AMERICAN SOCIETY OF HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC.
1791 Tullie Circle, N.E./Atlanta, GA 30329
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TC/TG/TRG MINUTES COVER SHEET

(Minutes of all TC/TG/TRG Meetings are to be distributed to all persons listed below within 60 days following the meeting.)

TC/TG/TRG NO TC08.08 DATE February 1, 2011

TC/TG/TRG TITLE Refrigerant System Controls and Accessories

DATE OF MEETING 2-1-2010 LOCATION (LVCC) N217, Las Vegas, Nevada

MEMBERS PRESENT	YEAR APPTD	MEMBERS ABSENT	YEAR APPTD	EX-OFFICIO MEMBERS AND ADDITIONAL ATTENDANCE
Mr Duane A Wolf, PE	2010 VM	Mr Frederic D Colsoul	2010 VM	Mr Kirk Stifle, PE CM
Mr W Vance Payne, PhD	2010 VM	Dr Pradeep Kumar Bansal	2010 VMNQ	Mr Dennis A Littwin CM
Mr Robert A Jones, PE	2010 VM	Mr Ernest W Schumacher	2007 VM	Mr David Scott Frey CM
		Prof Robert R Bittle	2010 VM	Mr Don Schuster CM
		Mr Steven R Szymurski	2008 VM	Xudon Wang
				Tom Bourquin
				Jim Jansen

DISTRIBUTION

All Members of TC/TG/TRG plus the following:	
TAC Section Head:	Mr William F McQuade, PE, LEED AP
TAC Chair:	Mr Charles C Wilkin, PE
ALI/PDC	Ms Filza H Walters
Chapter Technology Transfer	Mr Nathan P Hart, CTC
Manager Of Standards	Mrs Stephanie C Reiniche,
STAFF LIAISON/RESCH/TECH SVCS	Mr Michael R Vaughn
Research Liaison	Mr Richard D Hermans, PE
Special Pubs	Mr John A Clark, PE
Standard Liaison	Mr Martin Dieryckx

Minutes
ASHRAE TECHNICAL COMMITTEE 8.08
Refrigerant System Controls and Accessories
Meeting in Las Vegas, Nevada
Tuesday, February 1, 2011

TC 8.08 Refrig. System Controls and Accesories. Tuesday 1:00-3:30 p.m. (LVCC) N217

The meeting was called to order at 2:00pm by the Chairman, Duane Wolf.

I. Self Introductions were given from everyone in attendance. See attached Sign-in Sheet

III. Attendance:
There were not enough members present to represent a quorum (There are 6 Voting Members on the Roster.)

Name and Status	**Year Appointed**	**Year Roll-Off**
Duane Wolf, Chair, VM Present	2010	2012
Frederic Colsoul, Vice Chair, VM Not Present	2010	2013
Robert Jones, Secretary, VM Present	2010	2011
Robert Bittle, Program, VM Not present	2010	2014
Ernest Schumacher, VM Not present	2007	2011
Steve Szymurski, VM Not present	2008	2012
Vance Payne, Webmaster, Standards, CM Present.	2010	
Kirk Stifle, Handbook, CM Present	2010	

Scott Fry, Fujikoki America, CM
Dennis Littwin Formally with Fujikoki America, Guest
Xudong Wang, AHRI, Guest
Tom Bourquin, Parker Sporlan Division, Guest
Jim Jansen, Parker Sporlan Division, Guest
Don Schuster, Carrier Corp. CM

IV. Approval of Minutes from Albuquerque meeting.
No changes to the minutes, No quorum.

V. Report from the TC Chairs meeting.
Keep web pages up to date.
Post meeting minutes to the TC website within 60 days. TC8.8's website is up to date.
ASHRAE is going to provide a help wanted add to support the TC's. Any TC that needs assistance will be able to post it there.
ASHRAE is promoting google groups, and phone and web based meetings.
Don't forget your passports for Montreal.

VI. Subcommitte Reports

a. Kirk Stifle – Handbook
    a. Next revision is due 2014. Just published chapter 11, 2010 Refrigeration Handbook. Looking for volunteers for reviewers.
b. Membership – New roster and officers
    a. Bob Jones and Ernie Schumacher will Roll off.
    b. Steve Szymurski will be removed.
c. Programs – Robert Bittle
    a. No program to report.
d. Website – Vance Payne
    a. Agenda and minutes were posted.
e. Research – Duane Wolf
    a. Performance of 4-way reversing valves.
        i. There were three documents distributed. RTAR, Draft work statement, and a Cover letter. See attached.
        ii. Duane requested the committee review the RTAR and send comments to him.
        iii. Duane will send the RTAR to the committee by letter ballot.
f. Standards – Robert Jones/Vance Payne.
    i. Standard 17: MOT of thermostatic refrigerant expansion valves.
        a. Vance Payne volunteered to be chair.
        b. Duane kirk, Bob Jones, Freddie, Don.
        c. Duane will send in the form to recommend Vance as the Chair.
        d. Duane will send out a letter ballot for forming the subcommittee for Std 17.
    ii. Standard 28: MOT flow capacity of refrigerant capillary tubes.
        a. No updates required.
    iii. Standard 153: MOT capacity rating of four-way reversing valves.
        a. Duane and or Vance will follow up with Ernie on 153.
    iv. Standard 158.1: MOT capacity rating of refrigerant solenoid valves. Committee met on Sunday, 1-30-2011, 5-7pm, reviewed revision and approved for publication.
    v. Standard 158.2: MOT capacity rating of refrigerant pressure regulating valves. Committee met on Sunday, 1-30-2011, 5-7pm, reviewed revision and approved for publication.

VII. Old or New Business.

No Old or New Business was discussed.

VIII. Open Discussion

There was no additional open discussion.

IX. Adjournment. Adjourned at 1:50.

Submitted by Bob Jones 6/20/2011.

ASHRAE 2011 Winter Conference - Las Vegas, Nevada

TC 8.08 Refrigerant System Controls & Accessories Sign-In Sheet

February 1, 2011

Name	E-Mail Address	Committee Member? (VM, CM, Guest)	Position
DUANE WOLF	DWOLFE INDEPENDENTFORENSICS.COM	VM	CHAIR / RESEARCH
Xudong Wang	xwang@ahrinet.org	Guest	
DENNIS LITTWIN	dLittwin@fujikoki.com	GUEST	
KIRK STIFLE	KSTIFLE@FUJIKOKI.COM	CM	HANDBOOK
Scott Frey	sfrey@fujikoki.com	CM	
Vance Payne	vance.payne@nist.gov	CM	Standards / Webmaster
BOB JONES	[illegible]	VM	SECRETARY
TOM BOURQUIN	thomas.bourquin@parker.com	Guest	
JIM JANSEN	jljansen@parker.com	GUEST	—
Don Schuster	don.schuster@carrier.utc.com	CM	—

February 1, 2011

Dear Research Administration Committee members:

TC 8.08 – Refrigerant System Controls and Accessories – is submitting the following RTAR for your consideration. An earlier version was submitted in 2008, which was rejected.

The RTAR is entitled "A study of flow capacity, heat transfer and leakage characteristics in 4-way reversing valves", with the focus on application to unitary heat pump systems. The motivation for this research is to reduce or eliminate a significant portion of the 6 to 7% system performance loss attributed to valve losses which include leakage flow and heat transfer between the high and low pressure flow paths. The objectives of the research effort will lay the groundwork for analysis and a database accessible to the general user and design community. The proposed work aligns with two goals of the 2010 – 2015 ASHRAE Research Strategic Plan. These goals include the following: Goal (1) – To reduce significantly the energy consumption for HVAC & R, water heating and lighting in existing homes and Goal (9) – To support the development of improved heating, ventilating, air conditioning and refrigeration components ranging from residential thru commercial to provide improved system efficiency, affordability and reliability.

Reversing valves have been studied previously. A significant amount of research was performed at Purdue University's Herrick Labs back in the 1980's, which was sponsored by Ranco Controls. However, the proprietary nature of the data from that research resulted in a set of publications that are not, for the most part, functional for a system designer beyond suggesting general performance trends. Furthermore, the raw data from these studies is not available for additional analysis in lieu of performing new research to obtain a suitable database. Direct attempts by our committee to access proprietary data from reversing valve companies have all been declined. A more recent study by Fang and Nutter concludes that there is the need for a comprehensive component loss study on four-way reversing valves. The purpose of this project is to develop the necessary tools and present the results not only in a format which is widely accessible but also in a comprehensive manner as suggested in the study by Fang and Nutter.

Admittedly, previous work has been done on 4-way reversing valves in the past which has even made attempts at quantifying the losses associated with these valves. However, a more detailed analysis is necessary to not only quantify the magnitude of the losses associated with these valves but also to evaluate design characteristics which would contribute to a more efficiently designed and operating valve. The comprehensive nature of this research project will do just that.

But who cares about four-way reversing valve performance? One group includes US companies concerned about the new SEER and HSPF performance requirements. Currently, these mandated improvements are primarily being achieved in two ways: compressor efficiency improvements in conjunction with an increase in the physical size of the evaporator and condenser coils. Based upon our discussions with manufacturers of heat pump units, a larger physical size is not only a negative from an esthetic point of view, but also adds significantly to

shipping costs. By recovering performance in the reversing valve, a manufacturer could potentially reduce their unit's physical size. Who else cares? The automobile industry does. There is consideration being given to installing heat pump systems in hybrid vehicles. The basis for this consideration is that if a vehicle is running primarily on battery power on a cold day, then a heat pump is an option for heating the passenger space.

And finally, ASHRAE should care. Energy conservation alone is an excellent reason to pursue a component loss study. The public is recognizing the energy efficiency inherent in heat pump systems. This is demonstrated in US Census Bureau data (July 2006) that shows air-source heat pump shipment values increasing from 1.065 to 1.751 billion dollars between 2002 and 2005. Energy conservation always supports sustainability, which is ASHRAE's first theme in the current Strategic Plan for Research. Currently, heat pump manufacturers are aware of losses attributable to four-way reversing valves, but they are not seeing the leadership for reversing valve performance improvement, even though it's been known for years that there is potential performance recovery in the reversing valve. ASHRAE should lead the industry in improving system performance.

Respectfully submitted,

TC 8.08

Attachments:

1. Addendum to the cover letter addressing point-by-point the reasons given for the RAC rejecting the first version of this RTAR.
2. RTAR entitled "A study of flow capacity and leakage characteristics in 4-way reversing valves".
3. Addendum to the RTAR describing summaries of each paper sited in the Reference listing section.

Addressing the reasons given by RAC for rejecting the earlier version (2008) of the RTAR …

1. Why is a new tool needed?

   A new tool is needed for several reasons. First, the previous experimental work which was performed in this area was not as comprehensive as the scope proposed in this study. Second, the raw data from the previous work is currently unavailable, so it is unknown whether any additional information or "mileage" beyond the already published findings can be gained from the previous work. Third, this project will generate models which will allow system designers to predict valve performance. Fourth, part of this project will involve tests with air. If tests with air are deemed a successful indicator of performance with refrigerant, this will result in greatly simplified test method for 4-way reversing valves.

2. If the previous work has already quantified the magnitude of the losses associated with 4-way reversing valves, what changes will this new study offer?

   Yes, prior studies have quantified the magnitude of the losses but the previous studies have not provided the desired guidance and insight into the overall factors affecting these losses. Simply put, it is one thing to identify that there are 6 to 7% losses associated with 4-way reversing valves, but it is a much bigger question to answer what factors affect these losses and how can these losses be reduced? These last two questions are very large components in the goals for this research project.

3. This project will involve assessment of leakage for one or more existing commercial reversing valves. Won't the manufacturers simply address efficiency issues?

   Yes, this project will utilize currently available commercial reversing valve designs. By utilizing currently available designs, it is anticipated that various design factors will be examined as part of this project. This would also be considered a much simpler approach when compared to customizing a series of valves for these tests. Currently the manufacturers are indicating that they don't have the expanse of knowledge to do more with the designs of these valves. The comprehensive scope of this project is intended to change that.

4. Equipment manufacturers have the resources to understand the performance of these devices and/or the leverage to force component manufacturers to provide performance data.

   Based upon the research and contact with manufacturers performed by SPC 153, this information is either unavailable or the keepers of this information are unwilling to share it. This project will provide complete and open information so that this void in the knowledge base will be filled in.

5. Don't believe that this is a project that is appropriate for ASHRAE to fund with current scope. Suggest TC consider narrowing the scope to support SPC 153 only.

   SPC 153 has reviewed the scope of this project and is in support of the current scope. While some of the results of this project will supplement material in the handbook, it is anticipated that this project will have a significant effect on the content of SPC 153.

ASHRAE

Technology for a Better Environment

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Michael Vaughn, PE
Manager of Research & Technical Services

email: mvaughn@ashrae.org

TO: Mohsen Farzad, Chair TC 8.8, farzadm@utrc.utc.com

FROM: Mike Vaughn
Manager of Research and Technical Services

CC: Ronald Bailey, Research Liaison 8.0, RL8@ashrae.org
Dwayne Wolf, Research Subcommittee Chair TC 8.8, dwolf@independentforensics.com
James Braun, RPS Chair, jbraun@ecn.purdue.edu

DATE: May 5, 2008

SUBJECT: RTAR #1549, "A Study of Flow Capacity and Leakage Characteristics in 4-way Reversing Valves"

At their recent spring teleconference meeting, the Research Planning Subcommittee (RPS) reviewed the subject Research Topic Acceptance Request (RTAR) and voted to return it. The following comments and questions need to be fully addressed in the next submission for the RTAR:

1. Justify why a new "tool" is needed.

2. If the previous work already showed the effect on system performance - what will change with this new study? If the issues have already been identified and their effects quantified in previous studies, what does this new study offer?

3. Will involve an assessment of leakage for one or more existing commercial reversing valves. It would seem to be a case study with limited general results. As higher efficiency equipment is required, we believe that manufacturers' will address the issues that provide the most cost-effective efficiency improvements. If reversing valve performance is a critical issue, then no doubts that their performance can be improved.

4. Equipment manufacturers have the resources to understand the performance of these devices and/or the leverage to force component manufacturers' to provide performance data.

5. Don't believe that this is a project that is appropriate for ASHRAE to fund with current scope. Suggest TC consider narrowing the scope to support SPC 153 only.

Please incorporate the above information into the revised RTAR with the help of your Research Liaison, Ron Bailey, RL8@ashrae.org, prior to submitting it to the Manager of Research and Technical Services for further consideration by RAC.

If you wish this to be reconsidered at the fall meeting in Atlanta, a revised RTAR, together with a letter describing how each of the above items was addressed, should be sent (electronically) to Mike Vaughn, Manager of Research and Technical Services (morts@ashrae.net) by August 15, 2008. The submission deadline following this meeting is December 15, 2008 for consideration at the Society's 2009 winter meeting.

Unique Tracking Number Assigned by MORTS: 1549
RESEARCH TOPIC ACCEPTANCE REQUEST (RTAR) FORM
TC 8.8 – Refrigerant System Controls and Accessories

Title:
A study of flow capacity, heat transfer and leakage characteristics in 4-way reversing valves

Applicability to ASHRAE Research Strategic Plan:
The proposed research effort falls under two Research Opportunity Themes: Theme (A) ENERGY and SUSTAINABILITY, the first goal (produce energy savings in buildings), and Theme (D) – EQUIPMENT, COMPONENTS, and MATERIALS, the third goal (establish techniques/tools to improve refrigeration system components). As will be described in the sections to follow, the performance loss in unitary heat pump systems that is attributable to the four-way reversing valve has been shown to approach 7%. U.S. DOE mandated improvements in system performance are now in effect (13 SEER in cooling mode, and 7.7 HSPF in heating mode). Manufacturers have an obligation to recover some of the performance loss, consumers have the corresponding right of expectation, and ASHRAE should lead by sponsoring this fundamental research effort.

In addition, consideration has been given to the upcoming 2010-2015 ASHRAE Research Strategic Plan. This project falls most closely under two of the Research Goals: Goal (1) – To reduce significantly the energy consumption for HVAC & R, water heating and lighting in existing homes and Goal (9) – To support the development of improved heating, ventilating, air conditioning and refrigeration components ranging from residential thru commercial to provide improved system efficiency, affordability and reliability. As unitary heat pumps are installed as retrofit equipment in existing homes, more energy efficient equipment (due in part to anticipated advances in 4-way reversing valve designs) will help to achieve Goal (1). Also, as factors affecting losses in 4-way reversing valves are identified, the results of this research project will assist in the design and selection of more efficient components, namely 4-way reversing valves.

Research Classification:
Basic/Applied

TC/TG Priority:
Priority 1

TC Vote: 0 – 0 – 0 – 0 - 0)
(For – Against – Abstentions – Absent – Total)

Reasons for Negative Votes and Abstentions:
(Negative Votes) None
(Abstentions) None

Estimated Cost:
$175K

Estimated Duration:
2 years

Other Interested TC/TGs:
TC 8.11 – Unitary and Room A/C and Heat Pumps

Possible Co-funding Organizations:
ARTI is interested in co-funding the heat transfer portion of this work. The amount of their co-funding commitment will be determined after RTAR approval.

Application of Results:
The results of this project will include a comprehensive analysis and subsequent database to be accessible to valve and equipment designers/manufacturers. The results would also be summarized and incorporated into Chapter 11 of the *Refrigeration Handbook.* Empirical models based on fundamental theory and test data will be developed to predict pressure drop, heat transfer effects and leakage in the reversing valves. These models will be included in Chapter 11 and will provide reversing valve designers and system performance modelers with additional tools to optimize valve performance and system COP.

State-of-the-Art (Background):
Four-way reversing valves are the predominant device used to switch heat pumps between heating and cooling modes. Their status in the marketplace is not expected to change in the foreseeable future. Heat pump system test data has suggested that pressure drop, internal leakage and heat transfer within the four-way reversing valve can reduce the overall COP for the system by as much as 7% (Fang and Nutter[9]). Internal leakage inside the valve is driven by the condenser-to-evaporator pressure difference between the two flow streams; the compressor discharge gas and the suction inlet gas. Based on manufacturer's performance specifications, the leakage rate can be on the order of 10% of the rated flow capacity. The internal leakage bypasses the condenser and evaporator, yet has to be handled by the compressor. Thus, internal leakage is detrimental to system COP. Heat transfer occurs between the same two flow streams passing through the valve. The resulting increase in the suction inlet temperature causes an increase in specific volume, which increases the required compressor work and subsequently decreases system COP. Some researchers have also indicated that the suction line pressure drop through the reversing valve also contributes to COP degradation.

This research project was initiated at the request of SPC-153 due to a lack of available quantitative information regarding factors that affect the performance of four-way reversing valves. A review of the presently available literature revealed a number of published papers in this area, many of which were spawned by work at Purdue University's Herrick Labs in the early 1980's sponsored by Ranco Controls. However, the proprietary nature of the data resulted in a set of publications that are not, for the most part, usable to a design engineer beyond suggesting general performance trends. Plus, the raw data is not available to the ASHRAE community. Requests from TC 8.8 for the proprietary data from the manufacturers have been declined.

Advancement to the State-of-the-Art:
The primary advancement to the designer/manufacturer community will be the availability of a complete results package including analysis detail, empirical models, and raw data. The impact of internal leakage, heat transfer and pressure drop on system performance will be assessed using a system simulation model. Once these effects are determined, they will provide engineering direction for valve improvements, which will result in overall system performance improvements.

Justification and Value to ASHRAE:

According to the most recent US Census Bureau data issued in July 2006, between 2002 and 2005 air-source heat pump shipment values increased from 1.065 to 1.751 billion dollars. Due to recent increases in natural gas and propane prices, heat pump sales will continue to increase, and competition will drive the search for more competitive advantages. Furthermore, the increased demand for heat pumps as well as more stringent efficiency requirements are obligating equipment manufacturers to look more closely at all system losses. ASHRAE should be the leader in providing its members with relevant research to impact this growing sector of energy efficient systems.

Additionally, the current minimum efficiency standard of 13 SEER in cooling mode, and 7.7 HSPF in heating mode is an incentive for unitary system manufacturers to pursue improvements in all components. Currently, most of the performance improvements are coming from improved compressors and increases in the size of the evaporator and condenser coils. But not all the performance improvement needs to come with increased equipment size and footprint. If given the necessary tools, manufacturers would likely decide that a unit with a smaller footprint and a better reversing valve would out sell a larger unit with a more inefficient reversing valve.

Objective:

The primary objective of this research project will be to experimentally investigate the performance of four-way reversing valves used in unitary heat pump systems. Valve performance (flow capacity, heat transfer and pressure drop) will be measured using air and four refrigerants. The independent effects of leakage flow and heat transfer on system performance will also be assessed using a system simulation model (based on PMS recommendations.)

Tests will be performed with at least four different refrigerants covering a range of refrigerant properties so that results will be able to be "generalized" to a wide range of refrigerant properties without the need to test each potential refrigerant individually. The PMS will review the four-way reversing valves currently available and then suggest the number and capacity of the valves (maximum capacity – 10 tons) to be evaluated as part of this project. By utilizing a sampling of valves currently available, more efficient valve design characteristics will be identified.

Some tests will also be performed with air as the test media. An attempt will then be made to correlate or predict refrigerant results from the air test results. If successful, an air test method for the performance of four-way reversing valves will represent a significant simplification of current test procedures.

In addition, semi-empirical models will be developed from the experimental results. These models will provide reversing valve designers and modelers of system performance some additional tools to optimize valve performance and system COP.

Important questions to be answered include:

1. What factors (design and/or refrigerant) have the most significant effects on four-way reversing valve (and subsequently) overall system performance?

2. Can valve performance (flow capacity, pressure drop, heat transfer and leakage flow) using tests with refrigerants be accurately predicted using tests with air?
3. Does cycling of the valve over time result in increased leakage rates?
4. Do mechanical parameters such as a sliding or rotating mechanism affect leakage?
5. Do lubricant characteristics affect the leakage rate?

Once these effects are determined, they will provide engineering direction for valve improvements.

Key References:
(List references cited in the state-of-the art section.)

1. "Performance of Heat Pump Reversing Valves and Comparison through Characterizing Parameters", by G.D.S.Damasceno, W.N.T. Lee, S.P. Rooke, and V.W. Goldschmidt. *ASHRAE Transactions*, vol. 94 part 1 (1988): 304-317.

2. "Refrigerant Leakage in Heat Pump Reversing Valves including comparison to Air Leakage Measurements", by W.N.T. Lee, G.D.S. Damasceno, V.W. Goldschmidt, and R.T. Marks. *ASHRAE Transactions*, vol. 94 part 1 (1988): 458-466.

3. "Heat Transfer, Pressure Drop, and Mass Leakage in Reversing Valves: Characterizing Parameters", by G. Damasceno, W. Lee, L. White, and V.W. Goldschmidt. *ASHRAE Transactions*, vol. 92 part 2B (1986): 61-71.

4. "Evaluating Reversing Valve Performance in Heat Pump Systems", by R.R. Krishnan. *ASHRAE Transactions*, vol. 92 part 2 (1986).

5. "Characterizing Losses in Reversing Valves: Heat Transfer Losses", by G. Damasceno, H. Nguyen, W. Lee, V.W. Goldschmidt, and L. White. *ASHRAE Transactions*, vol. 93 part 1 (1987): 327-340.

6. "Measurement of Refrigerant Leakage in Reversing Valves", by V.W. Goldschmidt, R.R. Scharf and L. White. *ASHRAE Transactions*, vol. 90 part 1 (1984): 185-195.

7. "The Effect of Different Materials on Heat Transfer of Reversing Valves", by R.T. Marks. *ASHRAE Transactions*, vol. 92 part 2 (1986): 81-87.

8. "A Refrigerant Enthalpy Method for Measuring Reversing Valve Heat Transfer", by D.P. Hargraves. *ASHRAE Transactions*, vol. 92 part 2 (1986): 88-94.

9. "Analysis of System Performance Losses Due to the Reversing Valve for a Heat Pump using R-410A", by Wei Fang and Darin Nutter. *ASHRAE Transactions*, vol. 105 part 1a (1999): 131-139.

Addendum to the RTAR

Summary comments on the Reference listing papers:

1. "Performance of Heat Pump Reversing Valves and Comparison through Characterizing Parameters", by G.D.S.Damasceno, W.N.T. Lee, S.P. Rooke, and V.W. Goldschmidt. *ASHRAE Transactions*, vol. 94 part 1 (1988): 304-317.

    - This is a paper presents performance correlation coefficients for a specific valve. The measurements related to internal leakage were reported in two earlier papers.

2. " Refrigerant Leakage in Heat Pump Reversing Valves including comparison to Air Leakage Measurements", by W.N.T. Lee, G.D.S. Damasceno, V.W. Goldschmidt, and R.T. Marks. *ASHRAE Transactions*, vol. 94 part 1 (1988): 458-466.

    - This paper describes an attempt to correlate R-22 seat leakage with measured air leakage in the same valve. 35 valves were tested and compared. The correlation between the two was very weak, or as the authors state, "barely acceptable." We can surmise two reasons for this. One, the test method used to measure the refrigerant leakage is incapable of producing data with anywhere near acceptable accuracy or repeatability. Two, the leak path geometry in the variety of valves tested is temperature sensitive to varying degrees depending on valve design and materials of construction (which shouldn't be at all surprising.)

3. "Heat Transfer, Pressure Drop, and Mass Leakage in Reversing Valves: Characterizing Parameters", by G. Damasceno, W. Lee, L. White, and V.W. Goldschmidt. *ASHRAE Transactions*, vol. 92 part 2B (1986): 61-71.

    - This paper presents data that confirms well-known theory. Specific to the heat transfer losses, the characterizations are not dimensionless and will not predict heat transfer performance at other than test conditions.

4. "Evaluating Reversing Valve Performance in Heat Pump Systems", by R.R. Krishnan. *ASHRAE Transactions*, vol. 92 part 2 (1986).

    - A good paper, overall. Presents a combined loss for leakage and heat transfer, but no means for separating the two is given. The paper does not present a means of developing generalized correlation characteristics that may be used to predict valve performance at other than tested conditions and/or with other working fluids.

5. "Characterizing Losses in Reversing Valves: Heat Transfer Losses", by G. Damasceno, H. Nguyen, W. Lee, V.W. Goldschmidt, and L. White. *ASHRAE Transactions*, vol. 93 part 1 (1987): 327-340.

- A good paper describing the heat transfer mechanisms and paths in the valve tested. There is no general correlation presented that may be used to predict heat transfer performance of this or any other valve at different conditions or with other working fluids.

6. "Measurement of Refrigerant Leakage in Reversing Valves", by V.W. Goldschmidt, R.R. Scharf and L. White.
ASHRAE Transactions, vol. 90 part 1 (1984): 185-195.

   - This data presented in previous papers. The problem is that the test method is impractical and incapable of producing reliable data.

7. "The Effect of Different Materials on Heat Transfer of Reversing Valves", by R.T. Marks.
ASHRAE Transactions, vol. 92 part 2 (1986): 81-87.

   - This paper demonstrates that significant improvements in heat transfer losses may be possible with different materials. No characterizing parameters for predicting heat transfer in the same valve with different working fluids are developed.

8. "A Refrigerant Enthalpy Method for Measuring Reversing Valve Heat Transfer", by D.P. Hargraves.
ASHRAE Transactions, vol. 92 part 2 (1986): 88-94.

   - This paper describes a practical way of evaluating the heat transfer characteristics for reversing valves. However, no characterizing parameters for predicting heat transfer in the same valve with various temperature differentials or working fluids are developed.

9. "Analysis of System Performance Losses Due to the Reversing Valve for a Heat Pump using R-410A", by Wei Fang and Darin Nutter.
ASHRAE Transactions, vol. 105 part 1a (1999): 131-139.

   - This paper reported a study on a single 3-ton system using R-410A and R-22. The bottom line is that they showed really no difference in performance loss with the two refrigerants. The COP loss due to the reversing valve is on the order of 6 – 7%.