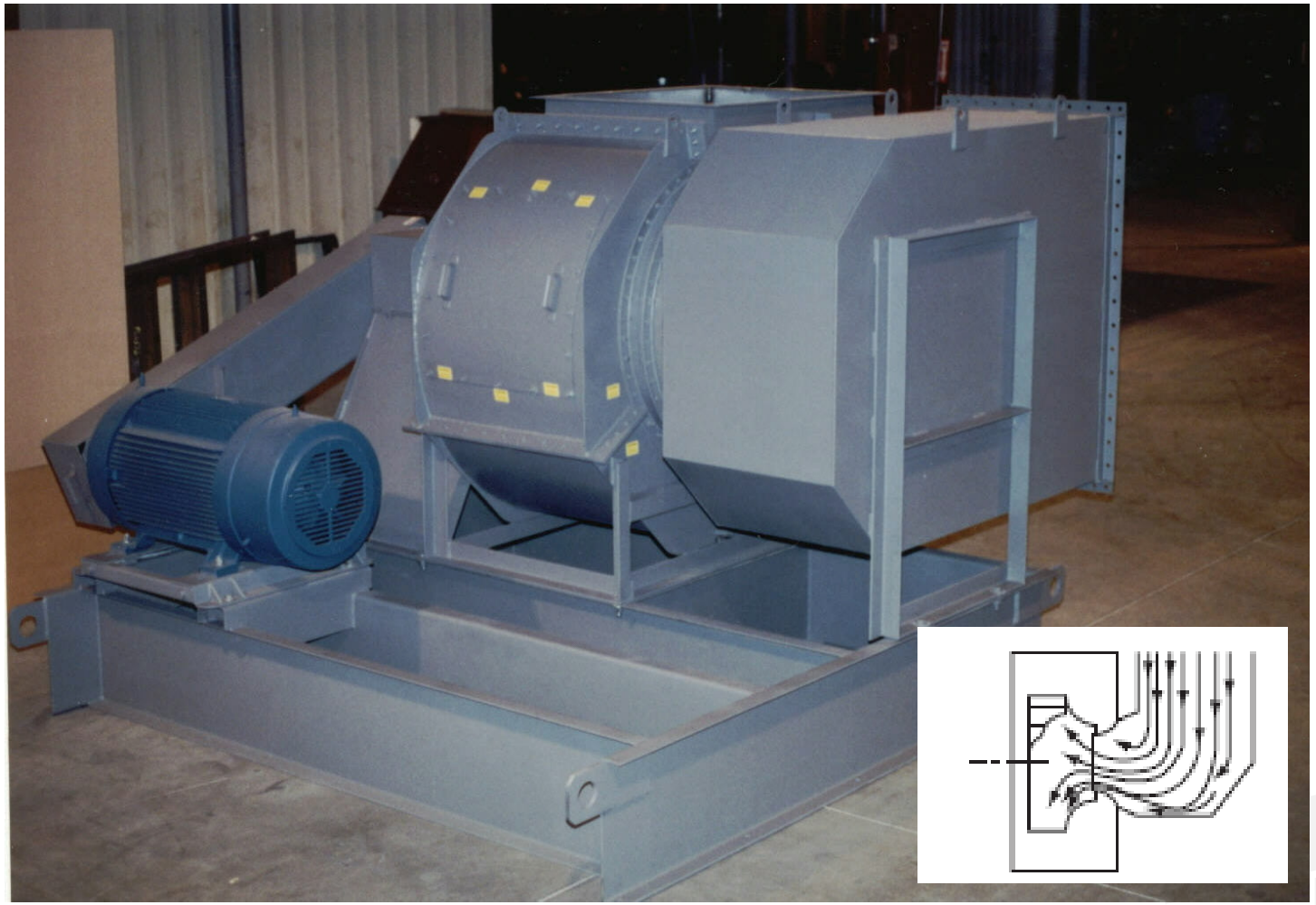


Cut-off Damper with Screen

Single Blade Damper, Filter with Cover

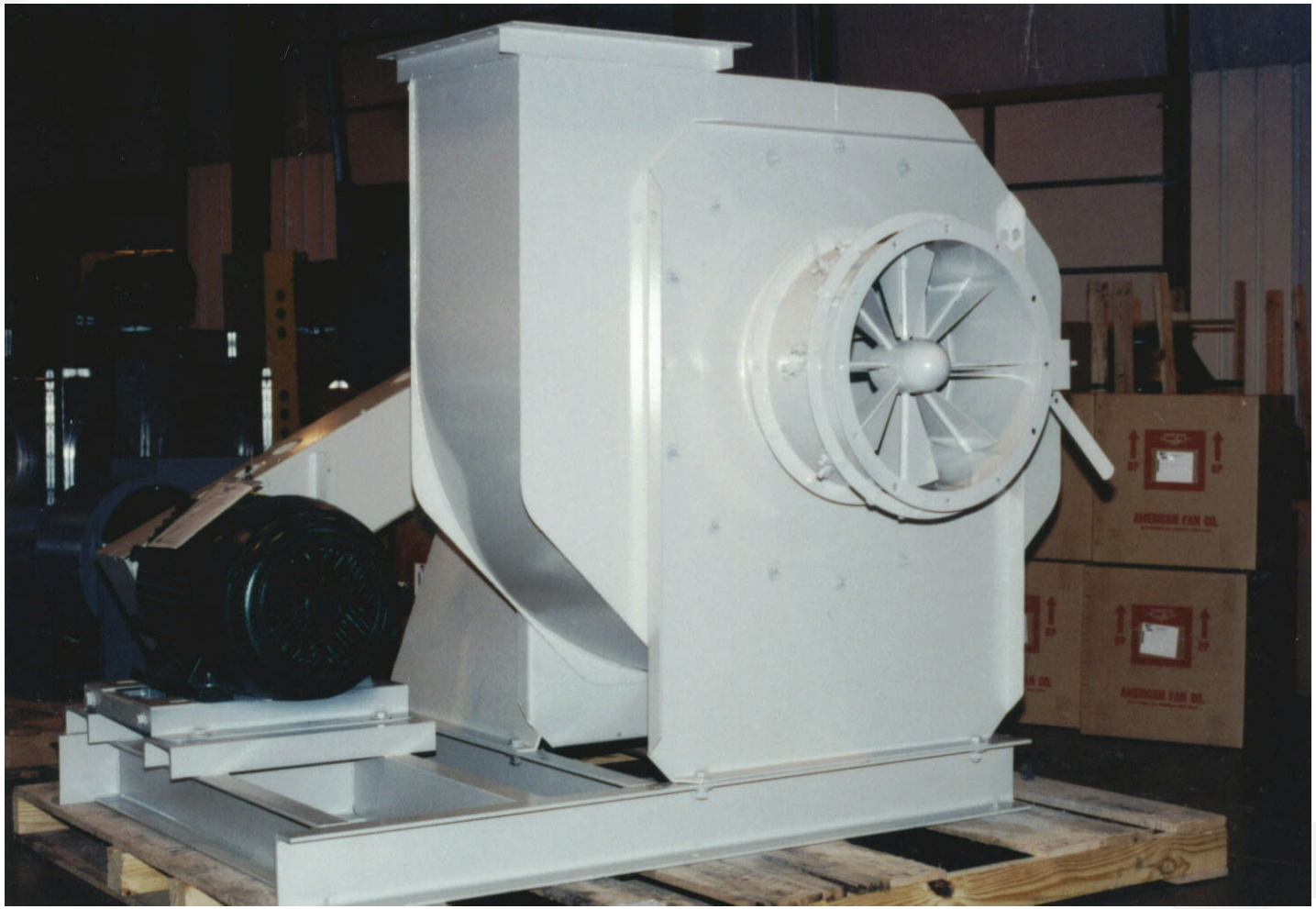


Inlet Box

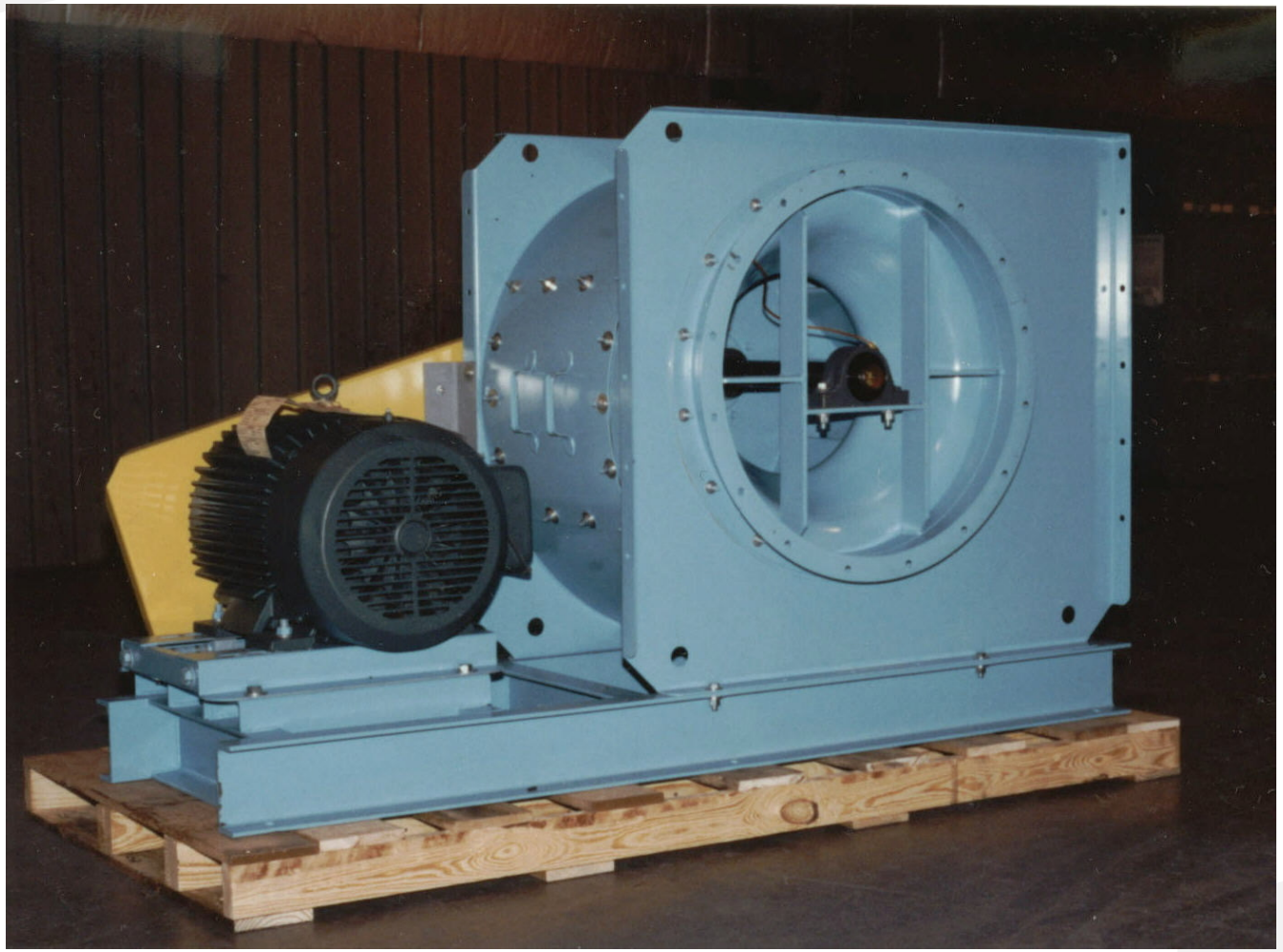


Inlet Box, Damper, Silencer

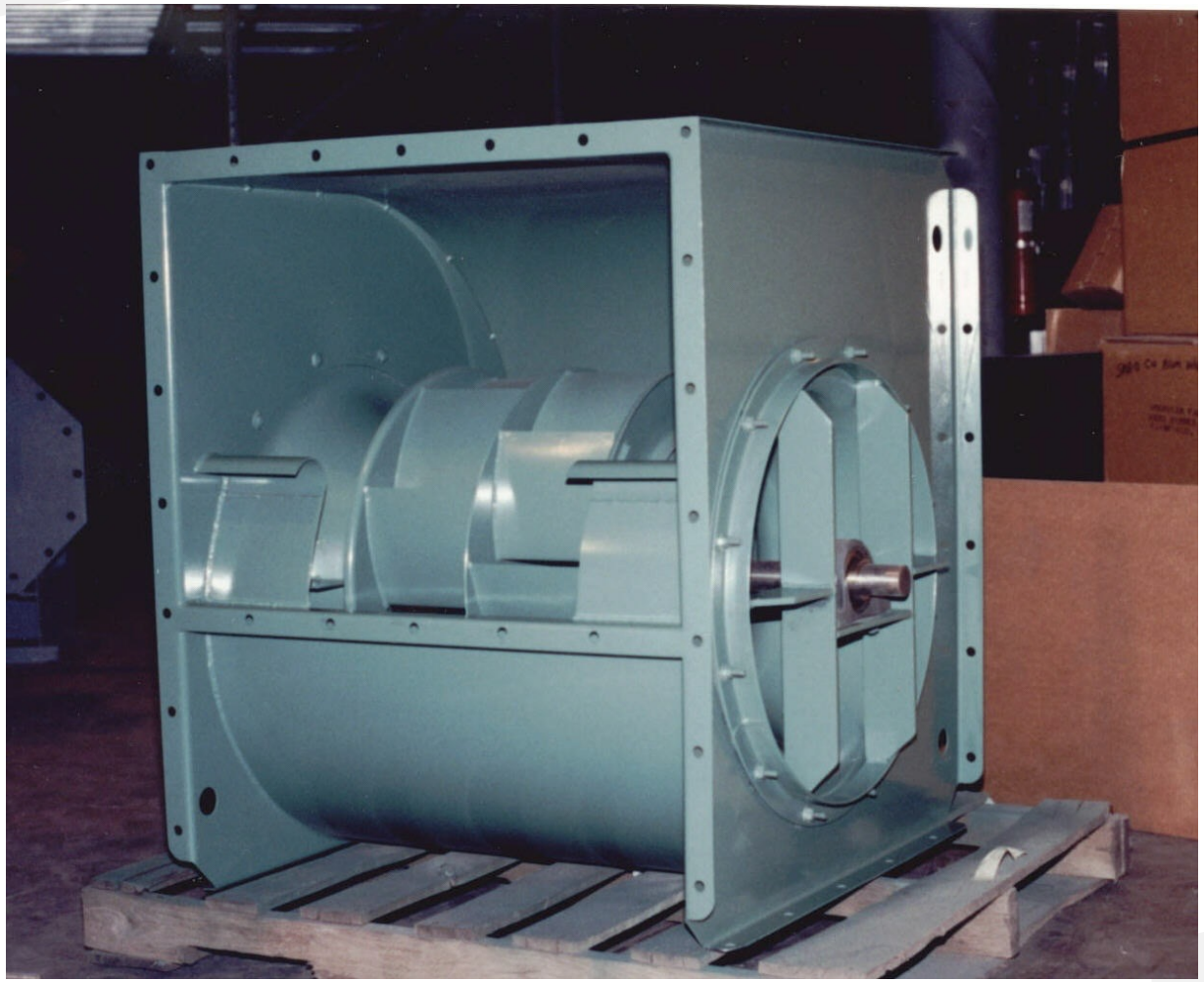
Radial Vane Inlet Damper



Arr’t # 3 SWSI Fan



Arr’t # 3 DWDI Fan



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The dreaded phone call…

WHY DOESN’T MY FAN PERFORM?

AMCA 202-98 (R2011) Troubleshooting

System Checklist:

- Improper installation of the fan.
- Damage in handling or transit.
- System design error.
- Faulty controls.
- Poor fan selection.

Insufficient Air Flow

- Fan/motor running in wrong rotation.
- Impeller installed backwards.
- Improper inlet cone to impeller fit.
- Dampers not completely open.
- Dirty or clogged filters.
- Obstructed fan inlet/outlet.

Fan Noisy

- Impeller hitting inlet or housing.
- Shaft loose in bearing.
- V-belts too loose.
- Defective bearing.
- Bearing requires lubrication.
- Shaft seal misaligned.

Power High

- Backward inclined impeller installed backwards.
- Fan speed too high.
- Gas density different than anticipated.
- Fan not selected at efficient point of rating.

Fan Does Not Operate

- Electricity turned off.
- Broken belts.
- Impeller touching housing.
- Motor horsepower too small.
- Low voltage.
- Load inertia too large for motor.
- Seized bearing.

Mechanical Vibration

- Impeller out of balance.
- Material build-up on impeller.
- Loose impeller set screws.
- Loose bearing set screws.
- Loose bearing bolts.
- Bearings misaligned.

Questions?

To receive PDH credit, you must complete the post-course evaluation