DOE/ID/13308

**Technology Reinvestment Program/Advanced "Zero
Emission" Control Valve (Phase II)**

Final Report – 11/23/1993 – 12/31/1998

J. Napoleon

RECEIVED
JUL 17 2000
OSTI

December 1998

Work Performed Under Contract No. DE-FC07-94ID13308

**For
U.S. Department of Energy
Assistant Secretary for
Energy Efficiency and Renewable Energy
Washington, DC**

**By
Curtiss-Wright Flow Control Corporation
Farmingdale, NY**

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

DOE/ID/13308

TECHNOLOGY REINVESTMENT PROGRAM/ADVANCED "ZERO EMISSION"
CONTROL VALVE (PHASE II)

FINAL REPORT
11/23/1993 – 12/31/1998

J. Napoleon

December 1998

Work Performed Under Contract No. DE-FC07-94ID13308

Prepared for the
U.S. Department of Energy
Assistant Secretary for
Energy Efficiency and Renewable Energy
Washington, DC

Prepared by
Curtiss-Wright Flow Control Corporation
Farmingdale, NY

U.S. DEPARTMENT OF ENERGY
FEDERAL ASSISTANCE PROGRAM/PROJECT FINAL REPORT

Technology Reinvestment Program/Advanced "Zero Emission" Control Valve

FINAL TECHNICAL REPORT DE-FC07-94ID13308

Reporting Period 11/23/93 through 12/31/98

1.0 EXECUTIVE SUMMARY

The Target Rock Corporation Advanced "Zero Emission" Control Valve Development Technology Reinvestment Project (TRP) was a 2 Phase Program that successfully achieved all program objectives.

Phase I Program Objectives were to:

- Demonstrate the feasibility of spinning-off TRC's "zero emissions" valve (ZEV) technology to meet the fugitive emissions requirements of the 1990 Amendments to the Clean Air Act.
- Significantly reduce the cost and expand the applications for a family of Advanced "Zero Emissions" Control Valves.

Phase II Program Objectives were to:

- Greatly improve the ZEV's marketability by making the ZEV capable of: meeting severe and corrosive operational environments; continuously lowering its cost and demonstrating performance from in-situ assessments.
- Define and develop a conceptual design of a full featured digital controller with growth potential to "smart valve" capability to meet evolving commercial applications.

The objectives of Target Rock's TRP program that was administered by the Department of Energy were successfully achieved. Target Rock's Advanced Zero Emissions Valve:

- Was recognized by Processing Magazine as a "1998 Breakthrough Product of the Year" at ISA Show – Houston Astrodome (See Attachment 1)
- Model 100 and Model 120 received California Air Resource Board (CARB) endorsement and the California Environmental Technology Certification as a closed system without the potential for fugitive volatile organic compound emissions. (See Attachment 1)
- Demonstrated 4 Years of successful operation in Beta site at Exxon, Baton Rouge Refinery.

Subsequent to the conclusion of the funded program, Target Rock has successfully penetrated non-nuclear applications for the ZEV and Smart Valve technology developed as a result of the DOE/TRP funding. Furthermore, TR's Nuclear Navy Customer has expressed interest in this technology for other shipboard applications. These efforts would not have been completed within the time frame without the ARPA/DOE funding.

2.0 APPROACH

- A. Determine economic and technical needs for zero emission valve application in the Hydrocarbon & Chemical Processing Industry (HPI & CPI) markets for meeting the 1990 Clean Air Act Amendment (CAAA) volatile organic compound fugitive emissions requirements.
- B. Spin-off the "zero emissions" valve (ZEV) technology that is critical to the U.S. Navy's Nuclear Powered Fleet to meet these technical and market requirements.
- C. Develop a ZEV family line of prototypical designs that will allow the transitioned valve technology to meet the cost, functional, operational, performance and non-leakage requirements.
- D. Fabricate, assemble and test selected prototype valves.
- E. Install and perform in-situ evaluations of prototype valve at targeted facilities.
- F. Design, build and test a down sized valve controller and actuator that reduces valve product cost and expands valve utility.
- G. Design, build and test a magnetically controlled "zero emissions" control valve.
- H. Perform in-situ assessments of prototype valve systems.

3.0 SUMMARY OF ACCOMPLISHMENTS BY YEAR

The following Sections provide a chronology of Annual Accomplishments consistent with the annual Technology Progress Reports (See Attachments 1) submitted in accordance with Program Reporting requirements. These Reports are provided as Attachments to this Final Report.

3.1 ACCOMPLISHMENTS IN 1994

- A. Completed initial market and user requirements definition for Hydrocarbon & Chemical Processing Industries. This included a design review of commercial valve line.
- B. Completed initial definition of valve line & positioner requirements for targeted applications.
- C. Completed development of upgraded positioner & controller design requirements.

- D. Successfully breadboarded a reduced sized, reduced cost controller.
- E. Completed initial ZEV Commercialization Plan
- F. Completed installation of prototype valve for in-situ evaluation in large petrochemical plant. Valve has been performing flawlessly for over 7 months.

3.2 ACCOMPLISHMENTS IN 1995

- A. The operational prototype valve that was installed in April 1994, in the large Petroleum Refinery in Louisiana, performed flawlessly. The one glitch in operation that had been noted by the customer just prior to scheduled detailed customer evaluation was pinpointed to a maintenance technician's error. The detail customer evaluation included disassembly of the valve and an examination of the internals for wear, breakage or corrosion. The valve was returned to Target Rock for additional testing and underwent some minor refurbishment prior to shipment back to the refinery. The valve was reinstalled and the customer is pleased with the valve's performance. The hazardous application was toluene.
- B. The MPR Associate's Silicon Control Rectifier (SCR) positioner design was completed and a portable prototype manufactured. The positioner was tested in TRC'S loop test facility. Test results showed that the control portion of the design was unstable and lacking control elements found in other TRC positioners. Based on the fact that the SCR driver does not deliver the full power of the conventional DC power supply, a decision was made to enhance and repackage an existing positioner design with the following design concepts from the MPR positioner:
 - 1. Package in a commercial, low cost explosion-proof enclosure
 - 2. Local position indication (bargraph) circuitry
 - 3. Packaging using the modular function block approach
 - 4. MPR test program
- C. The repackaged positioner was completed through the prototype stage and is in process of loop testing. Preliminary test results revealed a signal noise problem due to the signal line routing in the new packaging design. Work is in process to resolve the noise problem and finalize PC Board artwork and parts lists. This will be continued in Phase II under Task 3.
- D. Work has started on an improved solenoid coil design, which enhances the solenoid power through an improved magnetic circuit. Design consideration was also given to the serviceability of the unit once installed on the ZEV. A slip-over-the-bonnet coil design was completed incorporating the improved magnetic circuit. A preliminary design prototype has not yet been manufactured. This work will be continued in Phase II under Task 2.
- E. The development of the ZEV prototype has provided useful information and insights; however, it has been determined that the best alternative for bringing a competitively priced product to market will be to incorporate these lessons learned into a commercial valve design. This work will be continued in Phase II under Task 2.

- F. Work was completed on a preliminary permanent magnet design tool specifically geared for valve operators. Application of this tool was used to develop a design for a scale model of a permanent magnet valve operator. Status at this time is that the detail drawings for the scale model valve operator are complete, and work is ready to start on the manufacture. A close working relationship was formed with a permanent magnet vendor which has produced design calculation confirmations and further insights for dealing with permanent magnets in a production environment. This work will be continued in Phase II program under Task 4.

3.3 ACCOMPLISHMENTS IN 1996

During 1996, expenditures on this project were temporarily put on hold while Target Rock determined the appropriate market direction.

- A. Pursuant to this we continued market research with the installed base user sites and discussions with process control instrumentation companies.
- B. Discussions with process control companies have identified specific "smart" valve communications protocols that should be adapted into the design of the ZEV.
- C. Market research has also identified specific design features that the market would like to see in a severe duty ZEV, including a high temperature coil design and a long life disc design. Technical work based on this market direction will be performed in 1997.

3.4 ACCOMPLISHMENTS IN 1997

- A. Successfully adapted the analog electronic technology developed initially in the nuclear market to an analog technology acceptable to the industrial marketplace. These efforts resulted in:
 1. Completion of a cost-reduction design of the positioner. A prototype positioner is now available and will be subject to in-situ testing at the first opportunity.
 2. Development of special tooling that is suitable for industrial use to support field installations of this product.
 3. The design and prototype development of an Electronic Stroke Meter required for calibration of the controller system.
- B. A major marketing effort was undertaken to identify specific features required to be incorporated into the control valves in order to be a successful competitor in the industrial market. Additional marketing research efforts were contracted to three organizations:
 1. Bay Technologies Group provided an overall assessment of each of the segments of the non-nuclear industrial market to determine features and benefits demanded by those markets, prime competition, and pricing strategies to achieve success.

2. Automation Research Corporation provided marketing studies providing detailed information on the development of digital process control systems, including what systems are available and descriptions of their technologies. In addition, their Automation Advisory Service provides information on the latest industry developments that should be considered in ZEV design.
 3. Applied Digital Engineering provided detailed information on communication protocols and interface requirements with the digital control systems sold by others.
- C. This market research, along with other industry initiatives, resulted in consolidating technical efforts into three distinct areas:
1. Zero Emissions - The Model 120 ZEV has been accepted into the California Environmental Protection Agency Pre-Certification Program. Under this program, the Cal/EPA certifies manufacturer's claims regarding the capabilities of a pollution reduction technology. CWFC contracted with Radian International to perform independent testing and design review of the ZEV and has submitted the results to the Cal/EPA to prove that our valve designs allow zero stem leakage.
 2. Digital Controllers - Marketing studies determined that a digital, rather than the existing analog interface is required to install the ZEV into the next generation of process controls. Participating in the process market requires that CWFC develop a digital interface using the communications protocols evolving in this industry. Various communication protocols were studied, including HART and Fieldbus, to determine the necessary adaptations for the ZEV to operate in digital control systems. Work began on digitizing the functions of the ZEV using off-the-shelf hardware and software,
 3. Specifications - Marketing studies resulted in identification of a series of specification requirements that are important to the process industries. These include mechanical requirements (such as seal-welding, end-to-end dimensions, temperature ranges, corrosion resistance), electrical requirements (such as intrinsically safe power and explosion-proof), and performance characteristics (such as speed, accuracy, and hysteresis). Industry demands certain documentation, such as standardized drawing systems and sizing programs.
 4. A ZEV prototype was developed for submittal to Underwriter's Laboratories (UL) for "explosion-proof" certification of the electrical housing.

3.5 ACCOMPLISHMENTS IN 1998

- A. Zero Emissions** - The Model 120 and the Model 100 ZEV were certified by the California Environmental Protection Agency Pre-Certification Program as a valid pollution reduction technology. The certification served as the basis for launching this product line into the industrial market at the October 1998 ISA (Instrument Society of America) Show. It greatly reduces monitoring costs for meeting EPA regulations. The results of the independent testing and design review of the ZEV that was performed by Radian International were submitted to Cal/EPA to prove that CWFC's valve designs allow zero stem leakage. Cal/EPA verified that:
1. The Model 120 is "equivalent to a flange"
 2. The Model 100 is "equivalent to pipe" with respect to fugitive emissions
- B. Digital Controllers** - A prototype digital controller was developed and previewed to the industry. The digital controller is less costly to produce and provides the capability for the ZEV to:
1. Communicate with automated process communication protocols (HART, Fieldbus, Lanworks).
 2. Incorporate on-line diagnostics and integral process controls to create a "Smart" valve.
- C. Traditional Analog Interfaces** - A design that will accept traditional analog signals for customers that have not upgraded their plants to digital control systems is under development.
- D. Specifications** - A ZEV prototype was developed and submitted to Underwriter's Laboratories (UL) for "explosion-proof" certification of the electrical housing. This rigorous testing was completed at the end of 1998. UL certification is currently pending the review of the final test data. No problems are anticipated in obtaining the certification. (Certification was received).

4.0 CONCLUSIONS

- A.** Target Rock demonstrated that it achieved all of the technical objectives defined in its TRP Phase I and Phase II Proposals.
- B.** Target Rock is continuing efforts to achieve the projected Commercialization goals for market penetration. Delays in enforcement of the CAAA of 1990 have impacted the anticipated demand for this product in existing processing facilities. However, the benefits that are realized from zero emissions and reduced life cycle maintenance costs has resulted in market penetration for new processing construction.

ATTACHMENT 1

FINAL TECHNICAL REPORT

DE-FC07-94ID13308

ANNUAL TECHNICAL PROGRESS REPORTS

1994 -1998

California Environmental Protection Agency

Air Resources Board
Equipment Precertification Program

ATTACHMENT 2

**Evaluation of the Air Quality Performance Claims
for Curtiss-Wright Flow-Control Valves:
Models 100 and 120**

June 1998

ABSTRACT

The purpose of this report is to document the Air Resources Board's (ARB's) evaluation and verification of the air quality performance claims made by the Curtiss-Wright Flow Control Corporation (CWFC) concerning its Model 100 and 120 flow-control valves. Upon successful completion of the requirements associated with the ARB's Equipment and Process Precertification Program (Equipment Precertification Program), a report is issued with two companion documents: 1) a certificate; and 2) an Executive Order. These companion documents serve as official records that the ARB has independently verified the performance claims presented in this report.

Certificates earned under the ARB's Equipment Precertification Program are valid for three years from the date issued, presuming the holder of the certificate complies with: 1) the terms and conditions identified in this report; and 2) the general requirements discussed in the Equipment Precertification Program Guidelines and Criteria. In addition, Executive Orders issued under the Equipment Precertification Program identify requirements necessary to retain a valid certificate.

The CWFC has been producing flow-control valves for nuclear power generation facilities since the early 1970's. The flow-control valves, which do not employ a stem, packing, or bellows, were designed to meet the requirements of the Nuclear Regulatory Commission. The CWFC plans to further expand the use of its valves into other industries and believes that becoming certified under the ARB's Equipment Precertification Program will assist with meeting this objective.

As part of its Equipment Precertification application package, the CWFC requested that the ARB evaluate three proposed performance claims with respect to the ability of the subject flow-control valves (Models 100 and 120) to control fugitive emissions of volatile organic compounds. As part of the precertification evaluation, the ARB assisted the CWFC in designing a test protocol to verify the proposed claims. Radian International Limited Liability Company (Radian) was chosen by the CWFC to conduct the testing after the ARB approved the test protocol. During the test, a minor modification to the Model 120 flow-control valve was requested by the CWFC. The ARB approved the change and testing continued as originally planned. After review of the final test results, in conjunction with the other documents discussed throughout this report, the ARB recommends that precertification certificates be issued to the CWFC for flow-control valve Models 100 and 120.

Applicant:	Curtiss-Wright Flow Control Corporation 1966E Broadhollow Road East Farmingdale, NY 11735-1768	Application Number: 980601 Executive Order: 698-016-93109-12 Date:
Equipment:	Flow-Control Valve Model 100 Flow-Control Valve Model 120	
Contact:	Mr. Steven R. Pauly	Title: Technical Support Manager
Phone:	(516) 293-3800, extension 647	Fax: (516) 293-4949
E-Mail:	spauly@trc.curtisswright.com	Website: www.trc.thomasregister.com
ARB Staff Contact:		ARB Website: www.arb.ca.gov

**CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY
AIR RESOURCES BOARD**

EQUIPMENT PRECERTIFICATION PROGRAM

**Evaluation of the Air Quality Performance Claims
for Curtiss-Wright Flow-Control Valves:
Models 100 and 120**

June 1998

Table of Contents

<u>Contents</u>	<u>Page</u>
I. Introduction	1
A. <u>Fugitive Emissions of Volatile Organic Compounds</u>	1
B. <u>Organization of Evaluation Report</u>	1
II. General Information	2
A. <u>Equipment Precertification Program Background</u>	2
B. <u>Relationship to Air Quality</u>	2
C. <u>Health and Environmental Impacts</u>	3
D. <u>Manufacture / Ownership Rights</u>	3
III. Summary of Scope	3
IV. Statement of Claims	4
V. Materials Available for Evaluation	4
VI. Technology Description	6
VII. Technical Evaluation	10
A. <u>Design Review</u>	10
B. <u>Description of Test Protocol</u>	10
VIII. Evaluation of Claims	12
IX. Test Results	14
X. Quality Management	17
XI. Environmental and Economic Benefits	17
XII. Recommendations	17
XIII. Suggested Operating Conditions	18
XIV. Precertification Conditions	19
XV. Figures	

1. Curtiss-Wright Flow Control Valve Model 100	7
2. Curtiss-Wright Flow Control Valve Model 120	7
3. Curtiss-Wright Flow Control Valve Model 120 Cutaway	8
4. Curtiss-Wright Flow Control Valve Cutaway	9
5. Curtiss-Wright Flow Control Valve Cycle Test Loop	13

XVI. Appendices

Appendix A - Test Results for Curtiss-Wright Flow-Control Valve Model 120

Appendix B - "Testing to the Fugitive Emission Standards," Valve Magazine, fall, 1997.

I. INTRODUCTION

This report discusses the technology used by the Curtiss-Wright Flow Control Corporation (CWFC) in the design of its flow-control valves, the performance claims to be verified by the Air Resources Board (ARB), the test procedures used, the test results, and the findings and recommendations of ARB staff concerning the flow-control valves evaluated.

A. Fugitive Emissions of Volatile Organic Compounds

The control of fugitive volatile organic compounds (VOC) emissions from flow-control valves is part of the overall strategy to achieve and maintain healthy air quality in California. Through a series of complex atmospheric reactions, VOCs contribute to the formation of ground-level ozone. As such, federal, state and local air quality programs include strategies to reduce fugitive emissions of VOCs into the atmosphere. These control strategies rely heavily on promoting the development and use of continually improving technologies, as well as periodic inspection and maintenance procedures to ensure that performance is maintained.

The CWFC believes that its flow-control valve Models 100 and 120 are effective at reducing fugitive VOC emissions from a variety of industrial applications. As such, the CWFC submitted an application under the ARB's Equipment Precertification Program. As part of its application package, the CWFC requested verification of the claims that its flow-control valve Models 100 and 120 reliably reduce VOC fugitive emissions.

B. Organization of this Report

This report is organized into several

sections. The first section, General Information, provides background information on the ARB's precertification program, as well as the CWFC flow-control valves being evaluated. The next four sections: Summary of Scope; Statement of Claims; Materials Available for Evaluation; and Description of Technology discuss the breadth of our evaluation, the performance claims for the flow-control valves, the information that we relied on to conduct our evaluation, and a detailed description of the CWFC's flow-control valves (Models 100 and 120).

The following three sections: Technical Evaluation; Evaluation of Claims; and Test Results; present detailed information on our technical review and assessment of the performance of the flow-control valves. The sections entitled: Quality Management and Environmental and Economic Benefits provide supporting information on the CWFC's procedures to produce values which meet the company's claims. These sections also provide a brief assessment of the potential environmental and economic impacts of the technology.

Finally, the remaining sections: Recommendations; Suggested Operating Conditions; and Precertification Conditions discuss the ARB staff's determination of the performance of the valves relative to the company's claims. These sections also provide some general guidance with respect to air quality permitting considerations as well as specific conditions that must be met for the certificate to remain valid for three years. The Appendices contain additional information supporting the evaluation documented in this report.

II. GENERAL INFORMATION

Under the regulations established by the program, equipment or processes eligible for the Equipment Precertification Program must: 1) have an air quality benefit; 2) be commonly-used or have the potential to be commonly-used in the near future (market ready); and, 3) not pose a significant potential hazard to public health and safety and the environment. Furthermore, to be eligible for the program, applicants for the program must demonstrate that they have sufficient control over the manufacture of the equipment or process to ensure that they can consistently and reliably produce equipment which performs at least as well as that considered as part of this evaluation.

A. Equipment Precertification Program Background

The Equipment Precertification Program is a voluntary statewide program for manufacturers of commonly-used equipment or processes. A precondition for entry into the program is that the equipment has an air quality benefit. On June 14, 1996, the ARB adopted section 91400 of the California Code of Regulations which incorporates the Criteria for Equipment and Process Precertification. The regulation and Criteria were approved by the California Office of Administrative Law on October 31, 1996 and became effective on November 30, 1996.

Under the Equipment Precertification Program, manufacturers request that the ARB conduct an independent third-party verification of performance claims which focus on the air quality benefits of its equipment or process. If the claim is verified, the manufacturer is free to refer to the results

of the ARB's evaluation in its marketing literature. Upon successful completion of the verification process, the applicant may also request that the ARB notify specific air pollution control and air quality management districts (districts) in California of the ARB's determination. As a result of the ARB's notification, the district has an advanced opportunity to become familiar with the performance of the equipment or process.

On June 3, 1996, the ARB received a request from the CWFC that ARB determine if its flow-control valves Models 100 and 120 were eligible for the Equipment Precertification Program. After receiving confirmation from the ARB that the flow-control valves were eligible for the program, the CWFC submitted a precertification application package to the ARB. Based on our initial review of the application package, we advised the CWFC that emissions testing would be needed to support the proposed claims. In response, the CWFC contracted with Radian International to perform testing of the flow-control valves Models 100 and 120. Prior to conducting the tests, the ARB staff approved the emissions test protocol. Once the tests were completed, we evaluated the results along with other information concerning the past performance of the flow-control valves to determine whether the claims were verifiable.

B. Relationship to Air Quality

In an effort to make progress towards attaining healthy air quality in California, regulations restrict fugitive emissions of VOCs from a broad spectrum of activities. The reduction of fugitive VOC emissions from flow-control valves is one part of California's clean air strategy. Typically,

flow-control valves have a valve stem, several seals and bellows. All are common locations for VOC emissions. As such, local air district rules and regulations specify emission limits and inspection schedules (see section XIV. Suggested Operating Conditions). Because the use of the CWFC flow-control valves Models 100 and 120 is claimed to reduce fugitive VOC emissions, the ARB evaluated the valves as air pollution control equipment.

C. Health and Environmental Impacts

As part of our evaluation, staff conducted a cursory review of the potential environmental impacts associated with the CWFC's flow-control valves Models 100 and 120. Based on this review, we concluded that the valves would not likely present health or environmental impacts different from those associated with valves currently in wide use throughout California. Please note that the CWFC is required to meet all applicable health and safety standards with respect to the manufacture, installation, use, and maintenance of its flow-control valves Models 100 and 120.

D. Manufacture / Ownership Rights

The recommendations in this report are contingent upon the CWFC Corporation having the legal rights to produce and/or market flow-control valve Models 100 and 120. The CWFC documented its ownership of these rights in a letter to the ARB dated July 14, 1997, which stated, "Curtiss-Wright Flow Control Corporation confirms that we retain the ownership rights to manufacture or otherwise produce the equipment to be precertified, both in the form of precertification conditions and the requirements in the Criteria for Equipment

and Process Precertification, upon the production and marketing of the equipment."

III. SUMMARY OF SCOPE

The CWFC claims that the use of its flow-control valve Models 100 and 120 will control fugitive VOC emissions associated with the handling and storage of hydrocarbons. Most fugitive VOC emissions resulting from the handling and storage of hydrocarbons are leaks from process equipment and evaporation from open areas. Generally, the control of fugitive VOC emissions involves minimizing leaks and spills through the use of efficient air pollution control equipment (including state-of-the-art flow-control valves), modifying processes, increasing monitoring and inspection frequency, and improving maintenance practices.

For purposes of this report, VOCs are considered to be any compound containing at least one atom of carbon, except exempt compounds. Exempt compounds include:

- carbon monoxide
- carbon dioxide
- carbonic acid
- metallic carbides or carbonates
- ammonium carbonate
- 1,1,1-trichloroethane
- methylene chloride
- trichlorofluoromethane (CFC-11)
- dichlorodifluoromethane (CFC-12)
- chlorodifluoromethane (CFC-22)
- trifluoromethane (CFC-23)
- trichlorotrifluoroethane (CFC-113)
- dichlorotetrafluoroethane (CFC-114)
- chloropentafluoroethane (CFC-115)
- dichlorotrifluoroethane (CFC-123)
- 2-chloro-1,1,1,2-tetrafluoroethane

(HCFC-124)
pentafluoroethane (HFC-125)
1,1,2,2-tetrafluoroethane (HFC-134)
tetrafluoroethane (HFC-134a)
dichlorofluoroethane (HCFC-141b)
chlorodifluoroethane (HCFC-142b)
1,1,1-trifluoroethane (HFC-143a)
1,1-difluoroethane (HFC-152a)

and the following four classes of
perfluorocarbon (PFC) compounds:

1. cyclic, branched, or linear, completely fluorinated alkanes;
2. cyclic, branched, or linear, completely fluorinated ethers with unsaturations;
3. cyclic, branched, or linear, completely fluorinated tertiary amines with no unsaturations; and
4. saturated perfluorocarbons containing sulfur and with sulfur bonds only to carbon and fluorine atoms.

IV. STATEMENT OF CLAIMS

The following are the claims verified by ARB staff concerning the CWFC flow-control valve Models 100 and 120. The verification of these claims is predicated on the presumption that the flow-control valves are installed and operated in accordance with the manufacturer's installation and operating instructions.

1. The Curtis Wright Flow Control Corporation Model 100 flow-control valve is a closed system without the potential for fugitive VOC emissions.
2. The Curtiss-Wright Flow Control Corporation Model 120 flow-control valve has a calculated fugitive VOC emission rate that is no greater than

5.0E-8 kilograms per hour (.001 pounds per year).

3. The Curtiss-Wright Flow Control Corporation Model 120 flow-control valve showed no performance degradation after 112,109 cycles with respect to fugitive VOC emissions.

V. MATERIALS AVAILABLE FOR EVALUATION

The following materials were used as part of our evaluation of the CWFC's flow-control valve Models 100 and 120:

1. Request to Determine Eligibility for ARB Precertification of Equipment or Processes from Mr. James D. White of the Curtiss-Wright Flow Control Corporation to Chairman John Dunlap of the ARB transmitting the Determination of Eligibility application, June 3, 1996.
2. Application for the ARB Equipment Precertification Program from Mr. James D. White of the Curtiss-Wright Flow Control Corporation to Mr. Raymond E. Menebroker of the ARB transmitting the application for the ARB precertification program, April 11, 1997.
3. Curtiss-Wright Flow Control Corporation, General Reference Book for Model 100 "Leakless" Control Valves and Model 120 "Leakproof" Control Valves, September 22, 1997.
4. Target Rock Corporation, Quality Assurance Manual, Revision E, April 2, 1996.

5. Memorandum from Mr. Raymond E. Menebroker of the ARB's Stationary Source Division to Mr. George Lew of ARB's Monitoring and Laboratory Division requesting assistance in the evaluation of a testing protocol for the CWFC flow-control valves models 100 and 120, June 3, 1997.
6. Letter from Mr. Richard Corey of the ARB to Mr. Kurt Walderon of the Chevron Pipe-Line Company, July 25, 1997, thanking Mr. Walderon for the field tour where the CWFC flow control valve Model 120 is in use.
7. Letter from Mr. Steven R. Pauly of the Curtiss-Wright Flow Control Corporation to Mr. Richard Corey of the ARB transmitting the CWFC precertification application to the ARB, July 14, 1997.
8. Letter from Mr. Steven R. Pauly of the Curtiss-Wright Flow Control Corporation to Mr. Glenn B. Simjian of the ARB providing clarification of items in the CWFC application, July 28, 1997.
9. Letter from Mr. Richard Corey of the ARB to Mr. Steven R. Pauly of the Curtiss-Wright Flow Control Corporation confirming receipt of the application package, July 31, 1997.
10. Code of Federal Regulations, Title 40, Part 60, Appendix A, Reference Test Method 21. Determination of Volatile Organic Compound Leaks, U.S. Government Printing Office Washington, D.C., June 22, 1990.
11. Air Resources Board, California Clean Air Act Guidance for the Determination of Reasonable Available Control Technology for The Control of Fugitive Emissions of Volatile Organic Compounds from Oil and Gas Production and Process Facilities, Refineries, Chemical Plants, and Pipeline Transfer Stations, December 8, 1993.
12. Letter from Mr. Steven R. Pauly of the Curtiss-Wright Flow Control Corporation to Mr. Glenn B. Simjian of the ARB transmitting the testing protocol for flow-control valve Models 100 and 120, September 12, 1997.
13. Letter from Mr. George Lew of ARB's Monitoring and Laboratory Division to Mr. Raymond E. Menebroker of ARB's Stationary Source Division approving Curtiss-Wright's testing protocol, September 22, 1997.
14. Letter from Mr. Richard Corey of the ARB to Mr. Steven R. Pauly of the Curtiss-Wright Flow Control Corporation approving the CWFC's testing protocol for flow-control valve Models 100 and 120, September 26, 1997.
15. Letter from Mr. Steven R. Pauly of the Curtiss-Wright Flow Control Corporation to Mr. Richard Corey of the ARB requesting approval to modify flow-control valve Model 120, November 14, 1997.
16. Letter from Mr. Richard Corey of the ARB to Mr. Steven R. Pauly of the Curtiss-Wright Flow Control Corporation approving the modification to flow-control valve Model 120, November 18, 1997.

17. Report from Mr. Steven R. Pauly of the Curtiss-Wright Flow Control Corporation to Mr. Richard Corey of the ARB documenting the testing results for flow-control valve Models 100 and 120, January 13, 1998.
18. Curtiss-Wright Flow Control Corporation, Pre-Certification Report for Model 100 and 120 Control Valves, Fugitive Emissions Evaluation and Test Program (Project 97X-130 TRP No. 6319), January 13, 1998.

For information on how to obtain these materials, please contact the ARB at the number provided at the beginning of this document.

VI. TECHNOLOGY DESCRIPTION

The CWFC flow-control valve Models 100 and 120 are a departure from the standard air-or motor-operated valve design typically used for the storage and handling of hydrocarbons. Specifically, the Models 100 and 120 flow-control valves are solenoid-actuated; they do not use a stem, packing, or bellows. Further, flow-control valve models isolate all moving parts within the process pressure boundaries. The Model 100 flow-control valve is completely seal-welded, whereas the Model 120 flow-control valve is seal-welded except for one body-to-bonnet joint sealed with an O-ring (figure 1 and 2).

The CWFC flow-control valves are used to control the flow of liquids, steam, or gases. These valves are solenoid-actuated and employ a pilot disc to assist actuation. The two basic designs are on/off isolation valves and modulating control valves each with hard or soft seats and in either fail open or fail

closed configurations. As shown in figure 3 (typical), the stainless steel bonnet assembly, which encloses the moving parts (plunger, discs, connecting rods, and part of the position sensor assemblies), is either threaded and seal-welded to the valve body (Model 100) or bolted with an O-ring seal to the valve body (Model 120). The solenoid assembly, electrical hardware, and other parts of the position sensor assembly, are mounted on the outside of the bonnet assembly. Modulating control valves use a linear variable differential transformer (LVDT) as a position sensor (figure 3). On/off isolation valves use reed switch assemblies activated by a magnet assembly (figure 4) inside the bonnet for position indication. Both the Model 100 and 120 flow-control valves are designed to operate on AC or DC voltage.

As shown in figure 4, operation of the flow-control valves occurs when the solenoid assembly is energized. It develops a magnetic field, which lifts the plunger. This pulls the pilot off its seat in the main disc opening the vent port. This changes the differential pressure between the top and bottom surfaces of the main disc, which raises the main disc in servo motion to the pilot, and allows the fluid at the inlet to flow.

When the solenoid assembly is de-energized, eliminating the magnetic force on the plunger, the return spring seats the pilot disc in the vent port. As shown in figure 4, with the vent ports closed, the control pressure above the main disc increases. When the control pressure increases sufficiently, the combined influence of the differential pressure and the return spring exerts a downward force on the main disc, seating it in the body, thereby closing the valve. As the main disc moves, the motion is

Curtiss-Wright Flow Control Valves Models 100 and 120

Model 100

figure 1

Model 120

figure 2

Curtiss-Wright Flow Control Valve Model 120 Cutaway

figure 3

Curtiss-Wright Flow Control Valve Cutaway

figure 4

transmitted through the plunger to the position sensor element inside the pressure boundary. The internal movement is sensed by the external element of the position sensor assembly to signal the valve's position. In the absence of differential pressure, the solenoid coil develops sufficient force to fully open the valve directly.

The CWFC flow-control valve Models 100 and 120 differ from standard flow-control valves in several respects. Specifically, the Model 100 and 120 valves do not have a stem, packing, or bellows. Furthermore, the Model 100 does not have a bonnet flange. These components are eliminated because they are traditionally weak spots for leaks, fugitive emissions, or failure. The CWFC believes that by replacing these components, leaks from the following areas are eliminated:

1. Stem seal - this is a dynamic (moving) seal between the packing and the externally-actuated stem. The movement may be rotational, linear, or a combination of the two. This is the most common point where valves leak. The stem leakage rate almost always contributes the bulk of the total fugitive emissions.
2. Packing gland - this is a static seal between the packing and the valve body. This is also a common leak point, and as such can influence fugitive emissions from flow-control valves.
3. Bellows - the bellows is a flexible barrier that provides additional protection against fugitive emissions from typical valves. However, over time bellows can develop cracks leading to leaks.

In addition to not having a stem, packing gland, or bellows, the CWFC's Model 100 flow-control valve does not have a bonnet flange. The bonnet flange is a static seal between the upper and lower sections of the valve. It is typically a flanged connection, but may sometimes be screwed or welded. Bonnet flange leaks are less common than leaks from stem seals and packing glands.

The CWFC's flow-control valve Model 120 has a bonnet joint-sealed with an O-ring. As this is a potential location for fugitive emissions, the Model 120 was subjected to the testing procedures described in Section VII.

VII. TECHNICAL EVALUATION

A. Design Review:

Radian International, as a contractor to the CWFC, performed an independent design review of the flow-control valves Models 100 and 120. Based upon the materials evaluated as part of this report (see section V, Materials Available for Evaluation), including the design review conducted by Radian International, ARB staff has verified the following:

Model 100

It was determined that it was not necessary to test the Model 100 (figure 1) flow-control valve for fugitive VOC emissions because it is completely seal-welded. The CWFC requested that the Model 100 flow-control valve be verified as equivalent (from an emissions perspective) to four welded connections. In short, properly-welded connections do not have fugitive VOC emissions. As such, when properly installed and operated, the Model 100 flow-control

valve would not have fugitive VOC emissions.

Model 120

The Model 120 flow-control valve is seal-welded except for one body-to-bonnet joint (figure 2), sealed with one O-ring. This feature should enable the valve to reduce fugitive emissions as compared to more typical valves. The CWFC requested that the Model 120 flow control valve be verified as equivalent (from an emission perspective) to three welded connections and one flanged connection. The Model 120 flow-control valve that was tested on October 29, 1997 had two O-ring seals. One of the O-ring seals was at the main body-to-bonnet joint as described above. A second (figure 3) O-ring seal was located at the indicator tube-to-bonnet joint. However, on November 14, 1997, the CWFC notified the ARB that it intended to replace the second O-ring with a seal-weld. After receiving approval to modify the test plan from the ARB, a second test reflecting the modification was performed on December 17, 1997.

Figure 3 is a cut away view of the flow-control valve Model 120, showing the pressure boundary, location of the seal welds, and the O-ring. These are areas where emissions could possibly occur. For Model 120 flow-control valves, three of four pressure boundary joints are completely seal-welded. However, the body-to-bonnet joint is sealed with an elastomer O-ring (the pressure boundary is shaded in figure 3). All seals are static seals; there are no moving seals like conventional stem seals. In addition, all of the joints are flanged seals or are welded. The flanged joints are highly engineered and controlled to eliminate the lateral stresses that

exist on similar flanged connectors in plant piping systems and can contribute to connector emissions.

B. Description of Test Protocol

Prior to conducting an emissions test of flow-control valve Model 120, we requested that a test protocol be prepared. We received a test protocol from the CWFC on September 12, 1997. We approved the test protocol and notified the CWFC of our determination on September 26, 1997.

Radian International used the United States Environmental Protection Agency (U.S. EPA) Reference Test Method 21 (Determination of Volatile Organic Compound Leaks) for the testing of flow-control valve Model 120. The testing of Model 120 consisted of two phases. The key elements of the two phases of the tests are as follows:

Phase I - Pre-Acceleration Wear Testing (Model 120):

1. Pressurize the valve to 300 pounds per square inch gas (psig) with methane
2. Screen the valve for any sign of leakage using U.S. EPA Reference Test Method 21
3. Perform a blow-through bag test to measure leakage
4. Screen the valve for any sign of leakage using U.S. EPA Reference Test Method 21
5. Depressurize the valve and return it to the manufacturer for accelerated wear testing and modifications.

Phase II - Post-Acceleration Wear Testing (Model 120):

1. Pressurize the valve to 300 psig with

methane

2. Screen the valve for any sign of leakage using U.S. EPA Reference Method 21
3. Perform a blow-through bag test to measure leakage
4. Screen the valve for any sign of leakage using U.S. EPA Method 21.

Phase I of the testing of Model 120 was performed on October 29, 1997. The valve was then sent back to the CWFC where the modifications (o-ring replaced with seal weld) were made and a 112,109 valve cycle test was performed (figure 5). After the cycle test was completed, the valve was returned to Radian International for Phase II of the test on December 17, 1997.

Phase II of the test was identical to Phase I for the purposes of the emissions testing. The purpose of the second phase of testing was to verify that the Model 120 flow-control valve had no increase in fugitive emissions after 112,109 total cycles. Methane was used in this test because it is a light-end hydrocarbon and, as such, is an excellent surrogate for detecting fugitive VOC emissions.

The accelerated wear test was initiated once the valve was returned to the factory after the first phase of testing. The valve was installed in the test loop shown in figure 5. The valve was pressurized with shop air at room temperature at approximately 100 psig. The outlet needle valve was throttled down to limit outlet flow as necessary. The valve's position indicator circuit was connected to a system that relayed the position signal to a cycle counter. The valve was checked at least three times a day to record the number of cycles completed. An accumulator, to stabilize supply pressure, and a muffler were

also included in the testing loop. The test was administratively terminated when 112,109 cycles were achieved.

VIII. EVALUATION OF CLAIMS:

This section presents additional information relating to the claims verified by ARB staff as part of its evaluation. As stated earlier, the ARB staff evaluation and recommendations, as presented in this report, are predicated on the expectation that the flow-control valves are installed and operated in accordance with the manufacturer's instructions.

To assist the reader, each of the claims identified on page 4 (IV. Statement of Claims) are repeated in this section. Following each claim are supporting comments which may be helpful in interpreting the significance of each claim.

1. **The Curtiss-Wright Flow Control Corporation Model 100 flow-control valve is a closed system without the potential for fugitive VOC emissions.**

Based on our evaluation, the CWFC Model 100 flow-control valve should be treated as four welded connections from the perspective of fugitive VOC emissions. Given that properly-welded connections form a complete seal, no fugitive VOC emissions would be expected. As such, the valve would not be expected to require monitoring beyond that appropriate for welded connections.

2. **The Curtiss-Wright Flow Control Corporation Model 120 flow-control valve has a calculated fugitive VOC emission rate that is no greater than 5.0E-8 kilograms per hour (.001**

Curtiss-Wright Cycle Test Loop

figure 5

pounds per year).

The emission rate presented in the claim is an upper-bound estimate (i.e., actual emissions are expected to be lower). The upper-bound emission rate was calculated by considering the fact that the test gas (methane) used as a surrogate for fugitive VOC emissions was *not detected* at the lower limit of detection (1 ppm) of the analyzer used in the emissions test of the CWFC Corporation Model 120 flow-control valve. As is typically the case for emission results which are below the limit of detection, one-half of the detection limit was used in the calculation of a fugitive VOC emission rate for the Model 120 flow-control valve.

From the perspective of fugitive VOC emissions, the CWFC Model 120 flow-control valve should be treated as a seal-welded unit with one flange.

3. The Curtiss-Wright Flow Control Corporation Model 120 flow-control valve showed no performance degradation after 112,109 cycles with respect to fugitive VOC emissions.

This was documented by our evaluation of the emissions test results. Specifically, after 112,109 cycles, methane was not detected in any of the tests of the O-ring seal in the bonnet-to-body joint.

IX. TEST RESULTS:

The testing protocol for the CWFC flow-control valve Model 120 employed the U.S. EPA Reference Test Method 21 in conjunction with the procedure described in the Protocol for Equipment Leak Emissions Estimates (United States Environmental

Protection Agency, Publication Number EPA-453/R-39-026). The CWFC received the ARB's approval on September 26, 1997, to use the test protocol in the emissions testing. The summary of the test results submitted by the CWFC are presented in Appendix A.

The bonnet-to-body joint of the CWFC Model 120 flow-control valve was tested in the Radian Corporation laboratories before and after an accelerated wear test consisting of 112,109 open/close cycles. Two bag tests were performed before the accelerated wear test and three bag tests were performed after the accelerated wear test. One pre-acceleration bag test was conducted at a nitrogen flow rate of 2 liters per minute, while the other was conducted at 7 liters per minute. The post-acceleration bag tests were all conducted at nitrogen flow rates of approximately 2 liters per minute.

The purpose of the accelerated wear test was to demonstrate that the CWFC Model 120 flow-control valve showed no degradation, with respect to emissions, after a specific amount of use. An article appearing in Valve Magazine, entitled "Testing to the Fugitive Emission Standards", (included in Appendix B) was the basis for selection of the number of cycles in the test. The article referred to the use of 100,000 cycles as an appropriate value to use to evaluate accelerated wear in high performance control valves.

A Radfish total hydrocarbon analyzer with a lower detection limit of 1 part per million (ppm) was used to detect hydrocarbons. Methane was chosen as the test gas because, as a light-end hydrocarbon, it is an excellent surrogate for detecting fugitive VOC emissions. Methane was not detected at

the lower limit of detection (1 ppm) of the analyzer in any of the pre-acceleration or post-acceleration bag tests. Using the ARB's standard approach for evaluating emissions data which are below the detection limit, one-half of the detection limit was used in the calculation of the fugitive VOC emission rate for the Model 120 flow-control valve.

Test run number F3 was chosen as the basis for the emissions calculation because it represented the most conservative (highest) estimated emission rate. A calculation of the emission rate for the pre-accelerated wear test

is presented on the following page.

In summary, the CWFC flow-control valve Model 120 valve had no detectable emissions before or after the accelerated wear test. As stated in the claims section of this report, the resulting VOC fugitive emission rate from the bonnet-to body joint was calculated to be no greater than $5.0E-8$ kilograms per hour, which is equivalent to approximately 0.001 pounds per year.

Kilograms of volatile organic compounds (VOC) per hour =

$$\left[\text{HC} \right] \times \left[\frac{\text{CGMW}}{(\text{MV} \times \text{NC})} \right] \times \left[\frac{\text{N}}{1 - (\text{OR} + \text{VC})} \right] \times \left[\text{ML} \right]$$

Where:

VC = VOC concentration (reported as methane)

CGMW = Molecular weight of calibration gas (methane)

MV = Molar volume at normal conditions, 0 degrees Celsius (0°C)

NC = Conversion of normal cubic meters per hour at 0°C to cubic meters per hour at 1atm

N = Flow rate of nitrogen

OR = Ratio of oxygen concentration in sampling device, to oxygen concentration in ambient air

ML = Factor to convert from grams per minute (g/min) to kilograms per hour (kg/hour)

Inputs for test run:

$$\text{VC} = 0.5 \times 10^{-6}$$

$$\text{CGMW} = 16 \text{ grams/mole}$$

$$\text{MV} = 22.413 \text{ L/mole}$$

$$\text{NC} = \frac{22^\circ\text{C} + 273^\circ\text{C}}{273^\circ\text{C}} = 1.08$$

$$\text{N}_2 = 2.0 \text{ L/min}$$

$$\text{ML} = \frac{.06 \text{ kg/hr}}{\text{g/min}}$$

$$\text{OR} = 4.5\% / 21\% = .21$$

Note: 22°C was ambient temperature during testing

Test run calculations:

$$\left[0.5 \times 10^{-6} \right] \times \left[\frac{16 \text{ g/mole}}{22.413 \text{ L} \times 1.08} \right] \times \left[\frac{2 \text{ L/min}}{[1 - (.21 - 0.5 \times 10^{-6})]} \right] \times \left[\frac{.06 \text{ kg/hr}}{\text{g/min}} \right] =$$

$$\left[0.5 \times 10^{-6} \right] \left[\frac{16}{24.21} \right] \left[\frac{2}{.79} \right] \left[.06 \right] =$$

$$\left[0.5 \times 10^{-6} \right] \left[.66 \right] \left[2.53 \right] \left[.06 \right] =$$

$$5.0 \times 10^{-4} \text{ kilograms of VOCs per hour}$$

X. QUALITY MANAGEMENT

The CWFC has developed extensive quality management practices and standards for its flow-control valve Models 100 and 120. The standards are described in the CWFC, Target Rock Corporation Quality Assurance Manual, Revision E, April 2 1997. This Manual incorporates the provisions of Sections I and VIII of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code. The Manual contains established quality management practices for the following areas:

- Design, Drawing, Specification
- Material Control and Procedure Control
- Process Control
- Inspection and Testing
- Control of Measuring
- Valve Stamping and Test Equipment Sealing
- Record Retention
- Forms

The CWFC's Quality Management Program was reviewed by ARB staff as part of our evaluation of flow-control valves Models 100 and 120. As a result of our evaluation, ARB staff has determined that the quality management program is sufficiently comprehensive to support certifying the CWFC flow-control valve Models 100 and 120.

XI. ENVIRONMENTAL AND ECONOMIC BENEFITS

As part of our review, we evaluated the potential air quality impacts of the flow-control valve Models 100 and 120. The use of the flow-control valves will likely result in a reduction of fugitive VOC emissions when

compared to traditional valves with a stem, packing, and bellows.

As part of our evaluation, we also contacted current users of the CWFC flow-control valves. The users of the flow-control valves, which were from various industries, indicated that the flow-control valves have a significantly longer life, with less required maintenance, than conventional flow-control valves. The ARB staff also visited a petroleum bulk terminal where one of the flow-control valves has been used successfully for several years. It should be noted that under certain conditions, emission reductions resulting from the installation of the CWFC flow-control valves may be eligible for emission reduction credits. Therefore, appropriate air districts in California should be consulted to determine the eligibility for any emission reduction credits.

XII. RECOMMENDATIONS

After evaluating the information discussed in this report, ARB staff recommends that the CWFC flow-control valve Models 100 and 120 be certified under its Equipment Precertification Program. Specifically, we have independently verified the claims of the CWFC concerning its flow-control valves Models 100 and 120, as presented in the claims section of this report.

By accepting certification under the ARB's program, the CWFC assumes, for the duration of the three-year certification period, responsibility for maintaining the quality of the manufactured equipment and materials at a level equal to or better than was provided to obtain this certification. Certification under the ARB's program is also contingent on the recipient agreeing to be subject to quality

monitoring by the ARB as provided by law.

The ARB makes no express or implied warranties as to the performance of the manufacturer's product or equipment. Nor, does the ARB warrant that the manufacturer's product or equipment is free from any defects in workmanship or material caused by negligence, misuse, accident, or other causes. The ARB staff believes, however, that the CWFC's flow-control valves Models 100 and 120 will achieve performance levels presented in the claims section of this report. Our determination is based on our evaluation of the data submitted by the CWFC, as well as the other information identified in this report. Our recommendations are predicated on the expectation that installation and operation of the valves are performed in accordance with the manufacturer's specifications.

XIII. SUGGESTED OPERATING CONDITIONS

In California, stationary sources are permitted at the local level by districts. Each of California's 35 districts have rules and regulations which must be met to receive and maintain an air quality permit. The district rules and regulations reflect federal and state regulatory requirements as well as any additional requirements that the district boards determine to be appropriate for the region.

Technologies which have been certified under the ARB's Equipment Precertification Program are subject to the same federal, state, and local permitting requirements as sources which have not been certified. In short, receipt of a certificate under the ARB's Equipment Precertification Program does not in any way limit the authority of local air

districts. However, it is expected that local air districts will have an interest in considering the information presented in this report when making permitting decisions. Therefore, we have included some information on inspection frequency that districts may consider helpful when making permitting decisions on the valves discussed in this report.

After it has been determined that the valve has been properly installed, the inspection recommendations differ for the Model 100 and Model 120 flow-control valves. Specifically, it is recommended that the Model 100 be inspected on a frequency consistent with that which applies to welded pipe. That is because, if properly installed, the Model 100 does not include any features which would suggest that there is a potential for fugitive emissions.

For the Model 120, quarterly to semi-annual inspections (using a leak detection instrument) are suggested for the first year. A measurement of 10,000 parts per million or greater should be considered a leak. If four consecutive readings below 100 parts per million or less are recorded, it is recommended that the inspections be conducted annually.

If, during any inspection, a reading of 10,000 parts per million or greater is recorded, it is recommended that the valve be repaired and that quarterly inspections be resumed. Alternatively, if any readings are over 100 parts per million but less than 10,000 it is suggested that the cause of the reading be investigated and that the valve be repaired if needed. After any repair is completed, it is suggested that inspections take place on a quarterly basis until four consecutive readings below 100 parts per million are made, then

return to annual inspections.

XIV. PRECERTIFICATION CONDITIONS

The recommendations in this report are conditional on the flow-control valves being installed, inspected and maintained, in

accordance with the CWFC operator's manual and the CWFC General Reference book. In order for the precertification to remain valid, the CWFC must retain manufacturing rights to the flow-control valves Models 100 and 120.

Appendix A

Test Results for Curtiss-Wright Flow Valve Model 120

Bag Testing Report

Target Rock Control Valve Model 120

Introduction

This is a report of testing that was performed on the Target Rocket Model 120 control valve. The testing was done by Radian International LLC in our Austin, Texas, laboratory on October 29 and December 17, 1997. The test was performed in accordance with the test plan submitted to and approved by CARB with a few exceptions noted below.

Results

The Target Rock Model 120 control valve was tested in the Radian laboratories before and after an accelerated wear test of >50,000 open/close cycles. Two bagging tests were performed during the initial testing before accelerated wear, and three bagging tests were performed after the accelerated wear test. All test results were below the detectable levels of the Ratfisch total hydrocarbon analyzer, and the emissions are calculated as less than the emissions at the detection limit. Table 1 presents a summary of the test results.

In the initial test series, two bagging tests were done on the bonnet-to-body joint, one at a nitrogen flow rate of nominally 7 liters per minute and one at 2 liters per minute. Hydrocarbon concentrations were below the detectable level on both runs. The Ratfisch Model RS55CA total hydrocarbon analyzer had a lowest scale division of one part per million when calibrated with the certified 40 ppm methane in air standard. Half of that lowest division (0.5 ppm) was selected as the reading to use in calculations when no perceptible response was observed. This resulted in a mass emission rate from the bonnet-to-body joint of less than $4E-8$ kilograms/hour.

After accelerated wear, three bagging tests were done on the bonnet-to-body joint. All of these tests were at nitrogen flow rates of approximately 2 liters per minute and all resulted in non-detectable hydrocarbon concentrations. The emission rates calculated on the basis of the detection limit were less than $5E-8$ kilograms/hour. It should be noted that the emission rates were not really higher after the accelerated wear testing - all tests showed non-detectable hydrocarbons. The minor differences in calculated emission rates are due to variations in nitrogen flow rates, temperature, oxygen concentrations, and background hydrocarbon concentrations. Essentially, the control valve had no detectable emissions using Method 21 or bagging before or after accelerated wear. Based on the detection limits of the analyzer, it can be said that any emissions from the valve were less than ~~5 kilograms~~ per hour, which is about 0.001 pounds per year.

5E-8 kilograms

Table 1. Summary of Bag Test Results

Test	Conditions	Hydrocarbon Concentration (ppmv)			Calculated Emission Rate (kg/hr)	Comments
		Background	Sample Bag	Corrected Bag		
I1: body-to-bonnet joint	N2 = 6.97 l/m O2 = 0% T = 72.2 °F	6	<0.5	<0.5	<1.38E-7	High N2 flow/low sensitivity run to get a quick reading.
I2b: body-to-bonnet joint	N2 = 2.0 l/m O2 = 0% T = 72.6 °F	NA	<0.5	<0.5	<3.96E-8	Repeat of Test I2 with a fresh clean bag.
F1: body-to-bonnet joint	N2 = 2.05 l/m O2 = 3.9% T = 71.5	0	<0.5	<0.5	4.99E-8	
F2a: body-to-bonnet joint	N2 = 2.05 l/m O2 = 2.3% T = 71.6	0	<0.5	<0.5	4.56E-8	Repeat of test F2 which had too high an O2 reading (6%)
F3: body-to-bonnet joint	N2 = 2.01 l/m O2 = 4.5% T = 71.7	0	<0.5	<0.5	5.07E-8	

Exceptions/Variations from the Proposed Test Plan

The test plan (Attachment C) that was proposed for this pre-certification test and approved by CARB was adhered to with the following minor exceptions:

1. The initial tests pressurized the control valve to only 75 psig of methane instead of the 300 psig specified in the test plan. The regulator that was supplied with the standard gas limited the outlet pressure to 75 psig. Another regulator that would fit the cylinder threads could not be accessed in time for the initial test. A regulator that allowed the full 300 psig pressure was used for the post-accelerated wear test.
2. The test plan specified that final samples for hydrocarbon concentration would be collected in aluminized Mylar™ bags and analyzed on a laboratory GC/FID. Continuous emission monitors were used for both oxygen and hydrocarbon analyses. The Ratfish total hydrocarbon analyzer is an FID with a sensitivity equal to that available in the laboratory instrument that was originally specified. For the high nitrogen flow runs (about 7 liters per minute), both the oxygen analyzer and the hydrocarbon analyzer could be kept on-line with continuous output of results. This offered a much higher confidence in deciding when steady state conditions were achieved than the approach specified in the test plan (which was based on previous field bagging approaches). For lower nitrogen flow runs, only the oxygen analyzer was kept on-line and a 5 liter Tedlar™ bag was filled with the sample gas once steady state was achieved. The Ratfish hydrocarbon analyzer was then used to analyze the contents of the 5 liter Tedlar bag to get the hydrocarbon concentration for calculations of the mass emission rate. We believe that this approach offered better demonstration of steady-state conditions and equal sensitivity to the approach specified in the test plan, plus the advantage of having fast turn-around on sample results.
3. In the test plan, we did not propose to analyze a background bag. This was done because we thought that the background in the lab would not be a problem, but a tubing leak in the methane supply line did create an elevated background at one point in the testing. Because of this, we did collect background hydrocarbon concentration data and used it in the calculations. This had no effect on the tests of the bonnet-to-body joint tests, because oxygen concentrations were reduced to zero in the bag in the pre-accelerated wear testing and background VOC values were zero in the post-accelerated wear testing. There was only a minimal effect on the indicator tube-to-bonnet seal testing, and this slight effect is immaterial since the seal will be welded on the final control valve. The equation for correcting for the background hydrocarbon was taken from the *Protocol for Equipment Leak Emission Estimates* published by EPA in 1995:

$$CGC = GC - ((Tent\ O_2)/21) * BG$$

where:

CGC = Corrected Gas Concentration (ppmv hydrocarbons in the sample bag);

GC = Gas Concentration (ppmv hydrocarbons in the sample bag);

Tent O₂ = oxygen concentration in the tented volume (volume %); and

BG = background hydrocarbon concentration (ppmv hydrocarbons).

Appendix B

Article Entitled "Testing to the Fugitive Emissions Standards," Valve Magazine

TESTING

to the

Fugitive Emission Standards

by Matthew J. Wasielewski

Fugitive emission testing for chemical processing valves and seals has been ongoing by valve manufacturers since the release of the Clean Air Act Amendments of 1990. Testing has been performed at manufacturers' own labs and at independent testing laboratories. Since no nationally recognized standards were available, test parameters were compiled by the manufacturers with input from their customers and competitors. This method sometimes resulted in multiple tests of the same valve to satisfy different customers. The need for a standardized test method was evident.

During 1992-1993, committees from the Fluid Controls Institute, Inc. (FCI) and the International Society for Measurement and Control (ISA) were formed to write separate emissions standards for valves and packings. The titles of those documents are:

- ISA-SP-93 - Standard Method for the Evaluation of External Seal Leakage Performance of Manual and Automated On-Off Valves;

- ANSI/FCI 91-1- Standard for Qualification of Control Valve Stem Seals.

As of this writing, the ISA specification is out for review and has not been released to the public. However, the major parameters of the specification are not expected to change. Deciding which specification applies to your products may not be clear since many valves cross the line between an "on/off" and a "control" valve. With some foresight, it may be possible to comply with both standards with little impact on the number of valves needing to be tested. This article will provide some guidance in this respect.

Specification Summaries

The main contents of the specifications are the test parameters, which include the test pressures, temperatures, number of mechanical cycles, etc. A summary of the test parameters for each standard is listed in Table 1.

As shown, there are some similarities and some differences

Parameters	ISA-On/Off	FCI/ANSI-Control Valve
Temperatures-F	-50°F Ambient, 350°, 750°	Undefined
Pressures	ANSI B16.34 ratings	Undefined
Maximum Leakage	50, 100, 500	100 - Classes A1, B1, C1, D1, E1 500 - Classes A2, B2, C2, D2, E2
Mechanical Cycles	Undefined	5,000 - Classes E1 and E2 25,000 - Classes B1, B2, D1, D2 100,000 - Classes C1 and C2
Packing Adjustments Allowed	Unlimited	Zero, except for E1 and E2 classification which allows 1
Number of Thermal Cycles	A minimum of 3 thermal cycles for tests over 900 mechanical cycles or .0 for ambient temp. tests	3 - Classes A1, A2, B1 and B2 1 - Classes E1 and E2 0 - Classes C1, C2, D1, D2
Test Media	Min. 97% pure methane or other gas with results correlated to methane	Min. 98% pure methane
Test Fixtures Allowed	No	Yes

Table 1

to the two standards. If we consolidate columns 2 and 3 in Table 1 and eliminate the "undefined"s and combine the commonalities, we reduce the possible choices as shown on Table 2 (page 21).

The task of selecting parameters is now more manageable, but still, testing to all these parameters is not economically feasible for all manufacturers. To refine the choices further still, let us examine each one.

• **Temperatures and Number of Thermal Cycles**—For PTFE or graphite sealed valves, the most prevalent test temperature will be 350°F. This temperature has been used in corporate standards by Exxon, Arco, and others for several years. Since high-temperature testing will not predict or qualify valves for below ambient service, the -50°F test will also need to be performed as a second phase for valves marketed for cold services, such as chlorine. For a non-ambient test, at least three thermal cycles should be completed.

Thermal cycling does pose problems for some seals. As the seals cool from elevated temperature, they generally shrink at a greater rate than the metal around them. Without proper

constraint and loading, the shrinkage can cause leakage. If no previous testing of the seal design has been done, the recommendation for the first test is to test at ambient temperature. This will provide a good baseline for future tests.

Pressures

The FCI specification does not specify pressure, due to the fact that some seals do not follow the body pressure/temperature curves as listed in ANSI B16.34. This is especially true for soft seated valves, which are down rated primarily because of the seats. Since the emissions test is for evaluating the stem seals and body gaskets and not the seats, a higher pressure may be used. Because the same stem seals are often used with different seats of various pressure/temperature curves, it is recommended to test to the ANSI B16.34 rating.

Maximum Leakage

The 500 PPMv limit will eventually be replaced nationwide with 100. Therefore, 100 PPMv is the easy choice. However, some seal materials, such as some forms of graphite,

Continued on page 21

Parameters	Combined
Temperatures F	-50°, Ambient, 350, 750
Pressures	ANSI B16.34 ratings
Maximum Leakages	100, 500
Mechanical Cycles	5,000 25,000 100,000
Packing Adjustments Allowed	0 1
Number of Thermal Cycles	0 3
Test Media	Min. 98% pure methane
Test Fixtures Allowed	No

Table 2

Number of Cycles	Valve Type
5,000	Normally manual operated multi-turn valves
25,000	Standard performance quarter turn valves
100,000	High performance on-off and control valves

Table 3

are not capable of sealing for extended periods (or at all) below 100. This is generally discovered at the onset. This parameter can be altered at the start to accommodate the seal performance.

Mechanical Cycles

As noted at the beginning of the article, the ISA standard, as it stands now, does not list specific milestones for mechanical cycle numbers. This allows for an infinite number of variations, which makes it difficult for end users to evaluate valves on an apples-to-apples basis. The only problem with the FCI selections is that some valves, such as larger manually operated gate valves, may have difficulty cycling the

Continued on page 23

Deduttable Gears

1/4 Turn (90°) Gearboxes

T-Handle

Good for a top mount manual override. Fifteen sizes available from 1500 in/lbs output torque to 1 million in/lbs.

Sandwich w/ Overarm

When you need to add limit switches, positioners or other accessories to the top of a Pneumatic

actuator. Available from 9000 in/lbs to 30,000 in/lbs output torque.

Side Arm

Revolutionary new economy model - low profile, mount in between valve and actuator. Lockout

capability included as standard equipment. Sizes range from 1500 in/lbs to 30,000 in/lbs output torque.

MASTERGEAR

A Union of Regal-Schmidt Corporation

800.722.7643 • FAX 615.623.2635

Greene, IL 61073

Circle Reader Response #24

ISA	FCI/ANSI
The test results of a particular valve may be used to extend the classification to other valves if:	
Stem seal diameter is $\pm 25\%$ of the tested valve	Stem diameter is 5-2.0 times the tested stem. Seal cross section is .8-1.2 times the tested seal.
Body seal diameter is $\pm 25\%$ of the tested valve	Body seals not included in specification.
Lower pressure than test valve, but not vacuum	Manufacturer to specify
Lower temperature, but not less than ambient	Manufacturer to specify
Not specified	Lesser stem travel

Table 4

minimum 5,000 times. A typical lab test in which a year motor was used to turn the handwheels of various size gate valves has shown that yoke sleeve and retaining nut galling will likely occur on most valves before 500 cycles and in some cases less than 50. In these instances, air actuators were mounted to the stems to continue the test. A lower limit of 1,000 cycles may be suitable for some valves with continuation to 3,000 if performance is good. One prominent end user has set a standard of 3,500 cycles for its qualification test. Based on the FCI choices for cycle requirements, Table 3 (page 21) gives a recommendation for cycles versus valve types.

Whatever the cycle goal is, it may be wise to comply with a lower level first, then decide based on the results to go for the higher cycle number. If the ultimate goal is 100,000 cycles with three thermal cycles, it would be wise to perform the three thermal cycles up to 25,000 mechanical cycles. Then, if results are good to that point, continue the test to 100,000. This way, if the packing fails at 35,000 cycles, the valve would have met the 25,000 cycle requirements.

• **Packing Adjustments Allowed**—The ISA standard did not limit the amount of packing adjustments allowed, but requires that the adjustments be recorded in the final report and be part of the classification. FCI took a more definitive stance and stated that no adjustments are allowed, except for the E1 and E2 (5,000 cycles) classifications. Zero adjustment is an achievable goal.

• **Test Media**—The FCI standard requires the use of methane, while the ISA specification allows for gases other than methane to be used. For temperatures up to 350°F, methane is relatively safe and has been the preferred gas since fugitive

Continued on page 24

Standard

1/4 Turn (90°) Gearboxes
Available in Cast Iron,
Aluminum, or Bronze housings.

Cast Iron

Manual or
motorizable
valve
actuators
with output
torques from
1,700 to 2.4
million in/lbs.

Aluminum

Lightweight
aluminum
housings are
economical for
medium duty
1/4 turn or
rubberized,
butterfly valves.

Accessories

Various
handwheel
types and
sizes, pad-
lock flanges,
miller gears,
spur gears,
memory stops, limit switches, and
valve position indicators.

MASTERGEAR

Engineered Regal-Belco Corporation

800.722.7643 • FAX 915.623.5635
Reno, IL 61073

Circle Reader Response #25

Emission Standards...continued from page 23

emission testing began. If higher temperature testing is required, then helium should be used. The correlation between methane and helium leakage has proven difficult, since the primary modes of leakage can be molecular, viscous (turbulent and/or laminar), or a mixture of both. The ISA standard includes some guidance in its Annex C. For all but the 750°F test, methane will be the gas of choice.

Qualification of Valves

Now that the test parameters are settled, the next question to answer is "What size valves do I need to test to qualify the whole product line?" Both standards allow for valves other than the tested valves to be qualified to the standards as long as certain criteria are met. Unfortunately, as in the test parameters, both standards have different criteria. Some of the differences are due to the fact that the FCI document is

Criteria	Limits
Stem Seal ID	$\pm 25\%$
Stem Seal OD	$\pm 25\%$ as long as seal cross section is 8 - 1.2 times the tested seal
Body Seal Diameter	$\pm 25\%$
Pressure Rating	Lower pressure than test valve, but not vacuum
Temperature Rating	Lower temperatures, but not less than ambient
Stem Travel	Lesser travel qualifies

VMA Calendar

1997

18-19

13-14

Memorandum
in New Center
Cleveland, Ohio

Admission Made Here
San Antonio, Texas

1998

17-18

Valve, Research

22

The Queen Mary
Long Beach, California

24-26

General, Tulsa

26-28

Grand Hyatt Atlanta
Atlanta, Georgia

29-1

The Westin La Paloma
Tucson, Arizona

or check Reader Response #99 on insert card in this magazine.

Table 5

written for stem seals, whereas the ISA specification is for valve assemblies. A summary of the qualification criteria is listed in Table 4 (page 23).

These guidelines were developed somewhat arbitrarily by both committees, since leakages can vary considerably with small changes of seal cross section or loading. However, in order for the standards to be accepted by the valve and seal manufacturers, some allowance was needed to qualify untested valves. If we reduce Table 4 to the more stringent criteria, we get Table 5.

Whether or not these limits will cause a large sample of valves to be tested, depends upon the valve design and the size range of the product line.

Conclusion

Eventually these two testing standards will borrow criteria from each other in future editions, until they will become nearly identical, as occurred with British Standard and API fire test standards. For now, qualifying to both standards involves a little more planning, but is achievable. With the release of the ISA specification imminent, valve and seal market leaders have begun their testing programs. The requirement of complying with these standards will soon become common for suppliers to chemical companies affected by the EPA regulations. □

The author is President of Yarrow Research and Technology, Yarmouth, ME.

CURTISS-WRIGHT FLOW CONTROL

Electro-Magnetic control Valves Eliminate Fugitive Emissions and Maintenance

Curtiss-Wright Flow Control (CWFC) manufactures control valves, in sizes up to 8 inches, for liquids, gas and steam. The CWFC design is a departure from the standard air or motor operated valve designs typically used for the storage and handling of hydrocarbons. Specifically, the Model 100 and 120 valves are electro-magnetically actuated; they do not use any stem, packing or bellows. Further, there are few moving parts and they are all within the process pressure boundary. The main environmental and operational advantages of the CWFC design are:

- **No Fugitive Emissions** - CWFC valves have no stem seal, the most common point where valves leak. The stem leakage rate almost always contributes the bulk of the total fugitive emissions. Bellows can provide additional protection against fugitive emissions; however, over time bellows can develop cracks and leaks.
- **Low Maintenance** - Because it is all electric, there is no pneumatic supply system to maintain. Also, there are few moving parts to and no lubrication is

needed. In addition to not having any stem, packing, or bellows, the bonnet of CWFC's Model 100 valve is seal welded directly to the valve body to eliminate bonnet leaks. CWFC's Model 120 valve has a bolted bonnet joint sealed with an O-ring.

Basic Technology

These valves are solenoid actuated and employ a pilot disc to assist operation. The two basic designs are on/off isolation valves and modulating control valves. Operation of the valves occurs when the solenoid is energized to develop a magnetic field. This lifts the plunger and pulls a pilot off its seat to open an internal vent port. When the differential pressure between the top and bottom surfaces of the main disc changes sufficiently, the main disc follows in servo motion to the pilot and allows the fluid at the inlet to flow. In modulating designs, an electronic positioner controls electrical power to the solenoid to match disc position with desired flow.

Cal/EPA Certification

The ability of CWFC Model 100 and 120 control valves to control fugitive volatile organic compounds (VOC) emissions has been independently certified by the California Air Resources Board (CARB) (Cal/EPA). This certification is a basis for local Air Quality Management Districts to reduce permitting costs, eliminate monitoring requirements and issue pollution credits for use of CWFC valves.

Model 100 - "Equivalent to pipe"

Cal/EPA Evaluation

Cal/EPA performed an independent design review of both the Models 100 and 120. They determined that testing of the Model 100 was not necessary because it is completely seal-welded. The Model 120 is seal-welded except for one body-to-bonnet joint, sealed with an O-ring.

Since an O-ring joint theoretically has the potential for fugitive emissions, it was subject to testing. The testing of the Model 120 consisted of three phases: Pressurize the valve to 300 PSIG with methane; screen the valve using EPA Method 21; perform a blow-through bag test to measure leakage; and screen the valve again using EPA Method 21.

The accelerated wear aging test was conducted to show that emissions rates are unaffected by equipment age.

Model 120 - "Equivalent to flange"

The test was administratively terminated after 112109 cycles.

Final emissions testing consisted of: Pressurizing the valve to 300 PSIG with methane; screen valve using EPA Method 21; perform a blow-through bag test to measure leakage; and screen valve again using EPA Method 21.

Cal/EPA Test Results

The CWFC Model 100 control valve is a closed system without the potential for fugitive VOC emissions. As such, the valve would not be expected to require monitoring beyond that appropriate for welded connections.

The CWFC Model 120 control valve has a calculated fugitive VOC emission rate that is no greater than 5.0E-8 kilograms per hour. (.001 pounds per year). This upper-bound emission rate was calculated by considering the fact that the test gas (methane) used as a surrogate for fugitive VOC emissions was not detected at the lower limit of detection (1 PPM) of the analyzer used in testing. Therefore, one-half of the detection limit was used in the calculation of a fugitive VOC emission rate. From the perspective of fugitive VOC emissions, the CWFC Model 120 should be treated as one flanged connection.

The Model 120 control valve showed no performance degradation after 112,109 cycles with respect to fugitive VOC emissions. Aging has no effect on the ability of CWFC valves to control emissions.

Cal/EPA recommendations consisted of the following: Emission reductions resulting from the installation of CWFC valves may be eligible for emission reduction credits; the Model 100 should be inspected on a frequency consistent with welded pipe; for the Model 120, quarterly to semi-annual inspections are suggested for the first year. If four consecutive readings below 100 PPM are recorded, it is recommended that the inspections be conducted annually.

Low Maintenance

All CWFC valve require little maintenance. There are few moving parts to wear and these have been designed to operate for hundreds of thousands of cycles. The lack of packing, bellows and lubrication eliminates typical periodic maintenance requirements.

Curtiss-Wright Flow Control,
1966E Broadhollow Rd.,
E. Farmingdale, NY 11735
www.trc.thomasregister.com

More Information - Write in 743

Attachment 3
1 of 2

The toughest environmental laws in the country are no match for our control valves.

NOW
CURTISS
WRIGHT
ELECTRO-
MAGNETIC
CONTROL
VALVES ARE
VERIFIED
BY THE
CALIFORNIA
EPA AS
EQUIVALENT
TO PIPE
WITH
RESPECT TO
FUGITIVE
EMISSIONS.

NO MONITORING!

- No packing
- No bellows
- Sizes to 3"
- Pressure class to 2500#
- Abate™ Pressure Drop Trim Available

**CURTISS
WRIGHT**

FLOW CONTROL CORPORATION

The Leader in Valve Technology

1966 E Broadhollow Road, Farmingdale, NY 11735-4760 • 516-291-2000 • FAX 516-291-2001

www.curtisswright.com

SEE US AT THE ISA SHOW
BOOTH #1824

4/11/01
2 of 2
3