

## ON THE USE OF 5-HOLE PROBES IN THE TESTING OF INDUSTRIAL CENTRIFUGAL COMPRESSORS - TP073

Jose L. Gilarranz  
Andrew J. Ranz  
Jason A. Kopko  
James M. Sorokes

Dresser-Rand Company, Olean, NY, USA, 14760

### ABSTRACT

This paper addresses the use of 5-hole probes in the testing of industrial centrifugal compressors. The 5-hole probes utilized for this work are of the conical-tip type and were used in a non-nulling configuration (i.e. the probes do not need to be rotated or moved in any way during the tests). These 5-hole probes proved to be fairly robust, making them practical for a non-laboratory setting such as an industrial multistage compressor test stand.

A discussion of 5-hole probes and how they function is provided, including an overview of the mathematical formulations and calibrations required to translate the pressure data gathered from the 5 holes into static and total pressures, velocities and flow angles. A method to transform these variables from a probe-based coordinate system to a machinebased coordinate system is also presented and schematics of this process are provided to aid the reader's understanding.

The testing performed on a prototype multistage centrifugal compressor using 5-hole probes is also discussed showing that the probes provided valuable insight into the flowfield exiting the impellers and at the return bend. The hub-to-shroud velocity profile exiting an impeller was found to be more skewed than expected and was contributing to poor performance in the downstream stationary components. The measured flowfield from one of the tests is also compared against 3-D CFD results and comments are offered regarding the agreement between the analytical and measured results.

Advantages and disadvantages of 5-hole probes as compared to more conventional instrumentation are presented. Finally, conclusions are drawn regarding the value of 5-hole probe data in the development and/or troubleshooting of high performance turbomachinery and in the validation / calibration of design and analysis tools.



# ASME.ORG Privacy and Security Statement

## [Terms of Use](#)

Last Revised: July 16, 2003

### **General Information**

The ASME.ORG web site ("ASME.ORG") is intended for public information, communication and the consumption of goods and services provided by The American Society of Mechanical Engineers (ASME International). This privacy policy ("Privacy Policy") describes the way that ASME International collects and handles information from visitors and members to ASME.ORG.

ASME International may rewrite this Privacy Policy at any time. We will post any changes to this web page and mark the date of the revisions above, so be sure to check back periodically. Your use of this web site after we post a change constitutes your agreement to abide by the new terms.

### **Collection of Anonymous Information**

The ASME.ORG servers automatically log certain information that ASME International uses for statistical analysis of web site traffic. The information is stored as log files on the ASME.ORG server. The log files are regularly collected and analyzed by software to produce visitor trend reports. The information that is collected includes:

- Your IP Address
- Your City
- Your State
- The length of time you stayed on ASME.ORG
- Where you came into the site
- Where you left the site
- The referring site that sent you to ASME.ORG
- The type of browser you are using

This information is used to determine:

- Traffic Patterns
- Average visitor session length
- Number of visitors to certain areas of the site
- Banner Ad Click-through
- Tracking results of Promotional Campaigns
- Other user trends

Server logs do not contain personally identifiable information on individual users, such as names, addresses, email address, occupation, etc. This type of data will only be collected in forms,

surveys or event registrations on ASME.ORG.

### **Collection of Personally Identifiable Information**

ASME International also collects personally identifiable information that you voluntarily submit through online forms on ASME.ORG, such as:

- Name
- Postal Address
- Email Address
- Business or Company Name and Address
- Phone Number
- Salary Information
- Educational Background
- Credit Card Information

Personally identifiable information is used for the following purposes:

- To fulfill your order for membership or goods or services;
- To process registrations for events, courses and other ASME activities
- To conduct surveys and polls
- To provide you with information on events, products and services, or other news that we think might interest you.

You can let us know that you do not wish to receive information by contacting us by email at [infocentral@asme.org](mailto:infocentral@asme.org) or by mail at ASME SERVICE CENTER, 22 LAW DRIVE, P.O. BOX 2900, FAIRFIELD, NJ 07007-2900, or by calling us at 1-800-THE ASME.

### **Sharing Information with Third Parties**

ASME International may share your information with third parties that offer information, goods or services that we think may be of interest to you. If you do not wish your information to be shared with third parties, please contact ASME International at [infocentral@asme.org](mailto:infocentral@asme.org) and we will respect your request.

ASME International will not share your email address with any third party; we use email addresses only for internal purposes and to promote efficient communications between ASME International and its members and customers.

ASME International uses third party network advertisers such as [list, e.g., "DoubleClick"] to deliver ads to you on our behalf. We may also use third-party service providers to facilitate some aspects of our Web site services or fulfill your requests. These service providers may be supplied with or have access to your personally identifiable information solely for the purpose of providing these services to us or on our behalf.

We may disclose and use personally identifiable information in special circumstances where it is necessary to protect our proprietary rights, in connection with a sale or transfer of some or all of our assets in ASME.ORG, or when we, in good faith, believe that the law requires us to do so.

## **Cookies**

Certain parts of ASME.ORG use cookies; a small file placed on your computer, to better enable visitors to use the web site. Generally, cookies enable our server to remember visitors, allow entry into password-protected areas, and to help ensure accurate measuring of web traffic. Cookies can be deleted or rejected by changing the settings on your web browser. However, the deletion or rejection of cookies on a visitor's part may impact your ability to use parts of the ASME.ORG effectively.

Because advertisers or third party web sites may use cookies in different ways, this statement regarding the use of cookies only covers ASME.ORG.

In no way are cookies on the ASME.ORG web site harmful to the machines on which they are placed or how the information is used.

## **Review and Correction**

ASME Members may review and update the personally identifiable information that you have provided to ASME International, by logging into [Members Only](#), or by sending a revision request by email to [infocentral@asme.org](mailto:infocentral@asme.org) or by mail at ASME SERVICE CENTER, 22 LAW DRIVE, P.O. BOX 2900, FAIRFIELD, NJ 07007-2900, or by calling us at 1-800-THE ASME.

ASME.ORG may display the email addresses of volunteers who serve as officers on ASME International committees and other units. These volunteers are leaders of ASME International and may have chosen to place their contact information online so as to be more accessible to the public. If you are a volunteer or member who has been listed on ASME.ORG and you no longer wish to have your email address posted, please send an e-mail to [webmaster@asme.org](mailto:webmaster@asme.org) with a subject line of: Remove Email Address from ASME.ORG and the page address where your email is listed.

## **Email Alias Service**

ASME International offers its members an email alias. The alias is a simple "store and forward" mechanism that accepts email sent to the alias name and forwards it to the member's actual email address. Once an email alias is issued to a member, ASME International makes no guarantees on the future privacy of the alias. ASME has taken measures to protect members from SPAM in the form of adding third party SPAM-blocking services; However, because the software cannot guarantee complete SPAM blocking, members must take sole responsibility for protecting against publication or misuse of their email aliases. Therefore, members use the email alias service at their own risk.

Under no circumstances, including, but not limited to, negligence, will ASME International or its directors, officers, employees, or agents be liable for direct, indirect, incidental, special or consequential damages that result from your use of (or inability to use) the email alias service.

For further explanation of the ASME.ORG email alias, please go to [www.asme.org/email](http://www.asme.org/email).

## **ASME Forums**

The ASME.ORG forums are used as a collaborative and communications device between users of ASME.ORG. Opinions, advice, statements, offers, materials and other information (together

"Posting") are generated by visitors to ASME.ORG and such Postings do not necessarily reflect the views, policies or opinions of ASME International. Postings are not endorsed, adopted, or published by ASME International, unless explicitly stated otherwise by one of ASME International's authorized agents acting in an official capacity. Under no circumstances, including, but not limited to, negligence, will ASME International or its directors, officers, employees, or agents be liable for any defamatory, offensive, or illegal conduct of third parties who participate in the ASME.ORG forums, or any direct, indirect, incidental, special or consequential damages that result from your use of (or inability to use) the ASME.ORG forums, or your use of or reliance on Postings on the ASME.ORG forums.

If you use any of the forums, you agree to abide by the following rules:

- You are solely responsible for any content you post on the forum;
- Your forum postings are non-confidential and any ideas, inventions, or know-how disclosed in your postings will be available to the public.
- You will not use the forums to send chain letters or any other junk mail.
- You will not impersonate any other user or entity.
- You will not upload any information, files, code or other materials that contain viruses or are able to disrupt or damage ASME software, hardware or equipment.
- You will not post any message that violates another person's copyright, or right to privacy or publicity, or any other proprietary right.
- ASME does not endorse external web sites that may be included, listed or found in the ASME Forums.
- ASME has the right to delete, modify or supplement the content of this site at any time for any reason without notification to anyone and to ban or restrict forum users for any reason at anytime.

If you do not want your email address to be public in a forum posting, please be sure to select "No" in the area of the screen labeled "Make Email Address viewable to others."

### **Protection of Children**

ASME will not knowingly collect personally identifiable information from anyone under 13 years of age, unless it is necessary to respond to a one-time request. Once the request has been answered, ASME will delete the requesting child's personally identifiable information.

### **Links to Third Parties**

ASME.ORG may contain links to third-party web sites and/or content providers that include information or services that may be of interest to you. ASME.ORG also carries banner advertisements that are placed by third-party advertisers. This privacy and security statement applies to the ASME.ORG web site only. This statement does not extend to third-party web sites and/or content providers, including related affiliate web sites and/or content providers such as ASME International's Division, Section or Region Web sites, advertiser web sites, and third-party service providers. ASME International is not responsible for the privacy and security practices of those sites. We recommend that you review the privacy policy at each of these Web sites to determine how that site protects your privacy.

### **Security**

ASME International uses online forms on ASME.ORG to collect specific information for event or

course registrations, surveys, polls, and other data collection uses. In cases where private information is collected, such as mailing addresses, phone numbers, work location, credit card numbers, etc., all forms are secured through Secure Socket Layers (SSL) encryption, the most widely accepted and tested form of data encryption. Of course, no transmission over the Internet can be guaranteed to be 100% secure. Therefore, you provide us with your information at your own risk.

In addition to Secure Socket Layer encryption during transmission, ASME takes these additional precautions with your information:

- All Web Servers are protected by state of the art, managed firewalls.
- Data is protected at the server level by IP Address range from ASME offices. This means that only necessary order fulfillment staff, product managers and web server support personnel have access to collected information.
- Administrative Screens can only be accessed from ASME offices using Secure Socket Layers.
- Credit Card Numbers are encrypted down to the database field level.

ASME International cannot ensure that third-party Web sites linked to ASME.ORG, including ASME International's affiliate groups, will provide equivalent security. You should check with the privacy policies of those web sites before submitting any personally identifiable information.

### **Transfer to the United States**

If you are located outside of the United States, please note that any personally identifiable information that you provide ASME International will be transferred to the United States. By submitting your personally identifying information to us, you consent to this transfer.

### **Comments and Questions**

If there are any parts of this statement that require more explanation or clarification, please contact [webmaster@asme.org](mailto:webmaster@asme.org). If you have any comments or suggestions regarding changes and updates, please contact [webmaster@asme.org](mailto:webmaster@asme.org).

[Top](#)