HVAC SYSTEMS TESTING, ADJUSTING & BALANCING

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION, INC.

HVAC SYSTEMS TESTING, ADJUSTING & BALANCING

THIRD EDITION — AUGUST, 2002

SHEET METAL AND AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION, INC.
4201 Lafayette Center Drive
Chantilly, VA 20151-1209

HVAC SYSTEMS
TESTING, ADJUSTING & BALANCING

**SHEET METAL AND AIR CONDITIONING CONTRACTORS'
NATIONAL ASSOCIATION, INC.**

4201 Lafayette Center Drive
Chantilly, VA 20151

Printed in the U.S.A.

FIRST EDITION - 1983
SECOND EDITION - JULY, 1993
THIRD EDITION - AUGUST, 2002

FOREWORD

This handbook has been extensively updated for 2002 from the original 1983 publication and includes all of the many changes that have takes place in the industry since the 1990's. We have added many new sections covering variable frequency drives (VFD), direct digital control (DDC) systems, lab hood exhaust balancing, and the latest changes in the balancing equipment and procedures.

All of the system testing, adjusting, and balancing fundamentals that make up the original text has been updated, and all helpful reference tables and charts in the Appendix have been extensively updated.

This handbook will provide any SMACNA contractor already familiar with mechanical system operation basics, with the information necessary to balance most heating, ventilation, and air conditioning (HVAC) systems. Chapters on both air and water side HVAC system adjusting and balancing are included, and the chapters on system controls have been totally rewritten to reflect the trend away from pneumatic controls and towards programmable micro-processor controls.

Most of today's HVAC systems are being designed with many more individually controlled temperature zones to improve occupant comfort, and variable speed fans and pumps are now commonplace to provide the exact amount of heating and cooling system capacity necessary to minimize energy usage. New occupant air ventilation codes are much more restrictive, at the same time building envelopes are becoming much tighter. The combination of constantly changing HVAC flows and increased demand for fresh and filtered ventilation air for all occupants is placing much more emphasis on proper HVAC system operation and balancing.

Any SMACNA contractor wanting to become part of this rapidly growing field is strongly encouraged to read other related SMACNA publications available, and take part in the many training courses offered to become a certified TAB Contractor. The International Training Institute provides a Certified Technician program for journeyman sheet metal workers who already have a basic understanding of system testing and balancing, and many of these courses are available in versions for home study.

The building construction industry is experiencing a major growth in demand for trained and experienced contractors who can balance today's much more complex HVAC systems.

SHEET METAL AND AIR CONDITIONING CONTRACTORS'
NATIONAL ASSOCIATION, INC.

TASK FORCE

Bill Freese, *Chairman*
International Testing & Balancing, Ltd.
Seaford, New York

David Aldag
Aldag-Honold Mechanical, Inc.
Sheboygan, Wisconsin

John Brue
Balancing Precision, Inc.
Bloomington, Illinois

Ray Coleman
Certified Testing & Balancing, Inc.
Riverton, Utah

Ben Dutton
SMACNA, Inc.
Chantilly, Virginia

Eli P. Howard, III
SMACNA, Inc.
Chantilly, Virginia

OTHER CONTRIBUTORS

J. R. Yago & Associates
Consulting Engineers
Manakin-Sabot, Virginia

NOTICE TO USERS OF THIS PUBLICATION

1. DISCLAIMER OF WARRANTIES

a) The Sheet Metal and Air Conditioning Contractors' National Association ("SMACNA") provides its product for informational purposes.

b) The product contains "Data" which is believed by SMACNA to be accurate and correct but the data, including all information, ideas and expressions therein, is provided strictly "AS IS", with all faults. SMACNA makes no warranty either express or implied regarding the Data and SMACNA EXPRESSLY DISCLAIMS ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR PARTICULAR PURPOSE.

c) By using the data contained in the product user accepts the Data "AS IS" and assumes all risk of loss, harm or injury that may result from its use. User acknowledges that the Data is complex, subject to faults and requires verification by competent professionals, and that modification of parts of the Data by user may impact the results or other parts of the Data.

d) IN NO EVENT SHALL SMACNA BE LIABLE TO USER, OR ANY OTHER PERSON, FOR ANY INDIRECT, SPECIAL OR CONSEQUENTIAL DAMAGES ARISING, DIRECTLY OR INDIRECTLY, OUT OF OR RELATED TO USER'S USE OF SMACNA'S PRODUCT OR MODIFICATION OF DATA THEREIN. This limitation of liability applies even if SMACNA has been advised of the possibility of such damages. IN NO EVENT SHALL SMACNA'S LIABILITY EXCEED THE AMOUNT PAID BY USER FOR ACCESS TO SMACNA'S PRODUCT OR $1,000.00, WHICHEVER IS GREATER, REGARDLESS OF LEGAL THEORY.

e) User by its use of SMACNA's product acknowledges and accepts the foregoing limitation of liability and disclaimer of warranty and agrees to indemnify and hold harmless SMACNA from and against all injuries, claims, loss or damage arising, directly or indirectly, out of user's access to or use of SMACNA's product or the Data contained therein.

2. ACCEPTANCE

This document or publication is prepared for voluntary acceptance and use within the limitations of application defined herein, and otherwise as those adopting it or applying it deem appropriate. It is not a safety standard. Its application for a specific project is contingent on a designer or other authority defining a specific use. SMACNA has no power or authority to police or enforce compliance with the contents of this document or publication and it has no role in any representations by other parties that specific components are, in fact, in compliance with it.

3. AMENDMENTS

The Association may, from time to time, issue formal interpretations or interim amendments, which can be of significance between successive editions.

4. PROPRIETARY PRODUCTS

SMACNA encourages technological development in the interest of improving the industry for the public benefit. SMACNA does not, however, endorse individual manufacturers or products.

5. FORMAL INTERPRETATION

a) A formal interpretation of the literal text herein or the intent of the technical committee or task force associated with the document or publication is obtainable only on the basis of written petition, addressed to the Technical Resources Department and sent to the Association's national office in Chantilly, Virginia. In the event that the petitioner has a substantive disagreement with the interpretation, an appeal may be filed with the Technical Resources Committee, which has technical oversight responsibility. The request must pertain to a specifically identified portion of the document that does not involve published text which provides the requested information. In considering such requests, the Association will not review or judge products or components as being in compliance with the document or publication. Oral and written interpretations otherwise obtained from anyone affiliated with the Association are unofficial. This procedure does not prevent any committee or task force chairman, member of the committee or task force, or staff liaison from expressing an opinion on a provision within the document, provided that such person clearly states that the opinion is personal and does not represent an official act of the Association in any way, and it should not be relied on as such. The Board of Directors of SMACNA shall have final authority for interpretation of this standard with such rules or procedures as they may adopt for processing same.

b) SMACNA disclaims any liability for any personal injury, property damage, or other damage of any nature whatsoever, whether special, indirect, consequential or compensatory, direct or indirectly resulting from the publication, use of, or reliance upon this document. SMACNA makes no guaranty or warranty as to the accuracy or completeness of any information published herein.

6. APPLICATION

a) Any standards contained in this publication were developed using reliable engineering principles and research plus consultation with, and information obtained from, manufacturers, users, testing laboratories, and others having specialized experience. They are

subject to revision as further experience and investigation may show is necessary or desirable. Construction and products which comply with these Standards will not necessarily be acceptable if, when examined and tested, they are found to have other features which impair the result contemplated by these requirements. The Sheet Metal and Air Conditioning Contractors' National Association and other contributors assume no responsibility and accept no liability for the application of the principles or techniques contained in this publication. Authorities considering adoption of any standards contained herein should review all federal, state, local, and contract regulations applicable to specific installations.

b) In issuing and making this document available, SMACNA is not undertaking to render professional or other services for or on behalf of any person or entity. SMACNA is not undertaking to perform any duty owed to any person or entity to someone else. Any person or organization using this document should rely on his, her or its own judgement or, as appropriate, seek the advice of a competent professional in determining the exercise of reasonable care in any given circumstance.

7. REPRINT PERMISSION

Non-exclusive, royalty-free permission is granted to government and private sector specifying authorities to reproduce *only* any construction details found herein in their specifications and contract drawings prepared for receipt of bids on new construction and renovation work within the United States and its territories, provided that the material copied is unaltered in substance and that the reproducer assumes all liability for the specific application, including errors in reproduction.

8. THE SMACNA LOGO

The SMACNA logo is registered as a membership identification mark. The Association prescribes acceptable use of the logo and expressly forbids the use of it to represent anything other than possession of membership. Possession of membership and use of the logo in no way constitutes or reflects SMACNA approval of any product, method, or component. Furthermore, compliance of any such item with standards published or recognized by SMACNA is not indicated by presence of the logo.

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLES

TABLES (continued)

FIGURES

FIGURES (continued)

FIGURES (continued)

FIGURES (continued)

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION TO TAB WORK

1.1.1 New Buildings

Testing, adjusting and balancing (TAB) of all HVAC systems in a new building is needed to complete the installation and to make the systems perform as the designer intended.

Assuming that the system design and installation meets the comfort needs of the building occupants, good testing, adjusting and balancing of the HVAC system provides occupant comfort with minimum energy input. This is extremely important in this era of rising energy costs.

It is also important to make sure all factory equipment startup service has been completed before beginning any TAB work. Most specifications on new building construction usually require a factory representative to be present during the initial startup and adjustment of central boilers, chillers, large variable speed motor drives, and cooling towers. This initial equipment checkout is also usually required to activate the factory warranties and are not be part of the TAB contractor's responsibility. After this initial startup service has been completed, the TAB contractor should be informed that the systems are operating properly, that all safety interlocks and protective devices are functioning, and the systems are ready to be balanced.

The Testing, Adjusting, and Balancing or TAB phase of any building construction or renovation is intended to verify that all HVAC water and air flows and pressures meet the design intent and equipment manufacturer's operating requirements. It is rare to find an HVAC system of any size that will perform completely satisfactorily without the benefit of TAB work. This is why it is necessary for the designer to specify that TAB work be part of the HVAC system installation. A sample TAB specification can be found in the Appendix.

Commissioning services for any new building construction or renovation are intended to verify all HVAC, lighting, plumbing, electrical, and security systems operate properly and meet performance criteria.

Commissioning also includes the testing of all building controls for each mode of operation to verify all systems are being sequenced correctly with each other, and that all interlocks are functioning. The commissioning agent must document the results of each equipment test performed as it is completed.

It should be made clear that the Testing, Adjusting, and Balancing (TAB) services may be the only HVAC system testing services contracted on most projects, but TAB work is not intended to be "commissioning." Most commissioning services are completed by firms having technicians experienced with each of the individual building systems mentioned above.

These firms will usually subcontract the services of an independent TAB contractor to verify HVAC system balancing as part of their more inclusive commissioning contract.

1.1.2 Existing Buildings

There are few buildings in existence that have not experienced changes in internal loads and wall relocations since they were designed and built. These buildings should have their HVAC systems rebalanced to achieve maximum operating efficiency and comfort. Many buildings require rebalancing twice each year with the seasonal change from heating to cooling or the reverse.

Firms with a good TAB team have had a natural lead-in to service contracts and retrofit work because the TAB work identifies system operating deficiencies.

1.2 THE TAB TECHNICIAN/TEAM

1.2.1 The Technician

Throughout this publication, TAB technician will be used to designate the person in charge of the TAB work being done on the HVAC system discussed.

It will be apparent after reading this publication and observing TAB procedures on a complicated HVAC system that the TAB technician must be a highly skilled and knowledgeable individual. This person must know the fundamentals of airflow, hydronic flow, refrigeration and electricity and be familiar with all types of HVAC temperature control and refrigeration systems. They must also know how to take pressure, temperature and flow measurements; and be able to perform effective trouble-shooting. The days of balancing using a wet finger and cigarette smoke are long gone!

1.2.2 The Team

There are TAB jobs that can be done by one person. However, many HVAC systems need a TAB team to complete the TAB work in a reasonable time period. It is equally important that the other members of the TAB team be trained and become knowledgeable in