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Pneumatic fluid power — Flow rating test procedure and reporting method — For fixed orifice components

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Foreword

This Foreword is not part of American National Standard *Pneumatic fluid power - Flow rating test procedure and reporting method - For fixed orifice components*, ANSI/(NFPA)T3.21.3-1990.

At the request of several pneumatic component manufacturers, in 1968 a search was made of all known published and private material and documents on this subject. The need for a single standard for the measurement of pneumatic flow became quite apparent. Similarly, a uniform method of rating and reporting flow characteristics is important.

The need stems, not from lack of adequate or accurate measurement procedures and rating methods, but, in fact, from the number of them.

Recognizing this need, the NFPA Technical Board approved undertaking this project. It was assigned to a Project Group of the Pneumatic Valve Section. The Project Group divided the work into two parts: rating basis and method of testing and reporting. Through a series of drafts and reviews, all the work was incorporated into one General Review Draft on 8 July 1970.

Comments received from the General Review Draft were reviewed on 10 August and a Ballot Draft was prepared on 30 August 1971.

Following a review of the ballot results at the 8 March 1972 Section meeting, a Proposed Redraft was prepared on 14 March 1972 and the Second General Review Draft was completed on 30 May 1972.

After studying the Second General Review Draft, the Project Group determined the assignment should further be broken down into two studies: (1) the method of measuring tare with the proposed test rig arrangement, and (2) the validity of the CETOP proposal for pneumatic flow rating.

A compilation of the results of these studies resulted in the Second Proposed Redraft of 3 April 1973. The Second Proposed Redraft was discussed at the 24 April 1973 meeting, and a Third Proposed Redraft was prepared at the following meeting on 28 June 1973. The Third Proposed Redraft was reviewed on 11 December 1973. Mr. C. Allen incorporated comments resulting from this review into a Fourth Proposed Redraft, which was received at NFPA Headquarters on 28 January 1974. Editing of this redraft was completed by Headquarters on 29 January 1974, after which the Fourth Proposed Redraft was circulated among Project Group members.

The Fifth Redraft resulted at the 9 November 1977 Project Group meeting and Headquarters received the Final Working Draft on 6 February 1978. The document was circulated for its Third General Review on 16 March 1978.

Third General Review comments were resolved by letters from Project Group Chairman Gerald Dalder (Ross Operating Valve). The NFPA Technical Board granted approval to ballot on 7 February 1979, and the NFPA Technical Staff prepared the Ballot Draft on 23 October 1979.

Because of a number of comments raised concerning the Ballot Draft, particularly the need to confirm the procedure, the Ballot Draft was used as a basis for a series of round robin tests of six pneumatic directional control valves by Parker Hannifin, Schrader Bellows and C. A. Norgren Co. The test program was defined in 1980 and also included flow rating tests per ISO Draft Proposal ISO/DIS 6358.2, Pneumatic fluid power - Components using compressible fluids - Determination of flow-rate characteristics, as well as response time tests conducted in support of NFPA Project T3.21.8.

The Cv flow ratings measured following the T3.21.3 Ballot Draft were not sufficiently consistent. The selection of different operating conditions, all within the limits allowed by the Ballot Draft, made it impossible to separate the effects of testing inaccuracies from possible inadequacies in the general correlation capabilities of the basic Cv relationships.

After each of the participants had rechecked the calibrations of the instrumentation used, particularly the flow meters (which were all of different basic types), another series of round robin tests was started in 1983. In addition to Parker, Schrader Bellows and C. A. Norgren Co., Ross Operating Valve Co. also participated. These tests were limited to Cv measurements at a specified inlet pressure of 95 psia and pressure differentials of 1, 2, 5 and 10 psi. The scatter in data was still greater than desired for a flow rating procedure.

In 1984, the four manufacturers who participated in the 1983 round robin tests completed another round robin test using two sizes of venturi-type flow meters instead of directional control valves. Each venturi included two sets of pressure taps (in the venturi section and in the integral inlet and outlet conduits). The purpose of this test phase was to minimize all variables related to the pneumatic valves, connecting pipes and pressure taps. The test results showed a significant reduction in the calculated value of C_v at higher pressure drop (5 and 10 psid) conditions for tests using the inlet and outlet pressures measured at taps in the connecting conduits. These taps were located the appropriate distances upstream and downstream from the venturi and were therefore spaced a significant distance apart. This reduction in C_v was attributed to the increased contribution of the frictional pressure loss in the conduit to the total value of pressure drop. During this test program, the static pressures at the inlet and the throat of the venturi were also measured. The values of C_v which were calculated based on the inlet-to-venturi throat pressure drop were considerably lower for corresponding values of pressure drop. This was attributed to the low static pressure at the pressure tap located in the throat. In the absence of typical straight sections of connecting pipe between pressure taps, these values of C_v were also more constant over the entire range of pressure drop investigated. Therefore, to minimize the effects of pressure drop in the flow straightening conduits necessary to measure the pressure drop in directional control valves, it was decided to limit the pressure drop for C_v measurements to the lower values of the range under study. The data for pressure drop condition of 1 and 2 psid are tabulated in Annex A.

A final round robin test of five pneumatic directional control valves was conducted at Parker, Ross, Schrader Bellows and Norgren in 1984 and 1985 following a more restricted range of pressure and flow conditions. The results are summarized in Annex B. Different types of flow meters were used in each laboratory (hot wire, orifice, rotameter and laminar) and multiple sizes of flow meters were required in each laboratory to measure the range of flows required. Although each participant checked the calibration of the flow meters used in the tests the calibrations of the flow meters were not directly compared with each other or against an independent standard reference. No single laboratory and no specific type of flow meter provided results which stood alone, distant from the other points.

A proposed Fourth General Review Draft was distributed on 11 April 1986 to members of the T3.21, Pneumatic Valve Section for review. Comments were received from two member

companies, none of which modified the basic procedure for measuring and presentation. None of the comments disputed limiting the application of the C_v factor determined by the proposed procedure to comparative valve flow ratings. The Fourth General Review draft was not distributed more widely because of the moratorium placed on all NFPA technical activities in 1986 and 1987. The 11 April 1986 draft is now referred to as the Sixth Working Draft.

At the 22 October 1987 meeting, the T3.21 Component Section voted unanimously to continue the T3.21.3 project and requested the T3.21.3 Project Group to update the 11 April 1986 draft to the Fourth General Review Draft. Further analysis of the data from the round robin tests was completed, and the results have been added as Annex A and Annex B for reference during the general review process.

With some exceptions, the calculated values of C_v at each test condition are within $\pm$ 10 % of the mean value. The most significant exceptions noted in the round robin test program were the values of C_v calculated for poppet- type valves. Subsequent analysis showed that some of the poppet valves partially shifted at certain conditions because of the test pressure differentialent analysis showed that the poppet valves partially shifted at certain conditions because of the test pressure differential, the unbalanced nature of some poppet valves, and/or the nonrigid connection between the normally-open and normally-closed poppet. As a result, appropriate instructions were added to the procedure. This investigation also revealed that some laboratories removed the actuation signal on double air operated or double solenoid operated spool valves during the test. Since this might allow the spool to partially shift during the flow test, an instruction was added to maintain all actuation signals throughout the flow test.

NFPA's Technical Staff issued the Fourth General Review Draft on 5 February 1988. Comments were received from four companies and appropriate revisions and correction were made. The Technical Board approved preparation and distribution of the ballot draft at their 15 September 1988 meeting.

NFPA's Technical Staff prepared the document for Third Ballot on 23 September 1988.

T3.21, Pneumatic Valve and Conditioning Product Section, met on 16 February 1989. All negative comments were resolved and incorporated into the document. The committee approved submittal of the document to the Technical Board for final approval. The NFPA Technical Board granted approval of the document on 16 March 1989.

Project Group members who developed this standard:

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(1979 to present)
NORGREN

Gerald Dalder*
Project Chairman
(1977-1979)
Ross Operating Valve Co.

Cliff Allen*
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WABCO Fluid Power Div.

Walter Forster
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On 15 September 1989, ANSI/(NFPA)T3.21.3 was submitted to Committee B93 for ballot. Balloting closed on 21 November 1989 with one editorial comment which was incorporated into the document.

ANSI/(NFPA)T3.21.3 was approved by ANSI's Board of Standards review on 25 January 1990.

The membership roster of Standards Committee B93 at the time of ballot:

Jack C. McPherson
Chairman

Daniel B. Shore
Vice Chairman

Shirley C. Seal
Secretary

American Society of Agricultural Engineers
David L. Newcom

Compressed Air & Gas Institute
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John Addington (alternate)

Construction Industry Manufacturers
Glenn Stewart

Fluid Controls Institute, Inc.
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E. C. Rutter (alternate)

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Introduction

In pneumatic fluid power systems, power is transmitted and controlled through a gas under pressure within an enclosed circuit. One factor governing the selection of individual components is the ability to pass system flow without undue power loss. A flow rating parameter provides one means for identifying flow performance of a pneumatic component.

Pneumatic fluid power — Flow rating test procedure and reporting method — For fixed orifice components

1 Scope and field of application

1.1 To define a rating parameter, test method, and method of reporting flow in fixed orifice pneumatic fluid power components.

1.2 To promote better pneumatic fluid power systems by providing manufacturers and users of components with an easily understood standard means of developing, verifying and communicating pneumatic flow ratings.

2 References

ANSI/B93.2, *Fluid power systems and products - Glossary*.

NFPA/T2.10.1M, *Metric Units for Fluid Power Applications*.

ISO 1000, *SI units and recommendations for the use of their multiples and of certain other units*.

ANSI/Y14.17, *Drafting Practices for Fluid Power Diagrams*.

ISO 1219, *Fluid power systems and components - Graphic symbols*.

ISO 6358, *Pneumatic fluid power - Components using compressible fluids - Determination of flow-rate characteristics*.

3 Terms and definitions

For definition of terms used, see ANSI/B93.2.

4 Units of Measurement

Units of measurement are used in accordance with NFPA/T2.10.1M. This document agrees with ISO 1000. Provision is also made for the use of “Customary U. S.” units.