FLOW ACCELERATED CORROSION PROGRAM CHECWORKS ANALYSIS ENHANCEMENT

Technical Report No. 00130-TR-001
Revision 0
Volume 1 of 1

Prepared for:

Consolidated Edison Company of New York, Inc.
Indian Point Unit 2

December 2000

altran

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1.0 INTRODUCTION

A Flow Accelerated Corrosion (FAC) program has been developed at Indian Point Unit 2 to predict, measure, analyze and mitigate the problem of pipe wall loss. An integral part of the FAC program is the Electric Power Research Institute program CHECWORKS [1][1]. CHECWORKS takes into account various flow, operating conditions, material data, and UT inspection data to provide a calculated estimate of component wear.

Indian Point Unit 2 is currently modeled in CHECWORKS Ver.1.0F. This effort will serve to enhance the existing CHECWORKS model by incorporating the latest operational data, water chemistry, UT data, and as-built geometric configuration. The enhanced models will be reanalyzed and used to select inspection locations for upcoming refueling outage 15.

2.0 SCOPE

The CHECWORKS models for the following systems were updated as part of this calculation: Condensate, Feedwater, Heater Drains, Moisture Separator Drains, Reheater Drains, Extraction Steam, Steam Generator Blowdown and Crossunder.

3.0 METHOD OF ANALYSIS

The EPRI CHECWORKS program is the basis for this analysis. CHECWORKS uses input for piping materials, operating conditions, water chemistry, and piping geometry to calculate a rate of wall loss for a specific component. Indian Point Unit 2 is currently modeled in CHECWORKS Ver.1.0F [1]. This effort will serve to enhance the existing model [8] by incorporating the latest input data. The following sections describe the enhancements made to the CHECWORKS model as part of this effort. There were no changes made to the existing model other than those detailed in the following sections.

3.1 Plant Period

The plant period module in CHECWORKS contains plant operating data. The period begin date, period end date, total effective full power hours, water treatment and power level are input for each operating cycle. The period begin date and end date are entered for each refueling outage or significant maintenance outage.

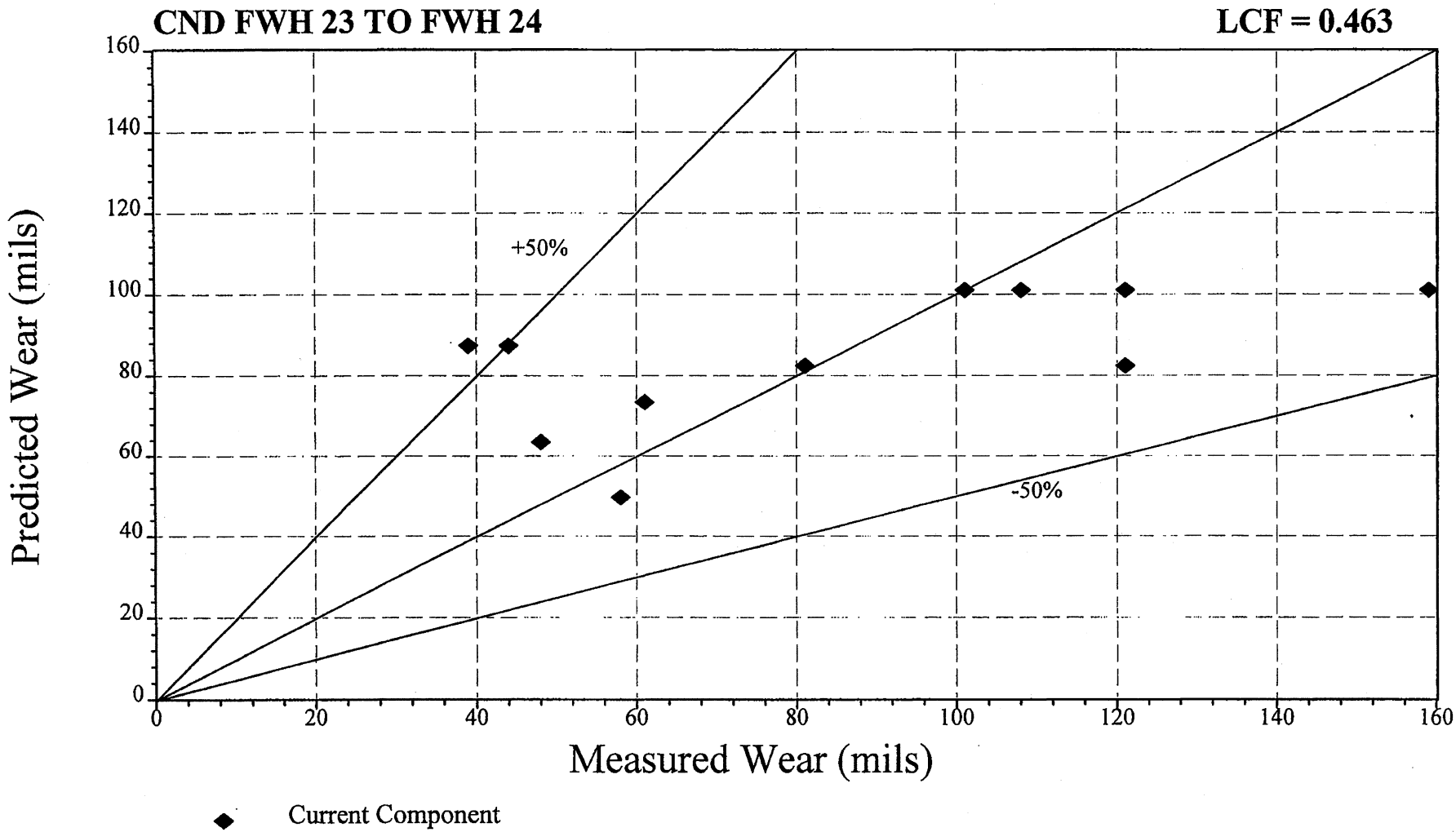
The existing CHECWORKS database contained the actual operating hours and dates through refueling outage 13. Consolidated Edison personnel provided actual operating hours and dates for operating cycle 14 and refueling outage 14 as well as an estimate for cycle 15. An estimate for cycle 16 was not available at this time so it was assumed to be the same length as that projected for cycle 15. The operational data provided by Consolidated Edison are included in Appendix

[1] Numbers within brackets [ ] indicate references located in Section 5.0.

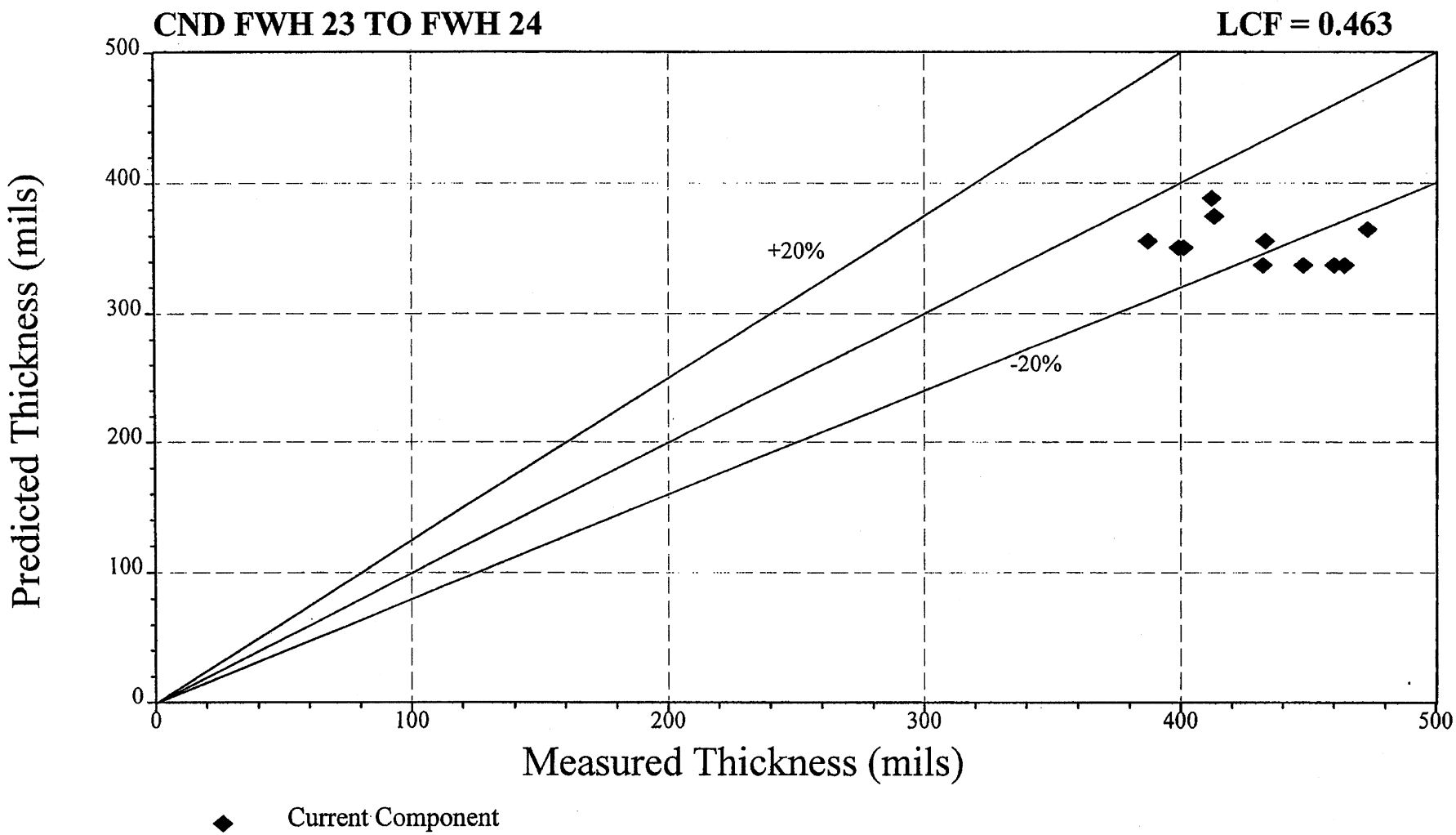
APPENDIX C:

CHECWORKS Wear Rate Analysis Results

Comparison of Wear Predictions



Comparison of Thickness Predictions



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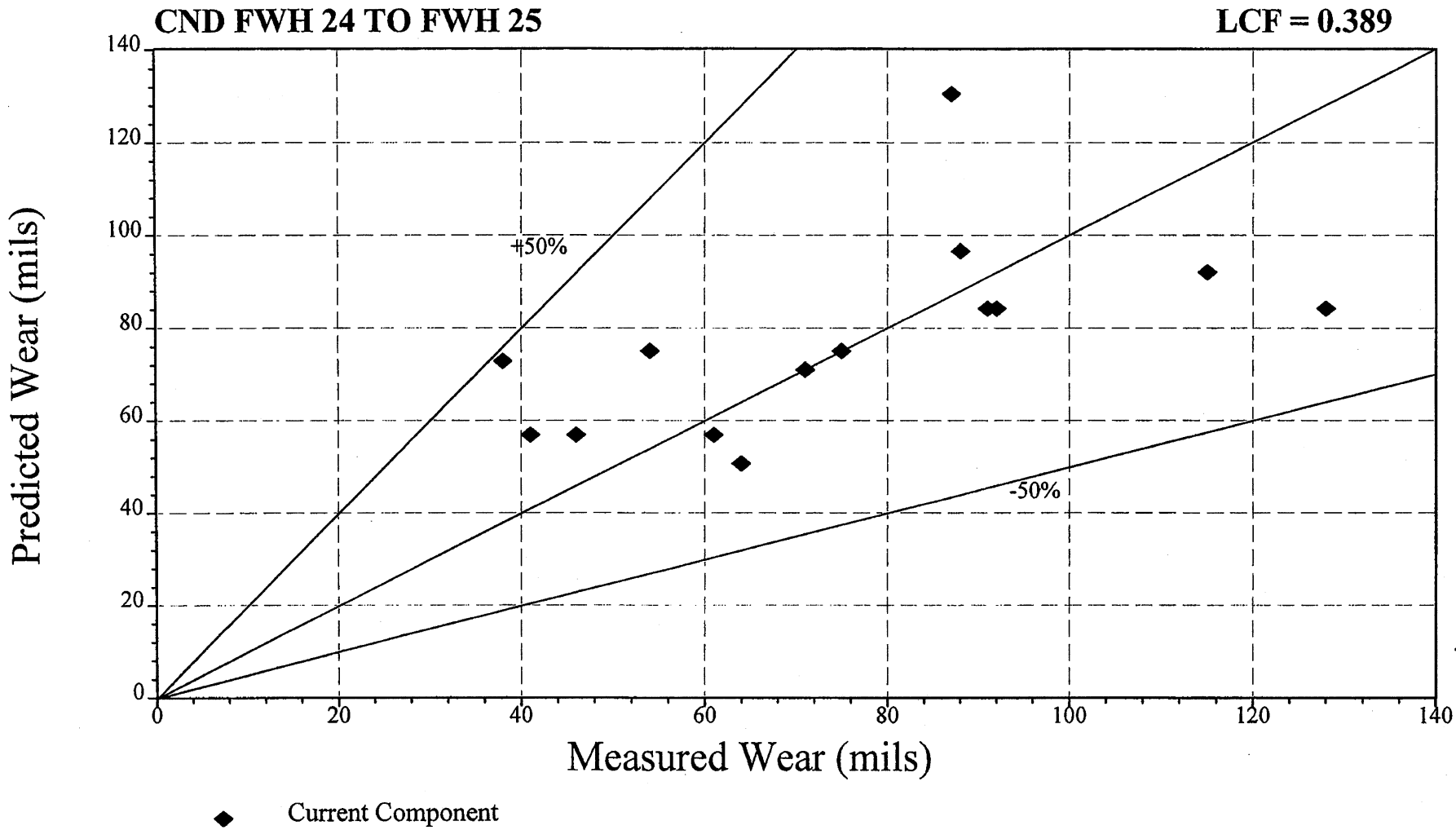

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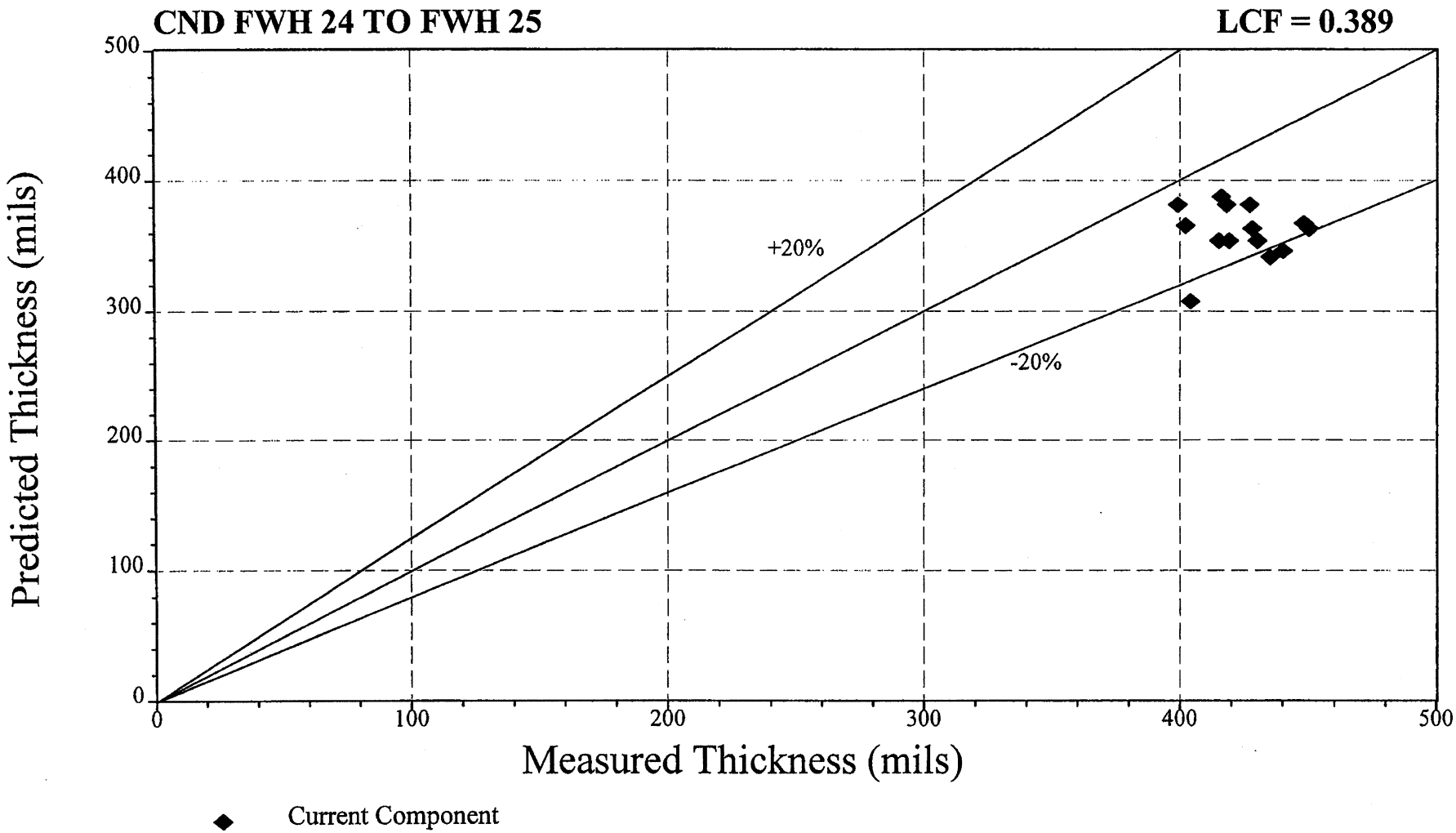

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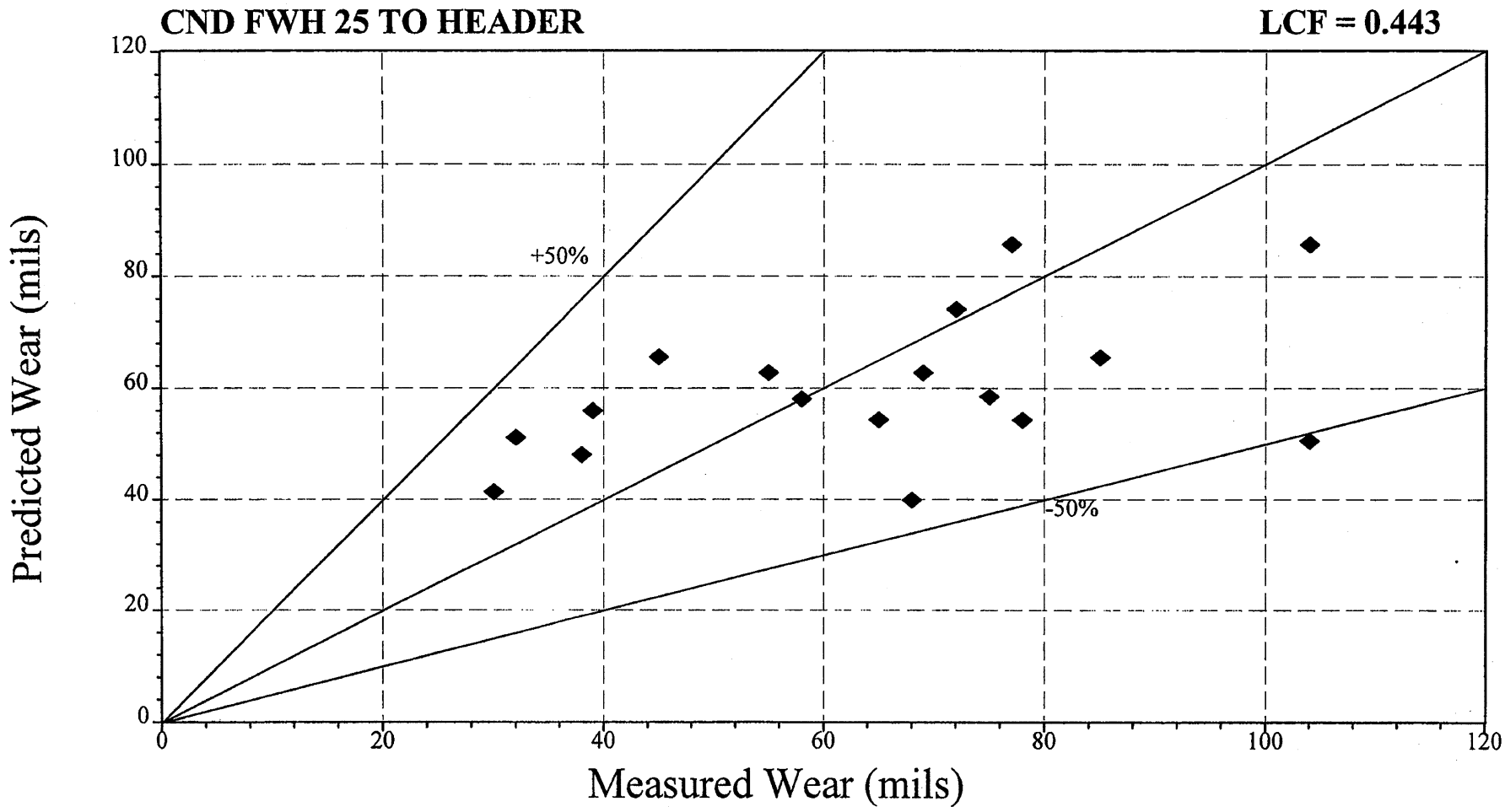

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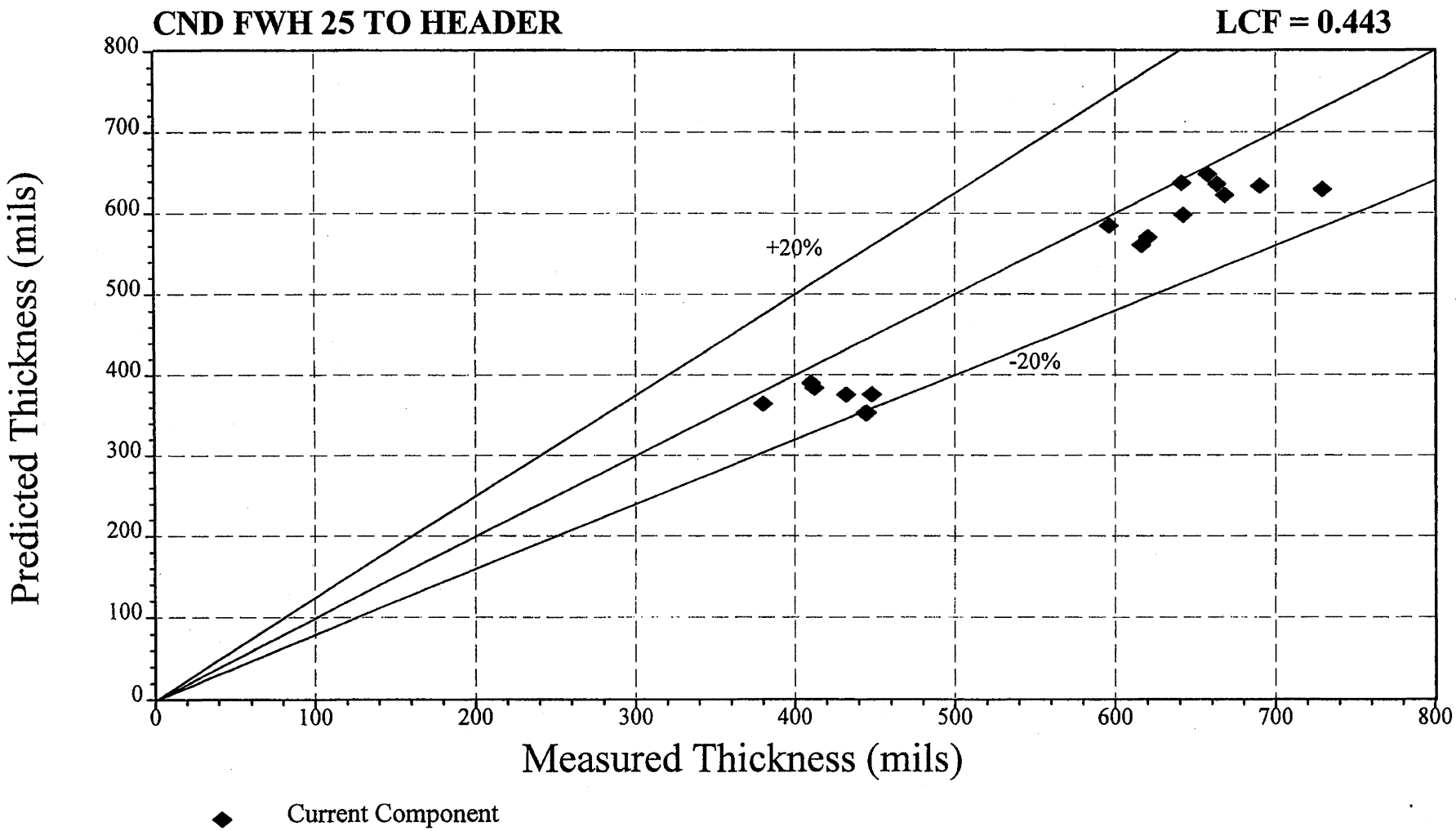

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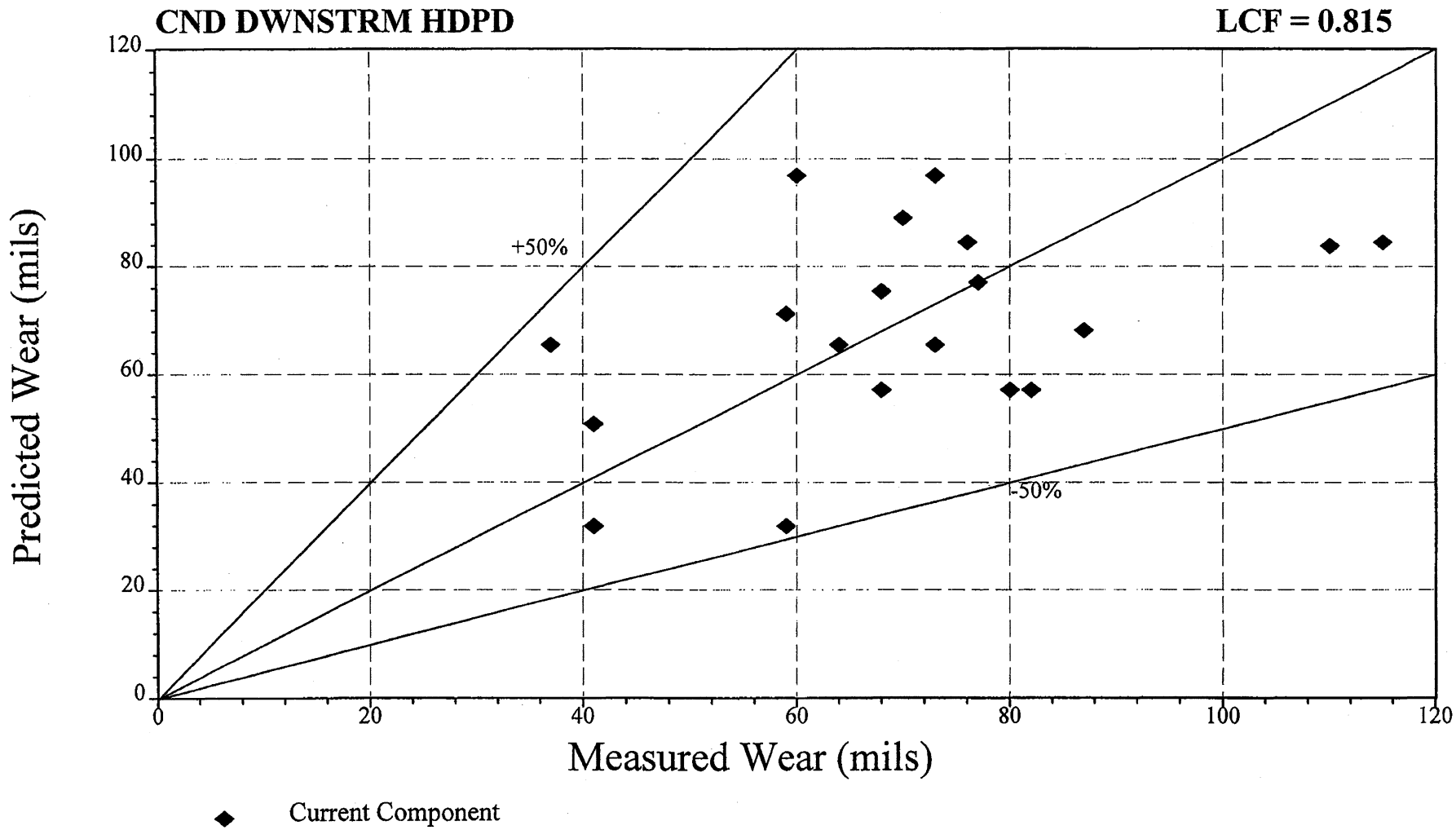

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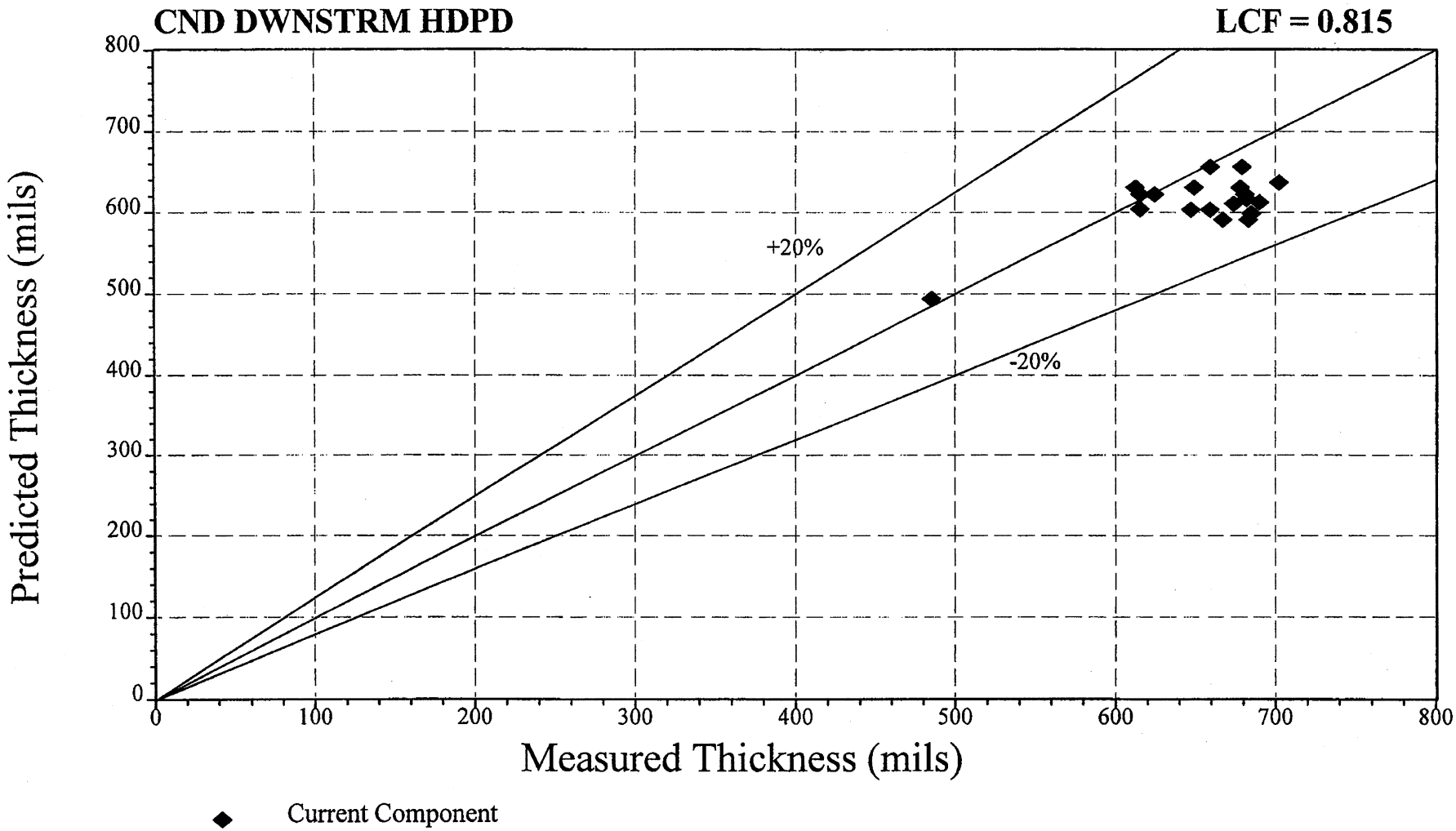

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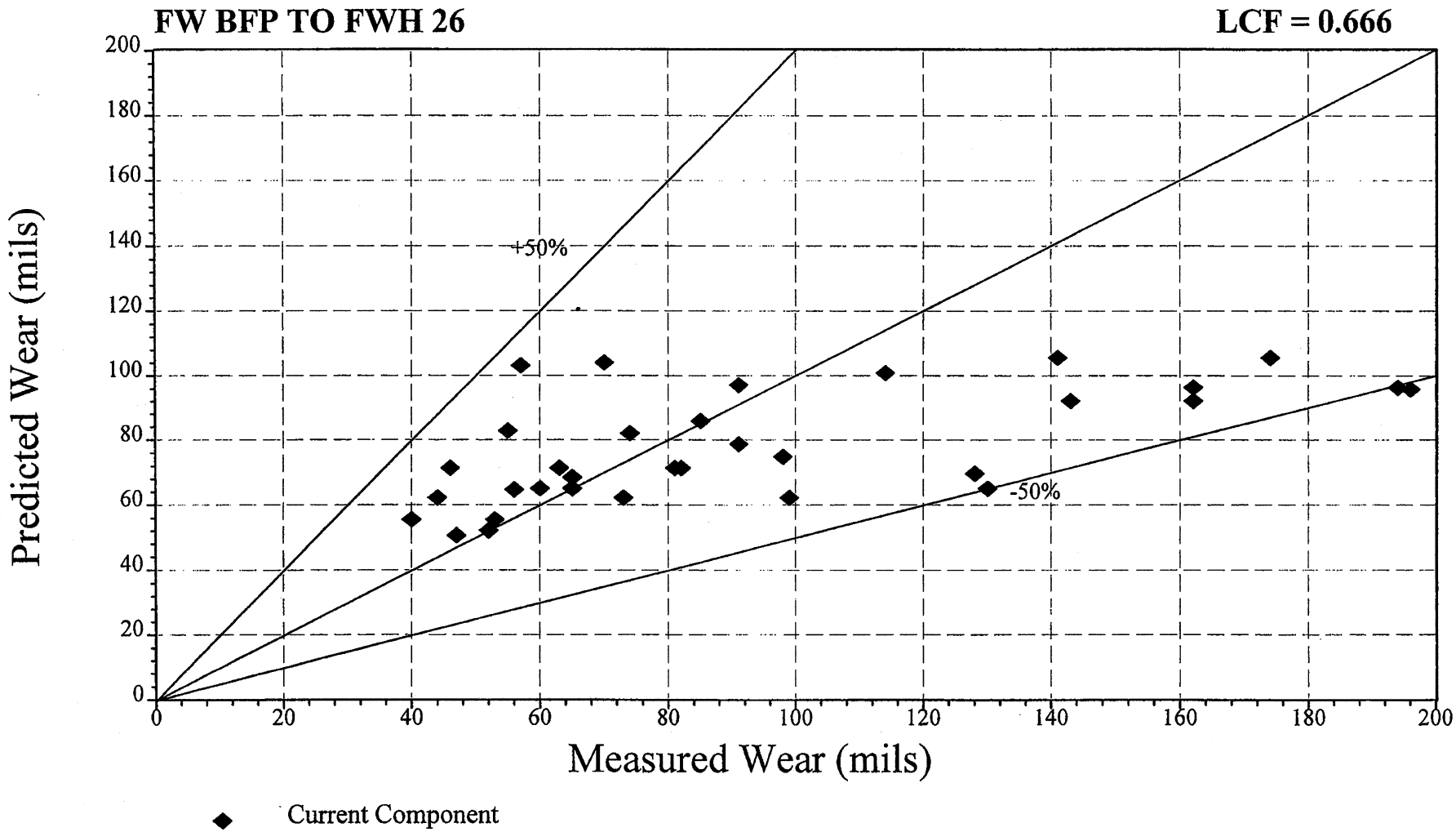

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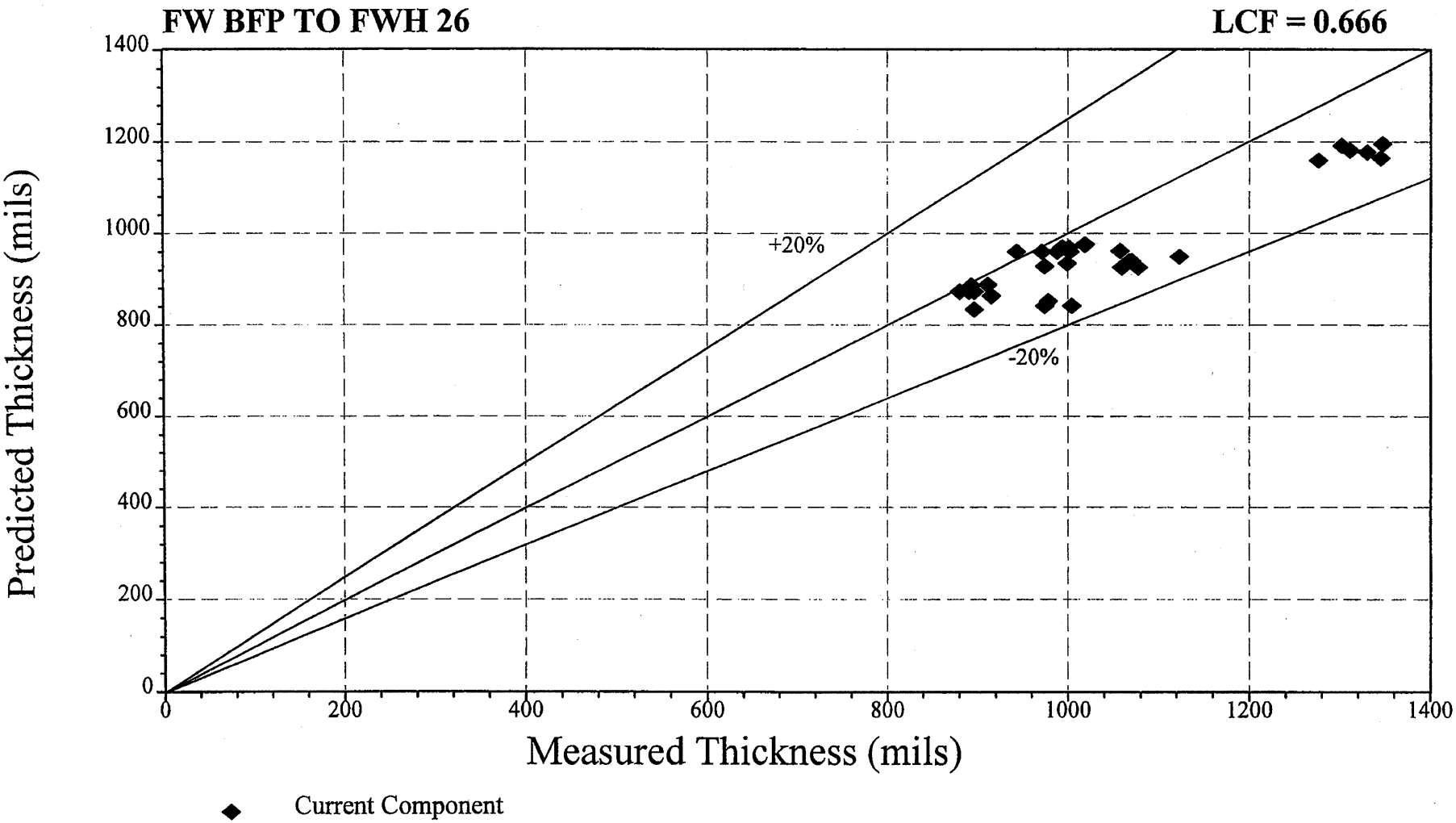

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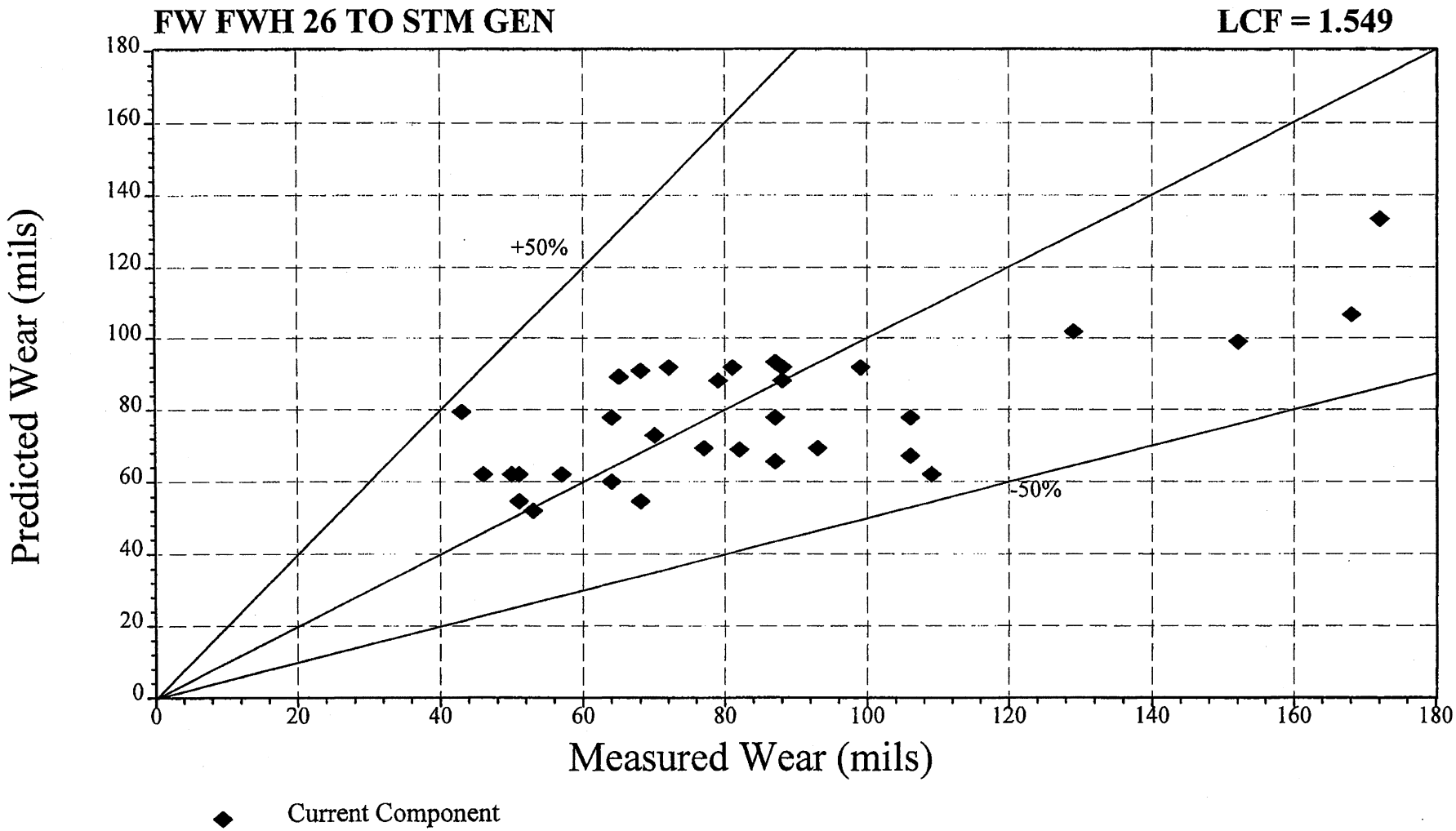

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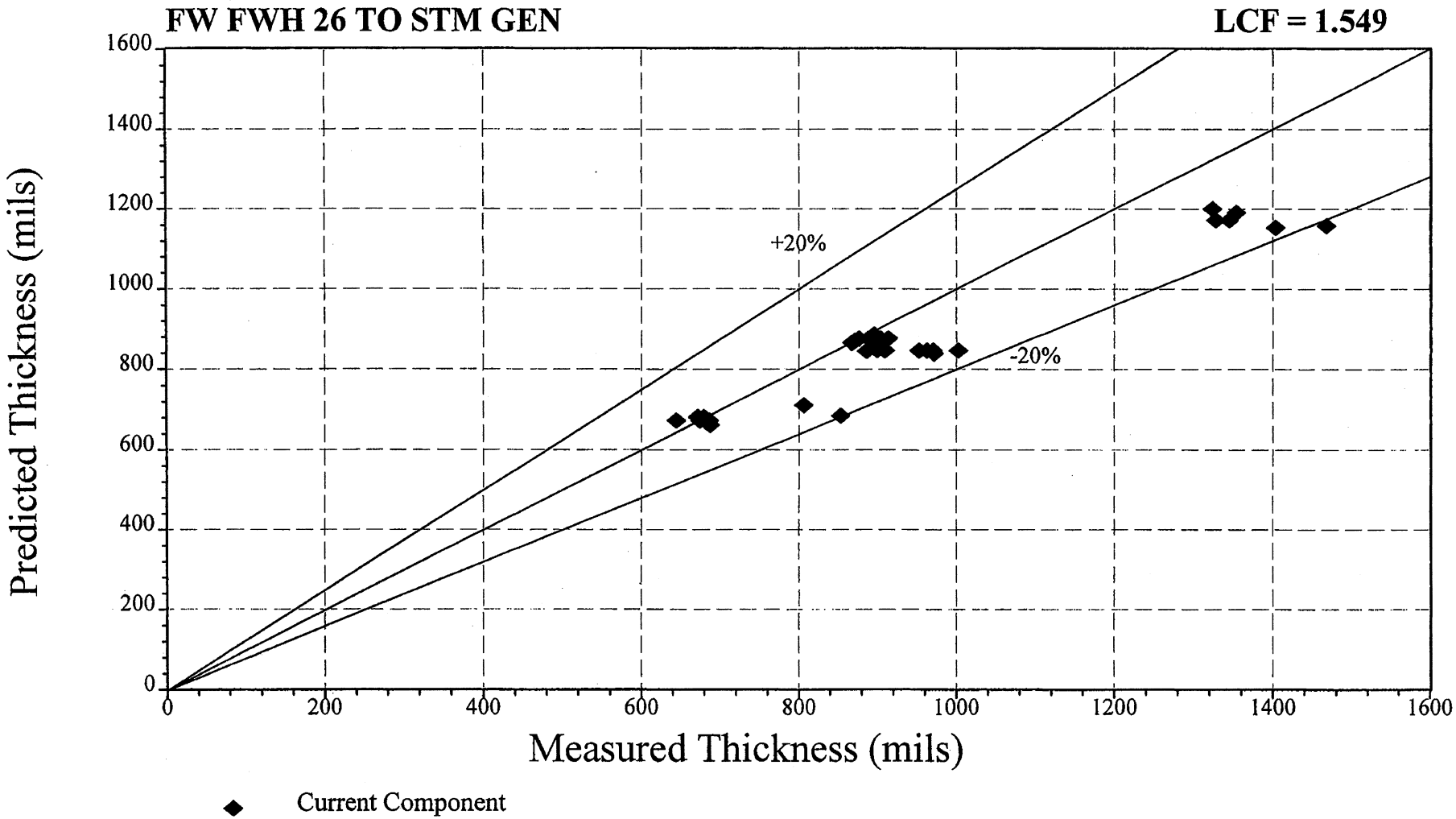

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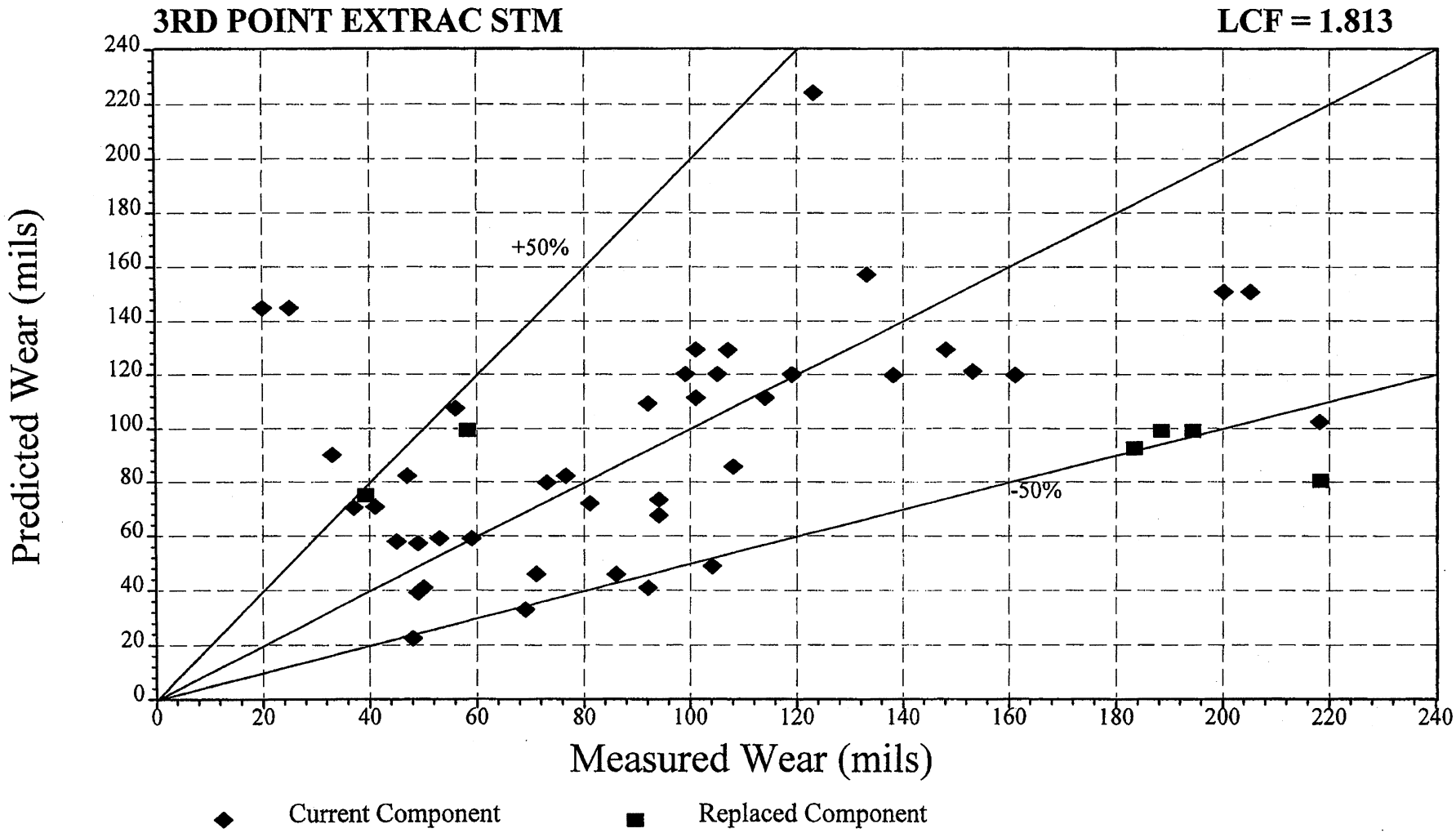

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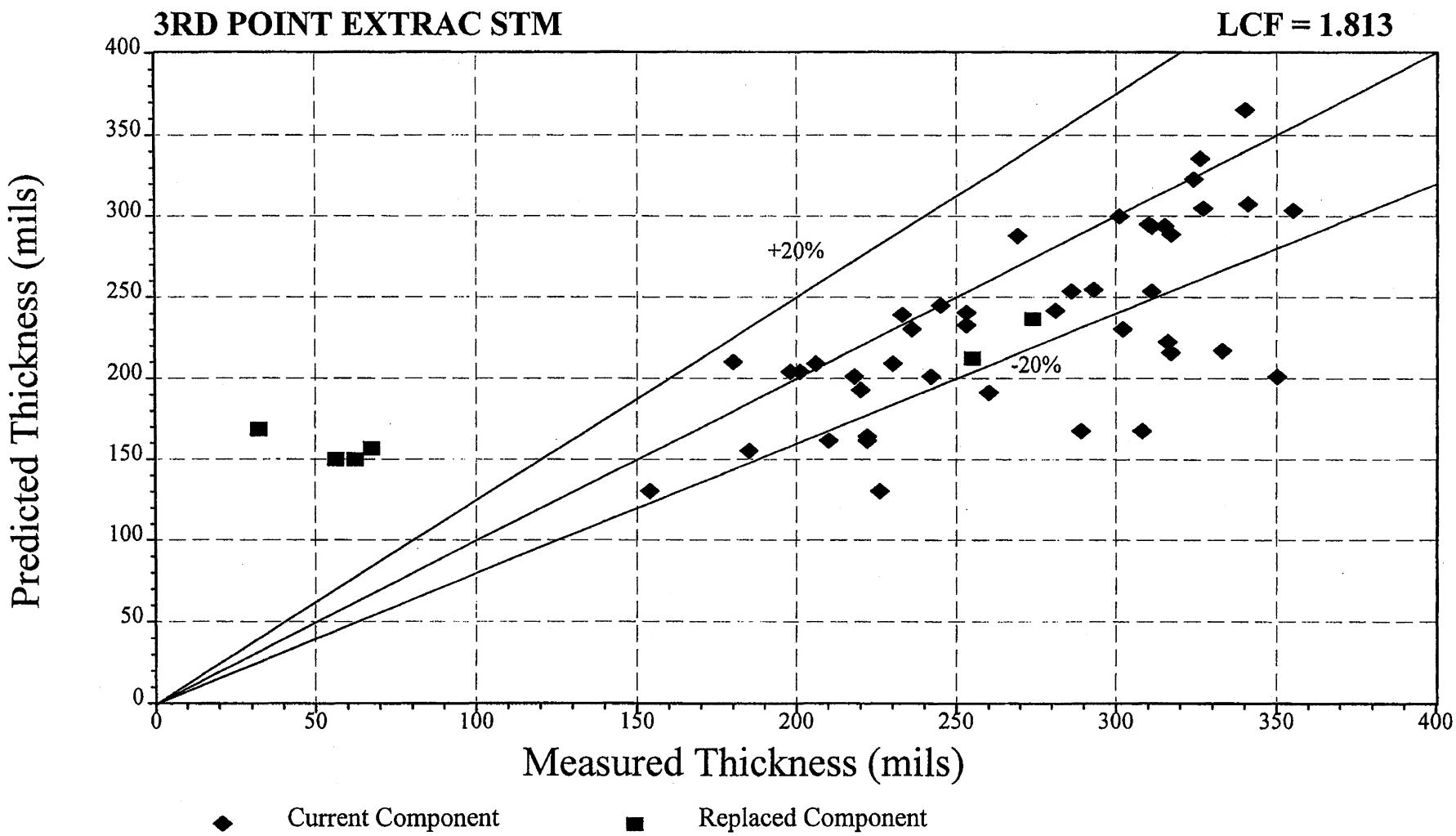

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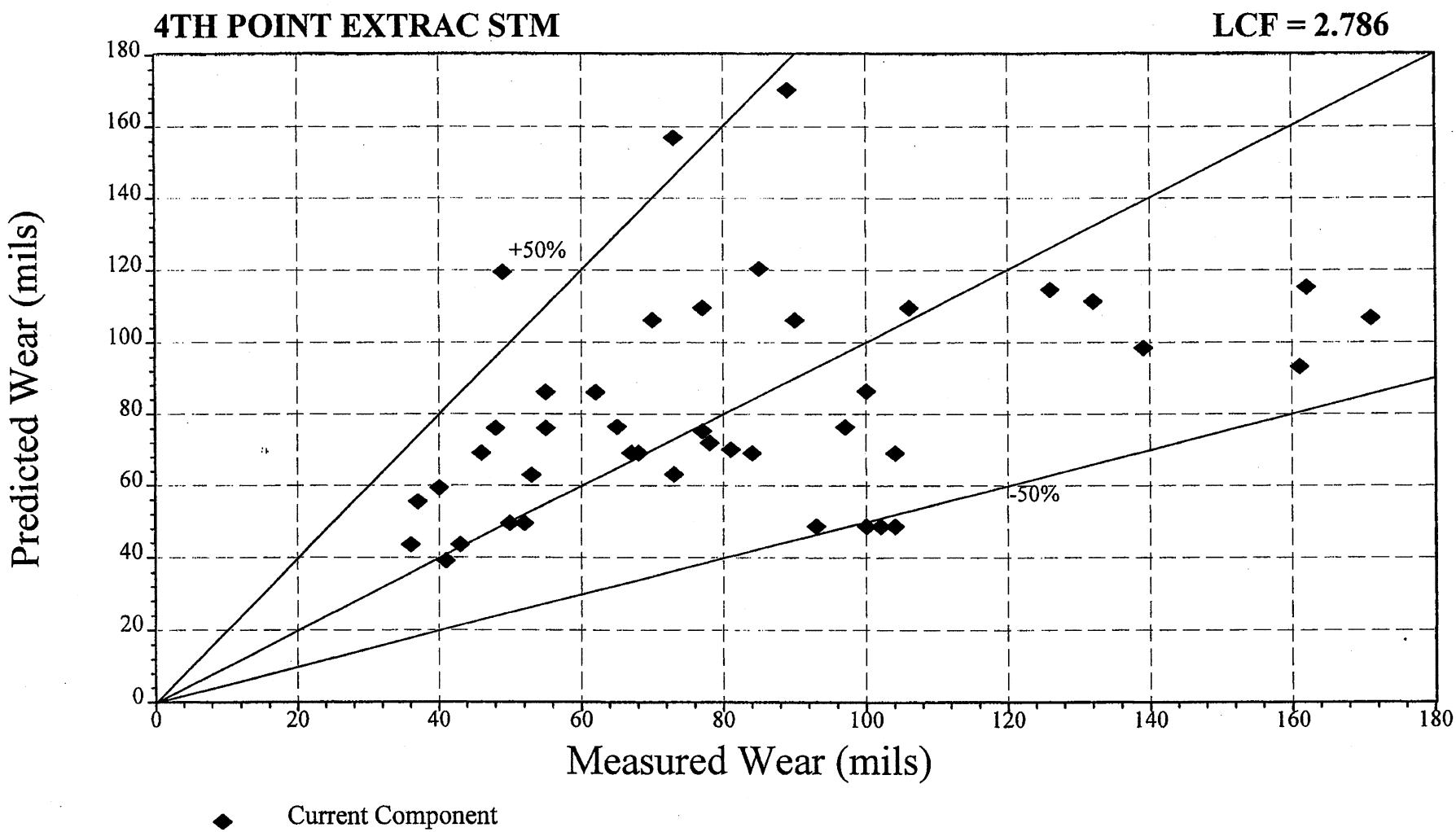

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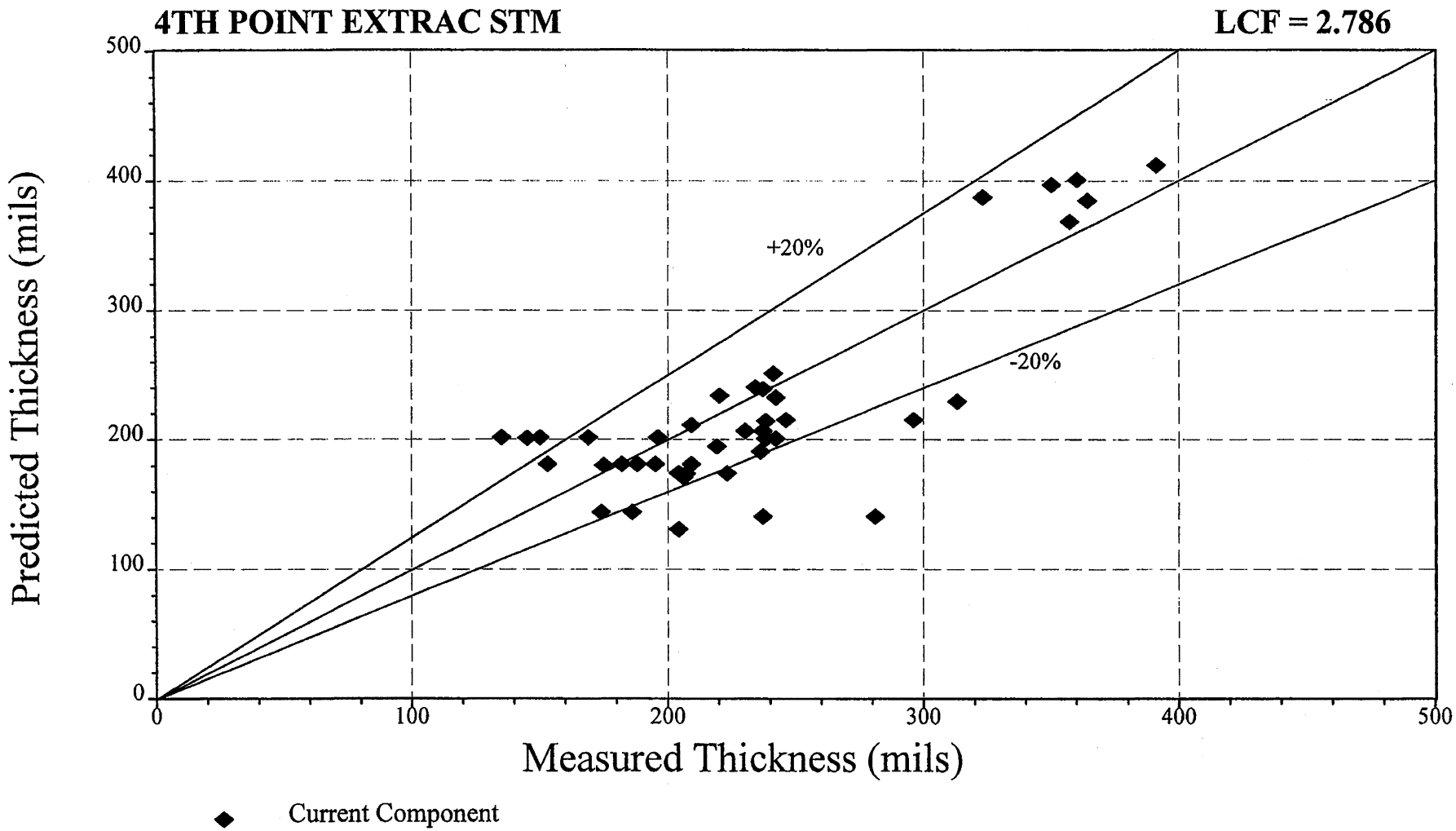

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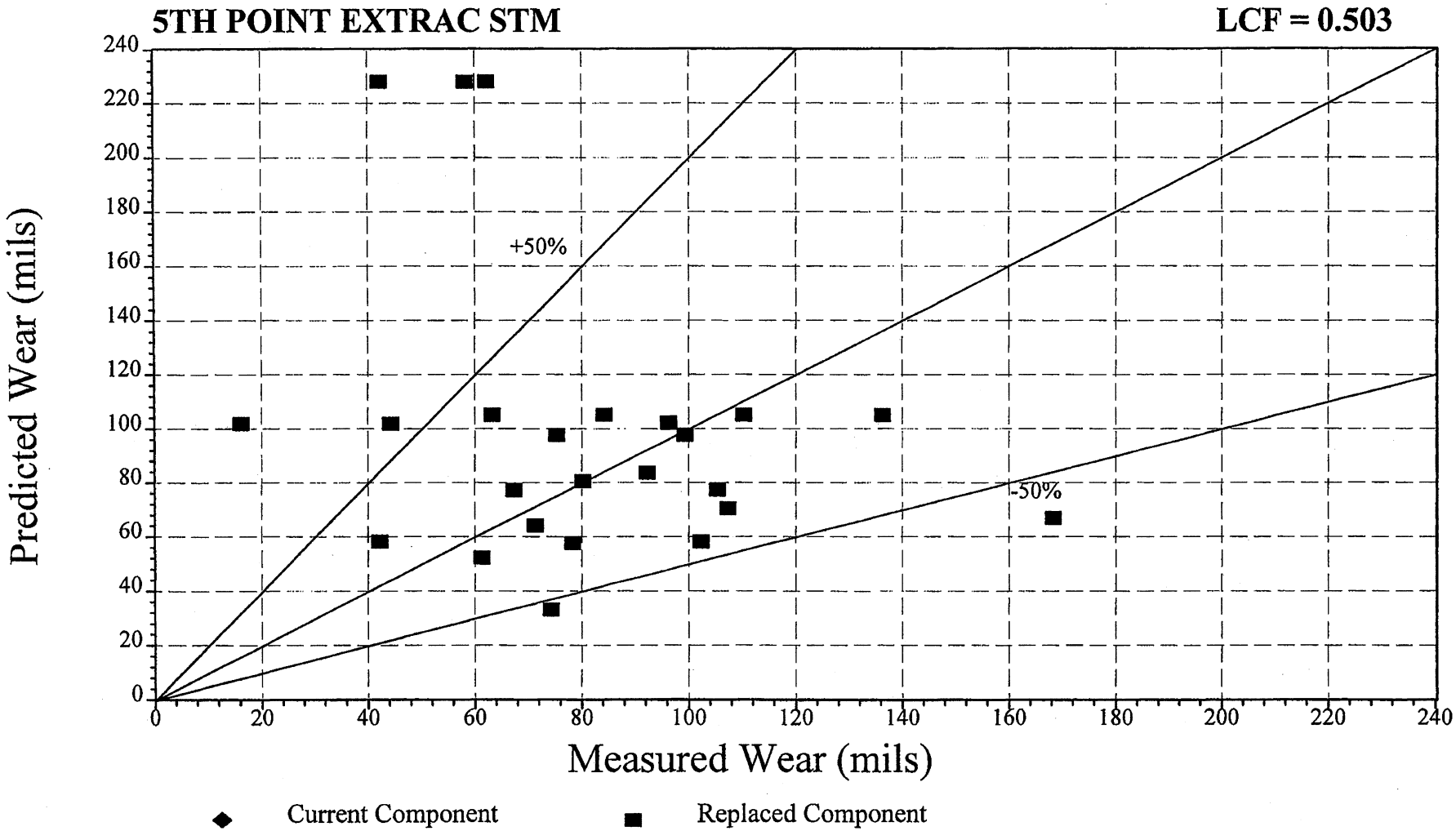

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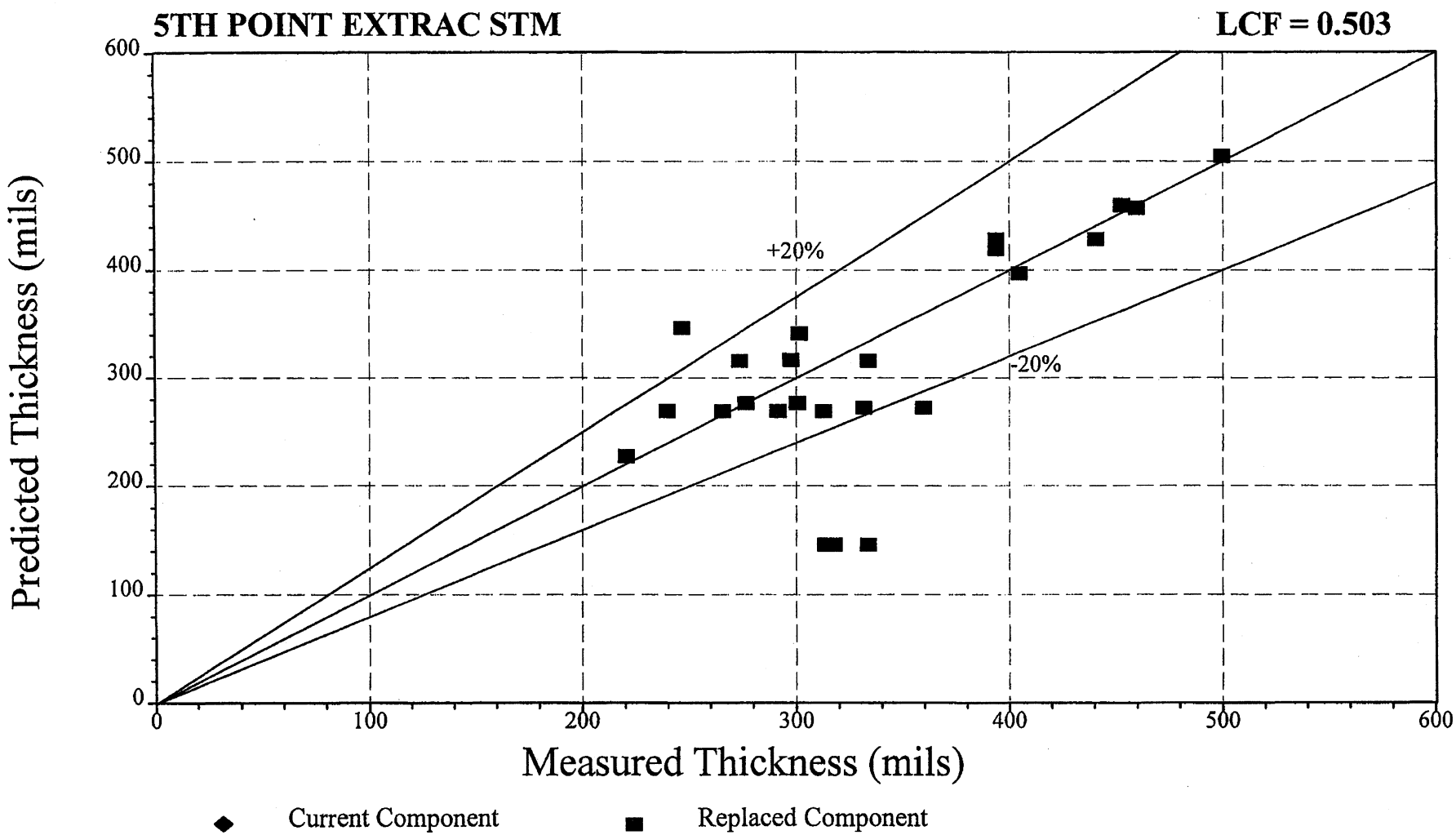

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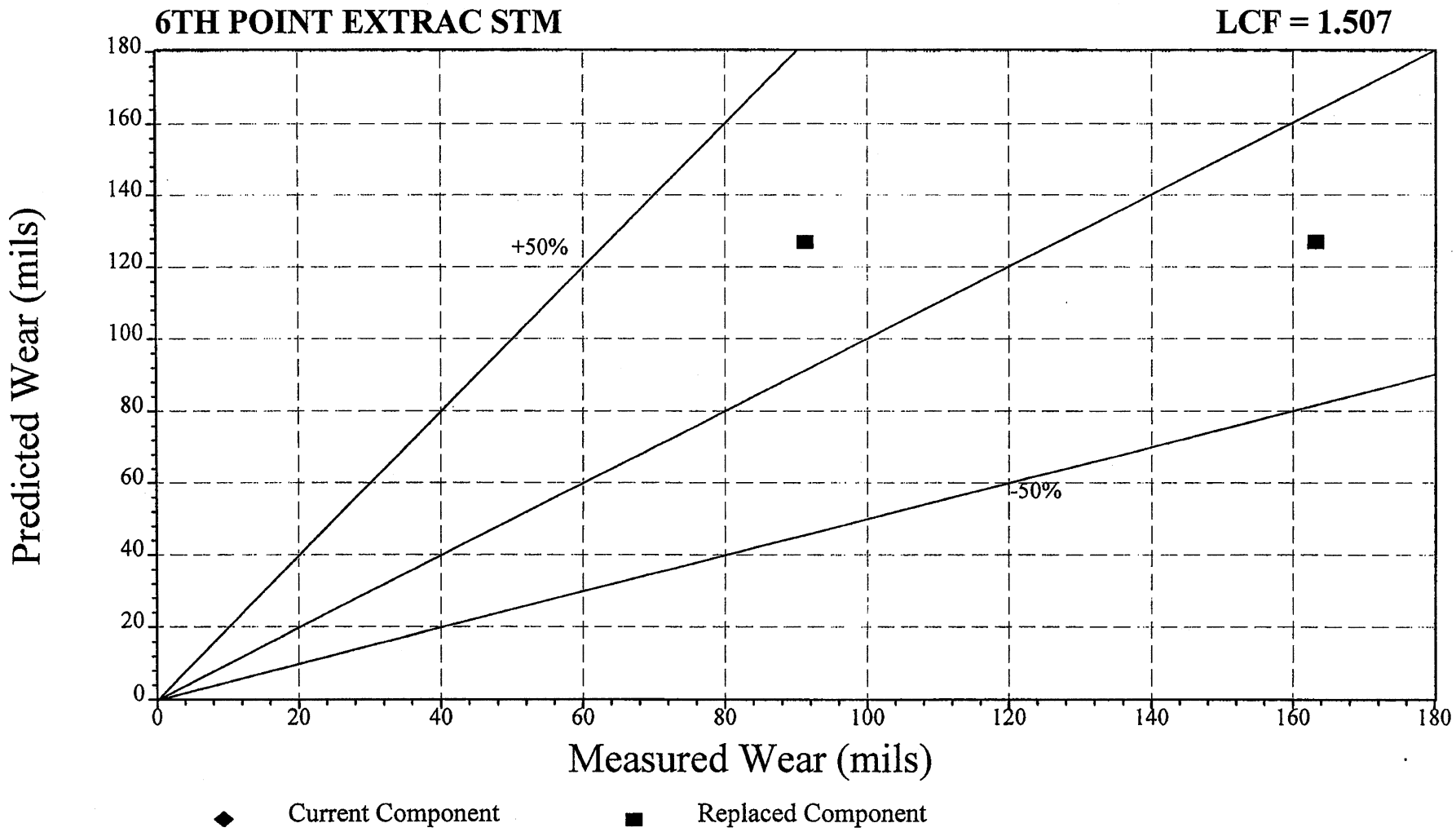

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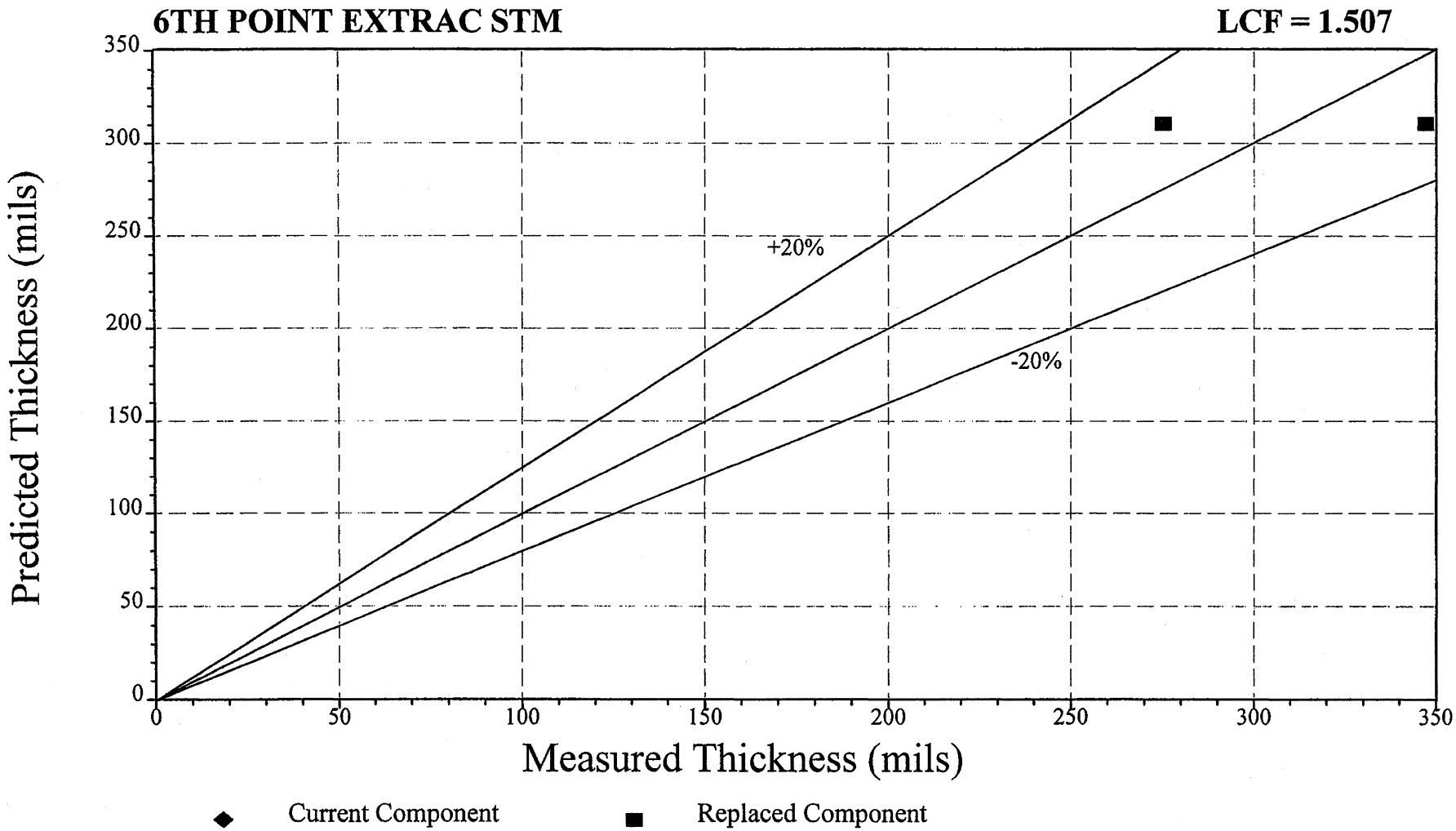

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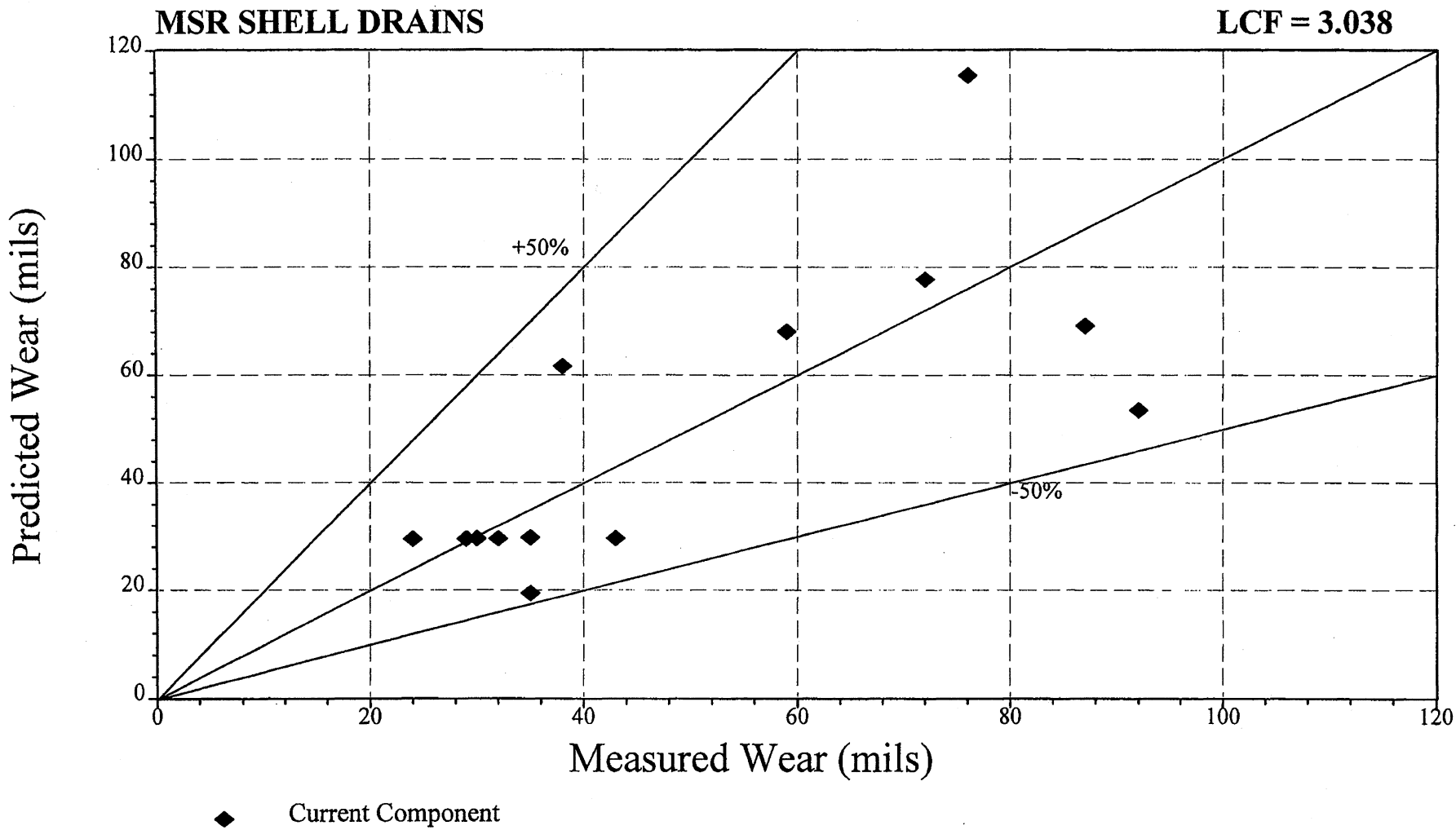

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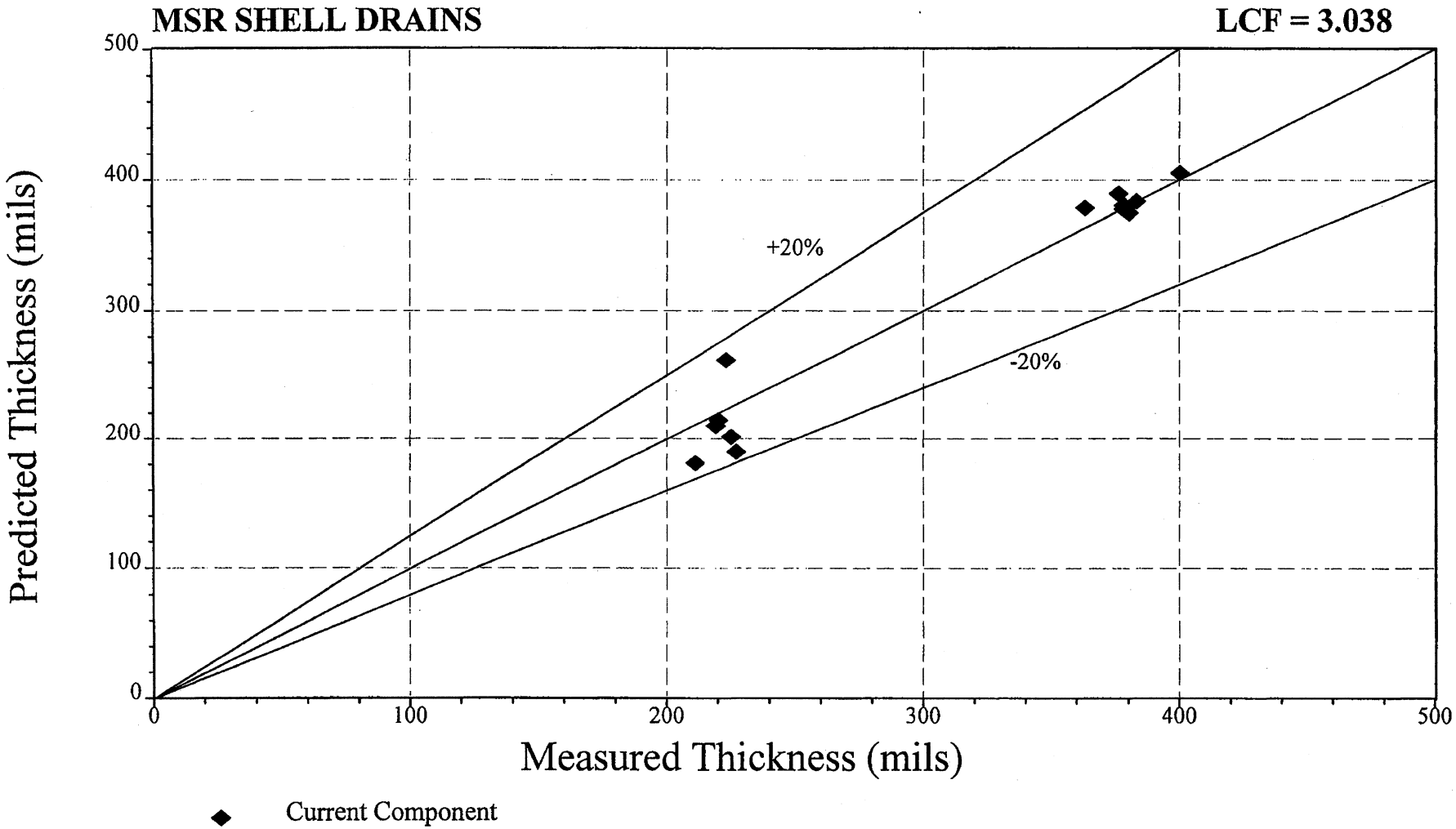

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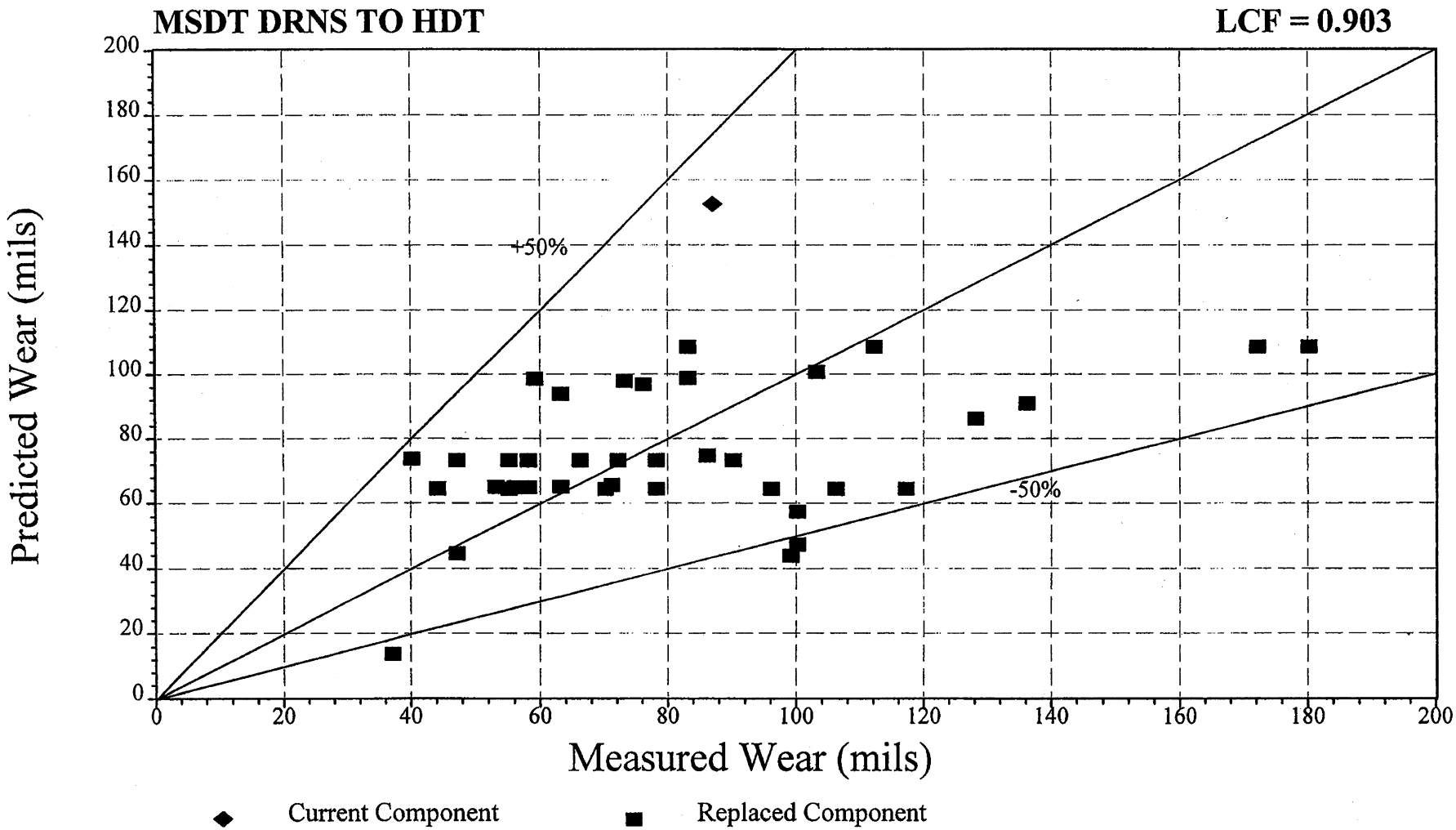

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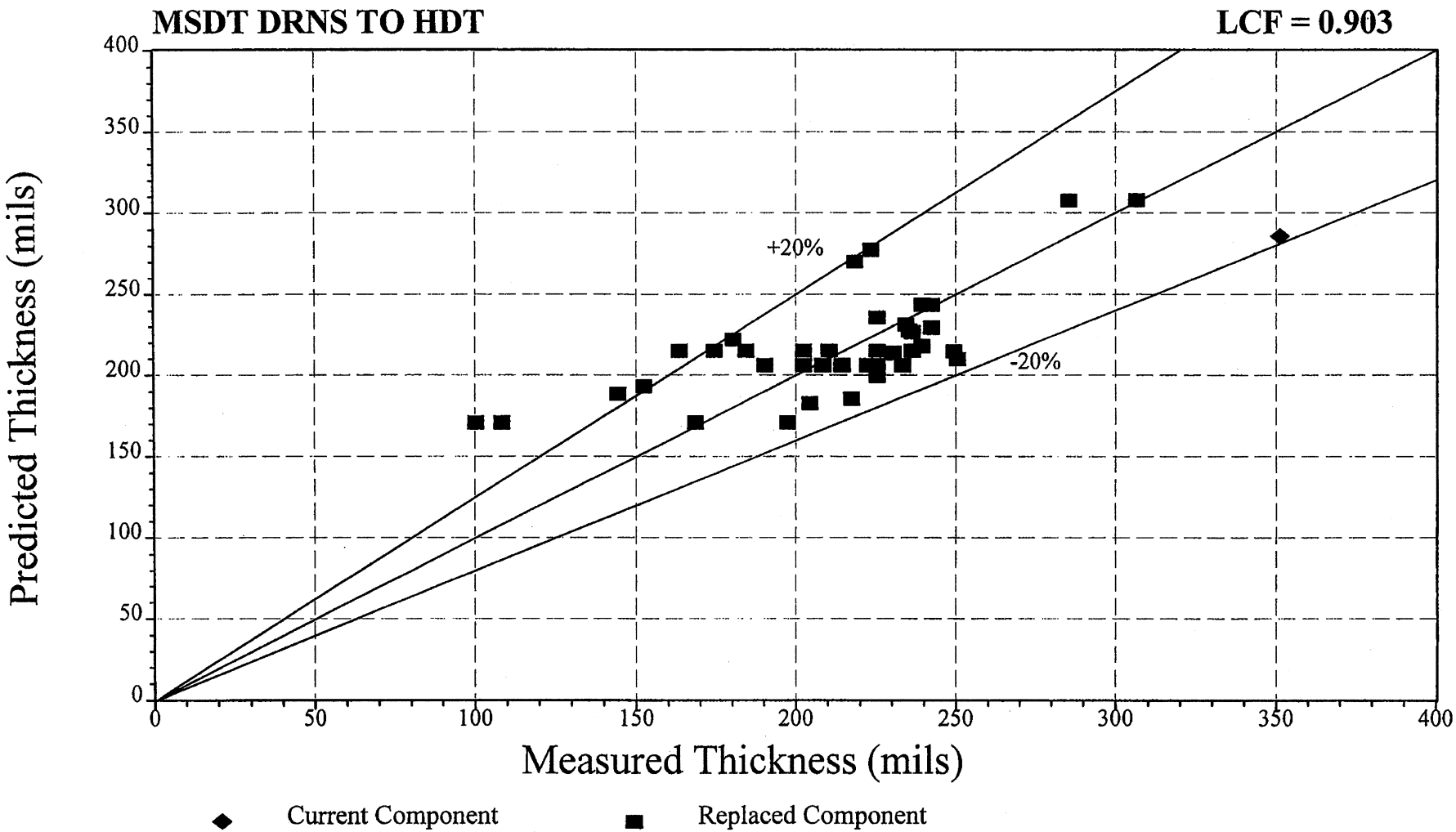

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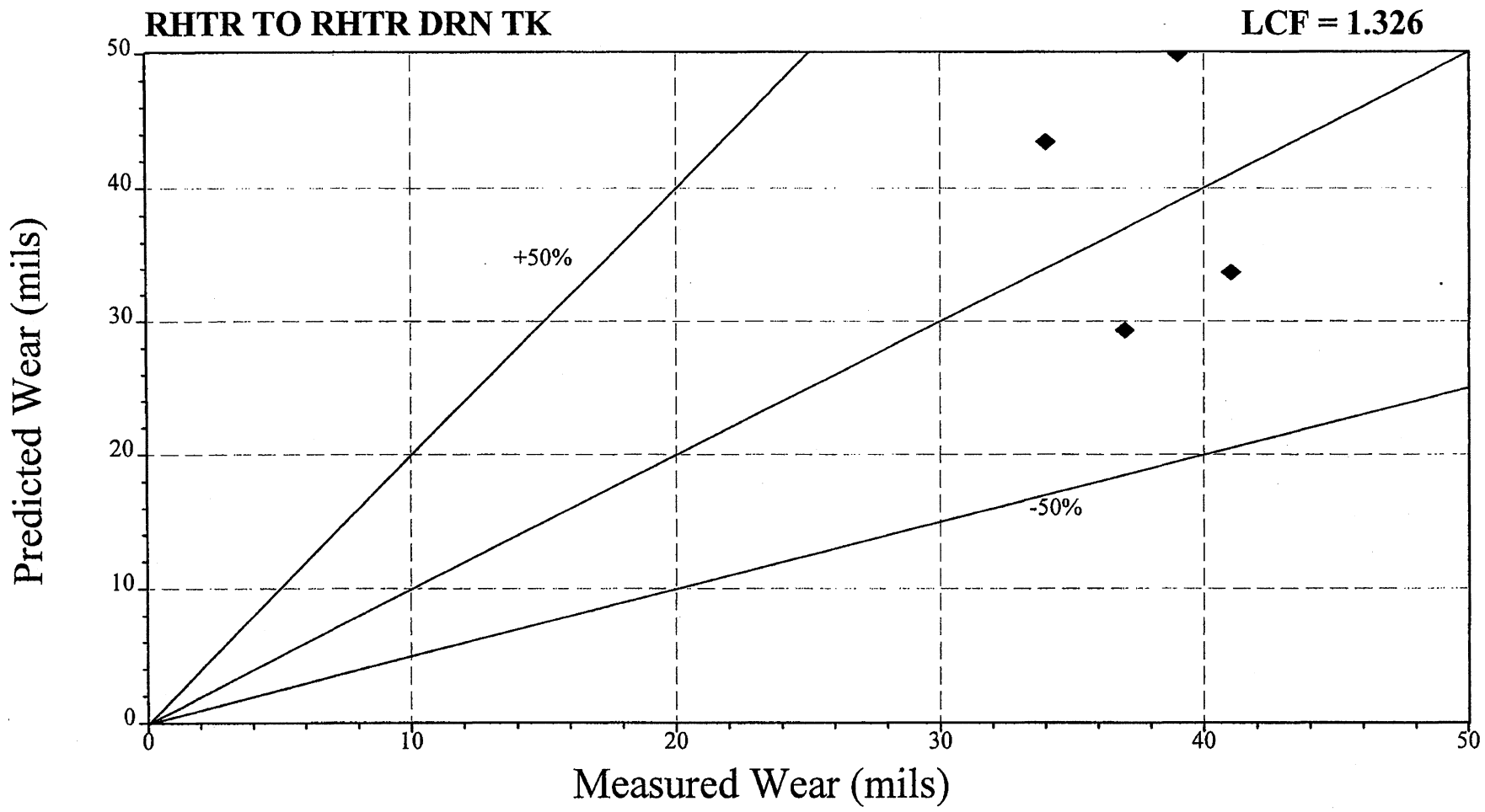

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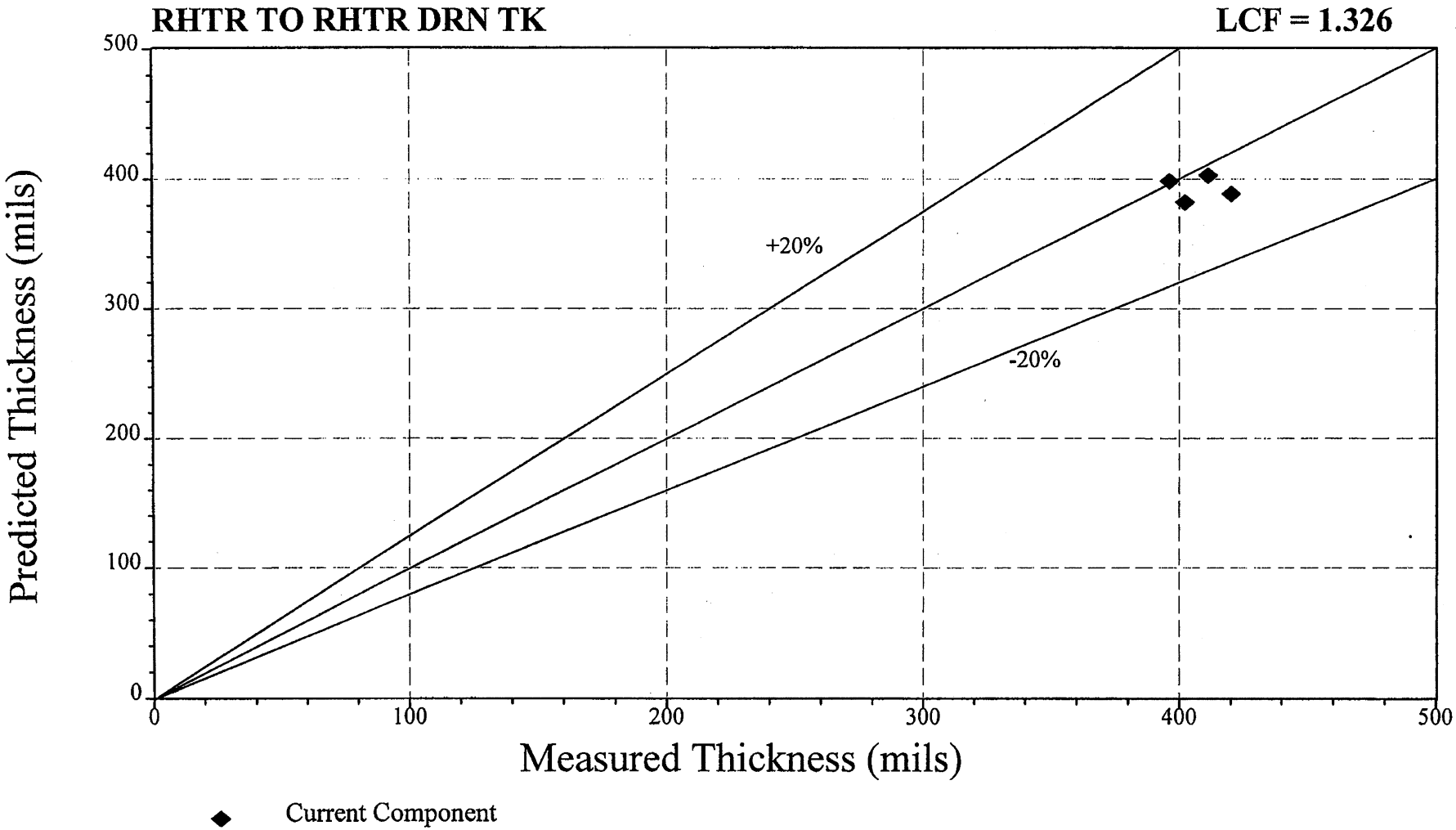

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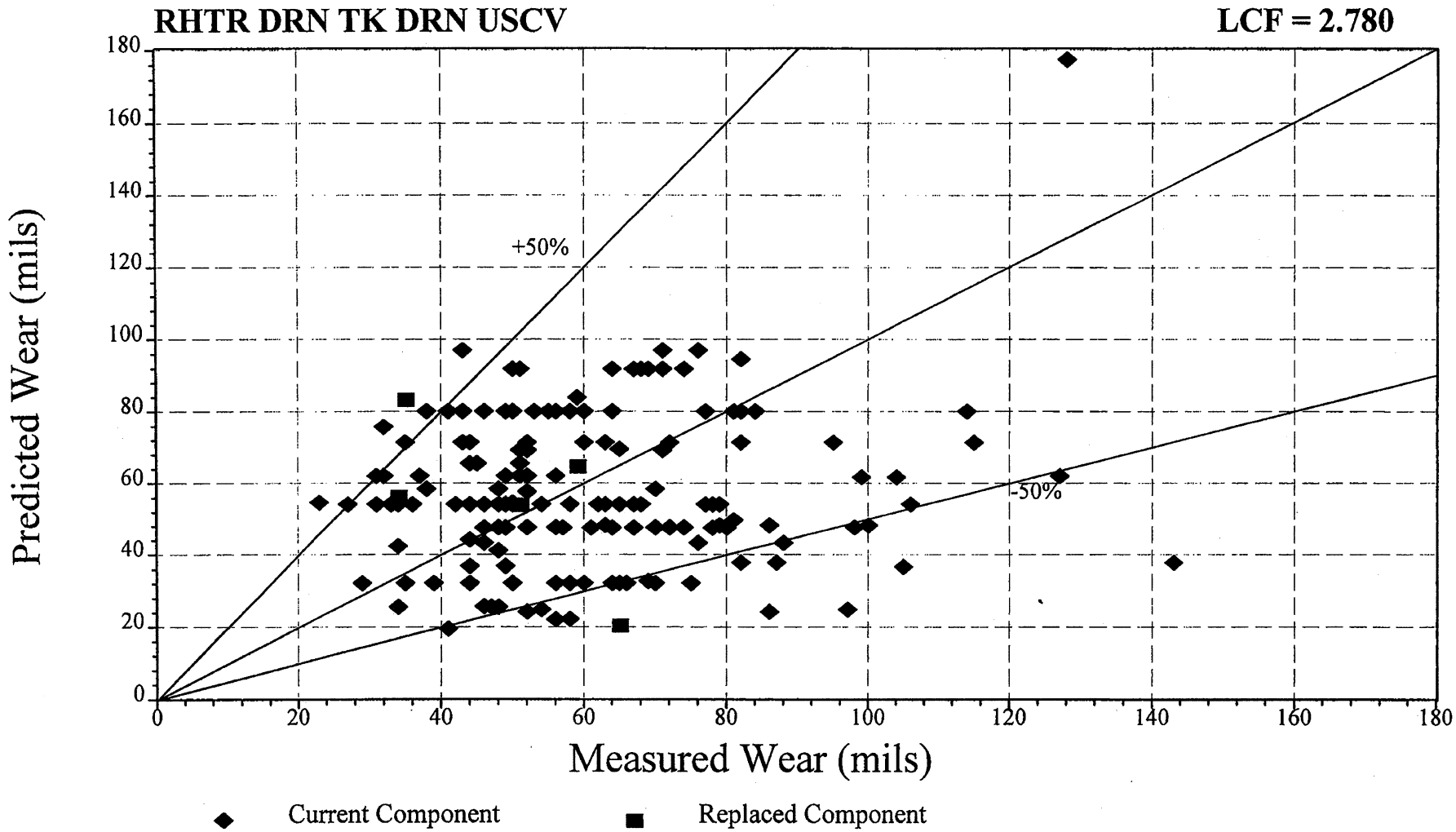

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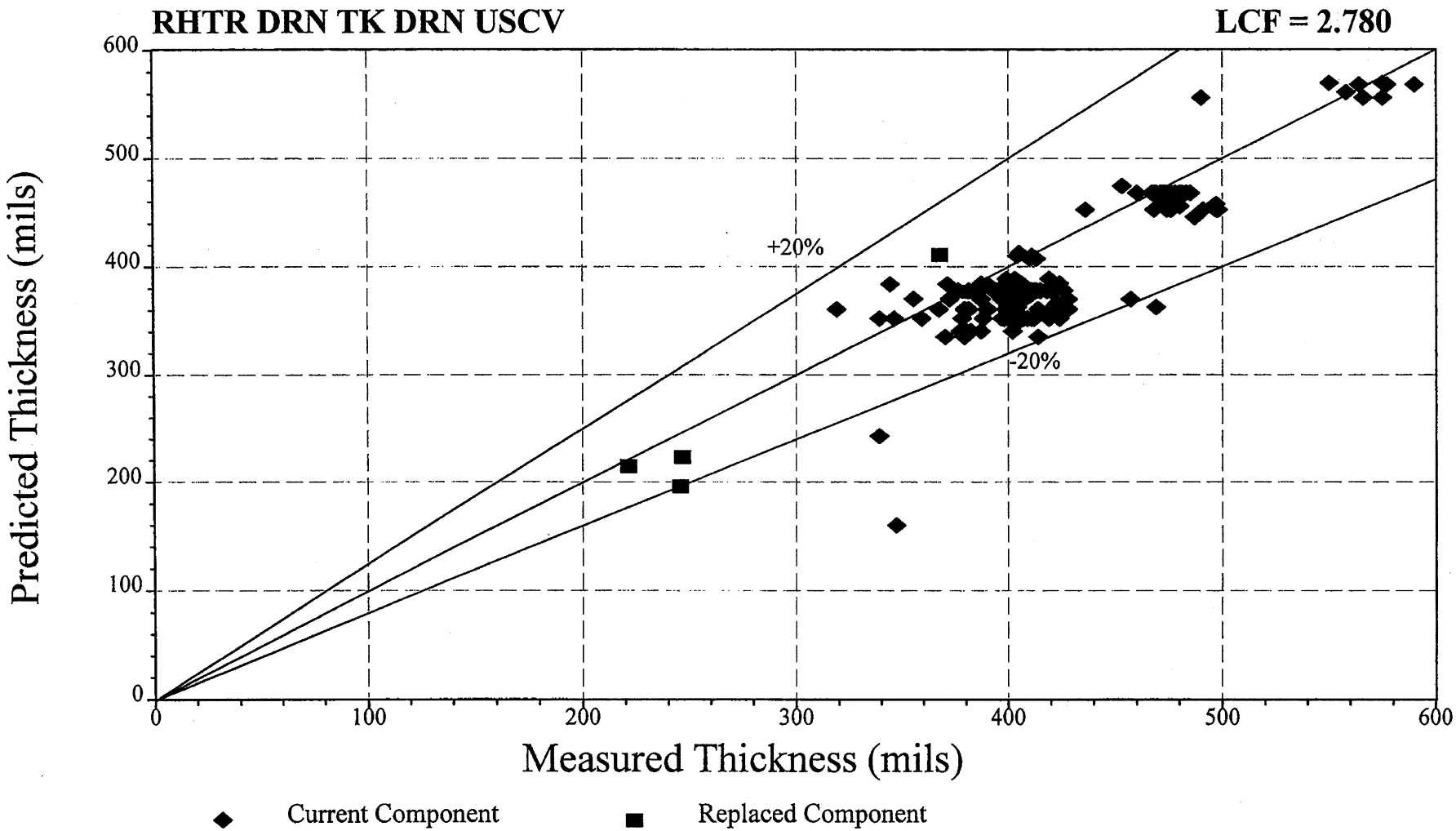

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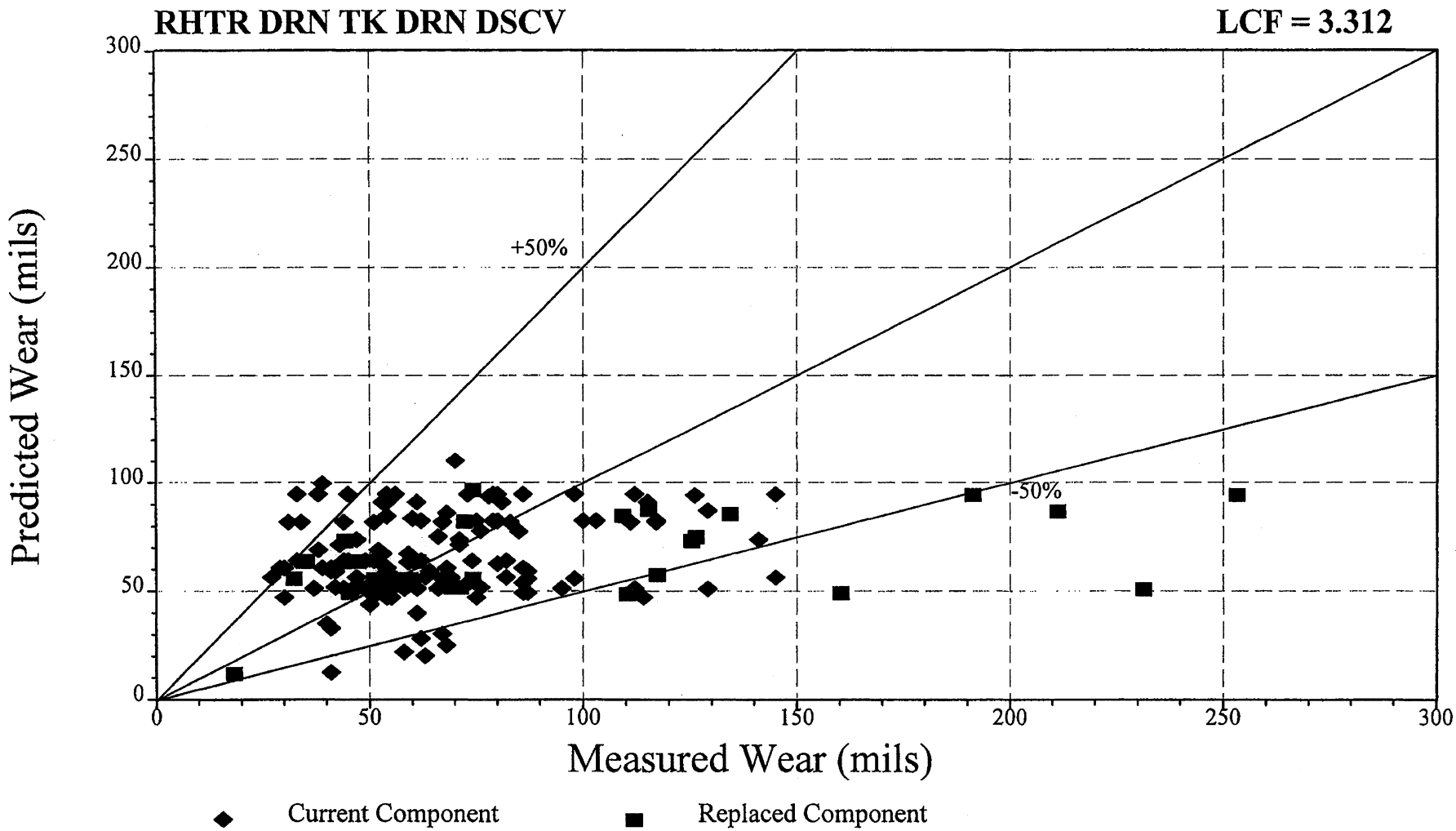

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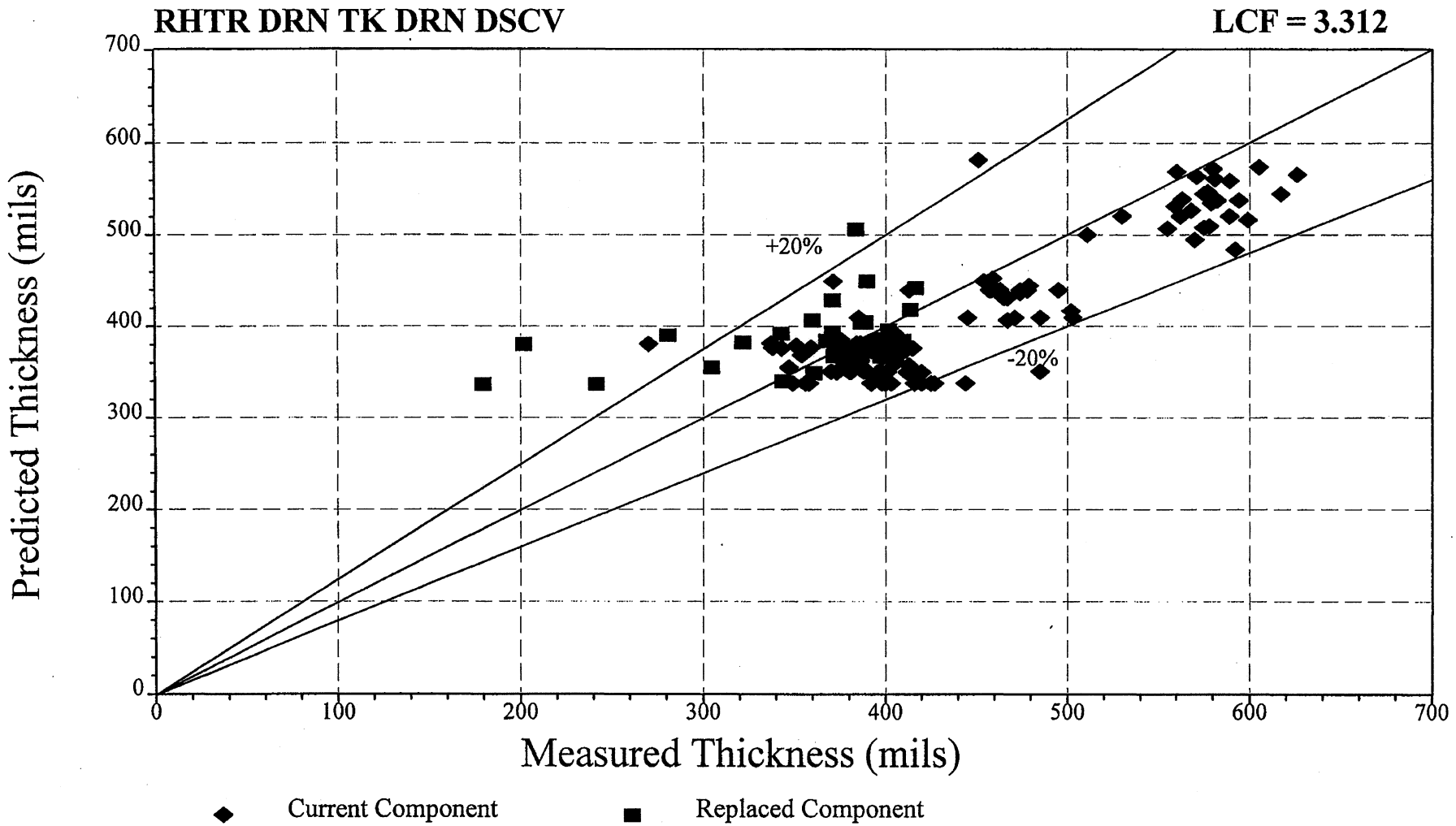

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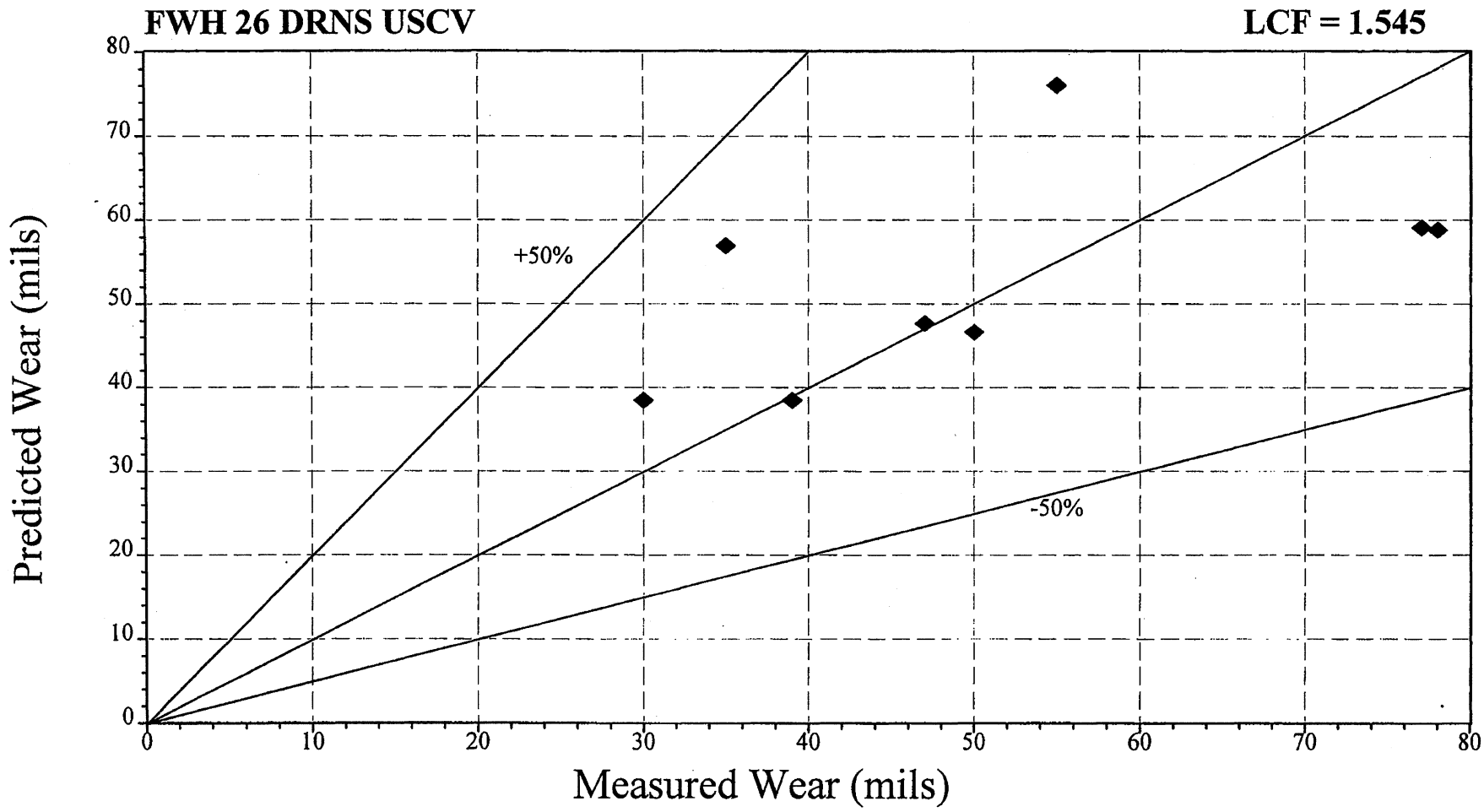

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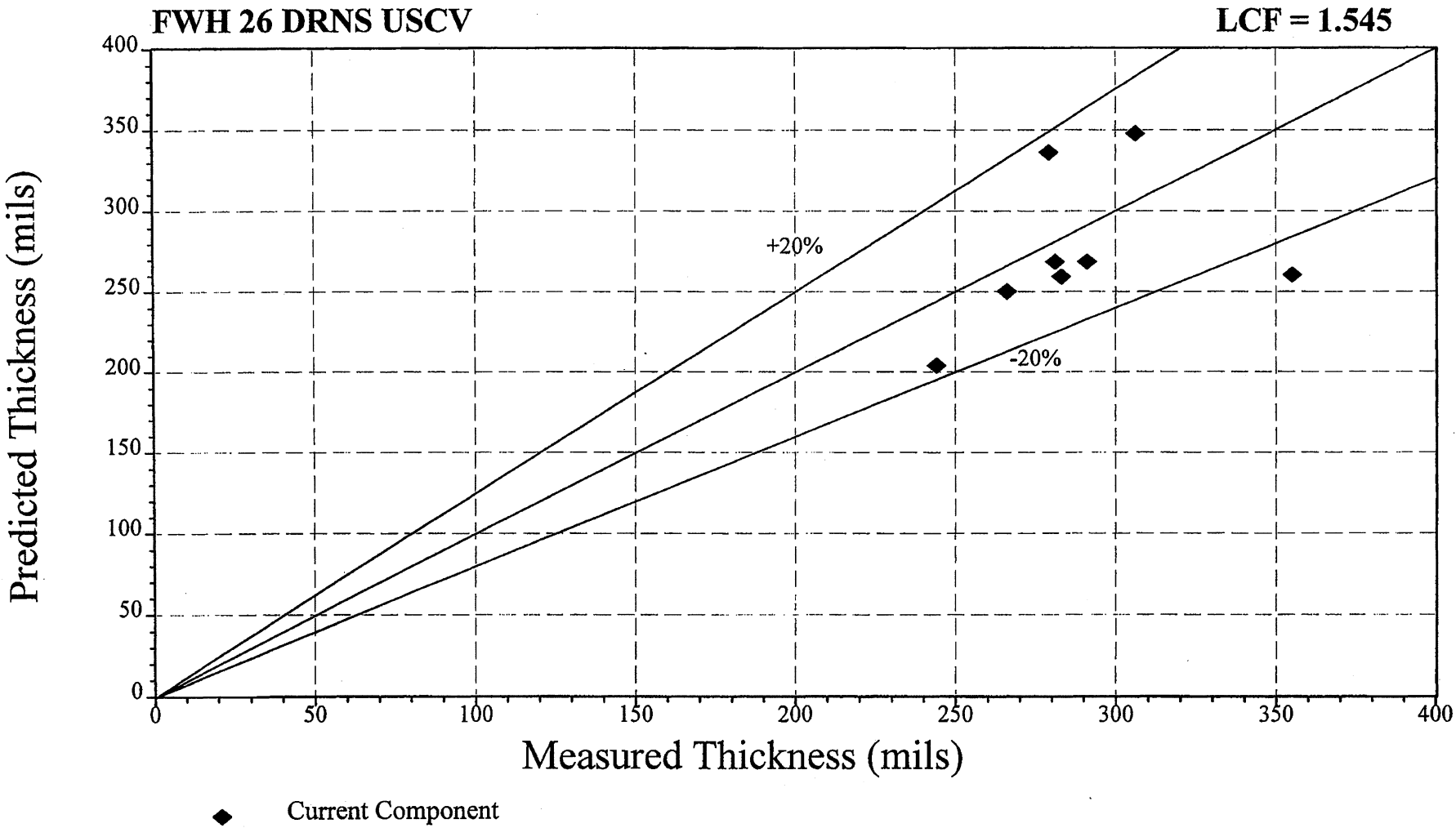

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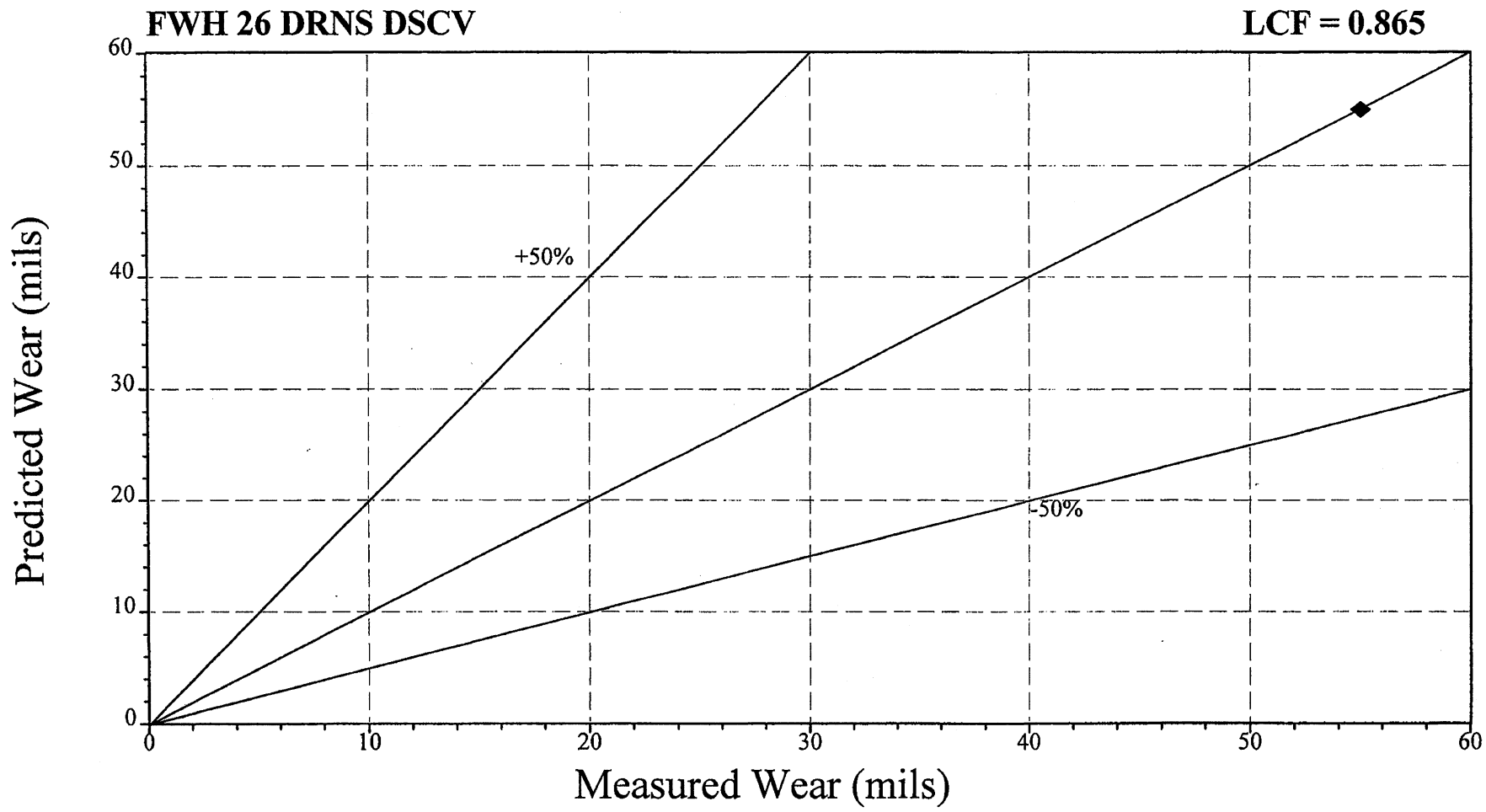

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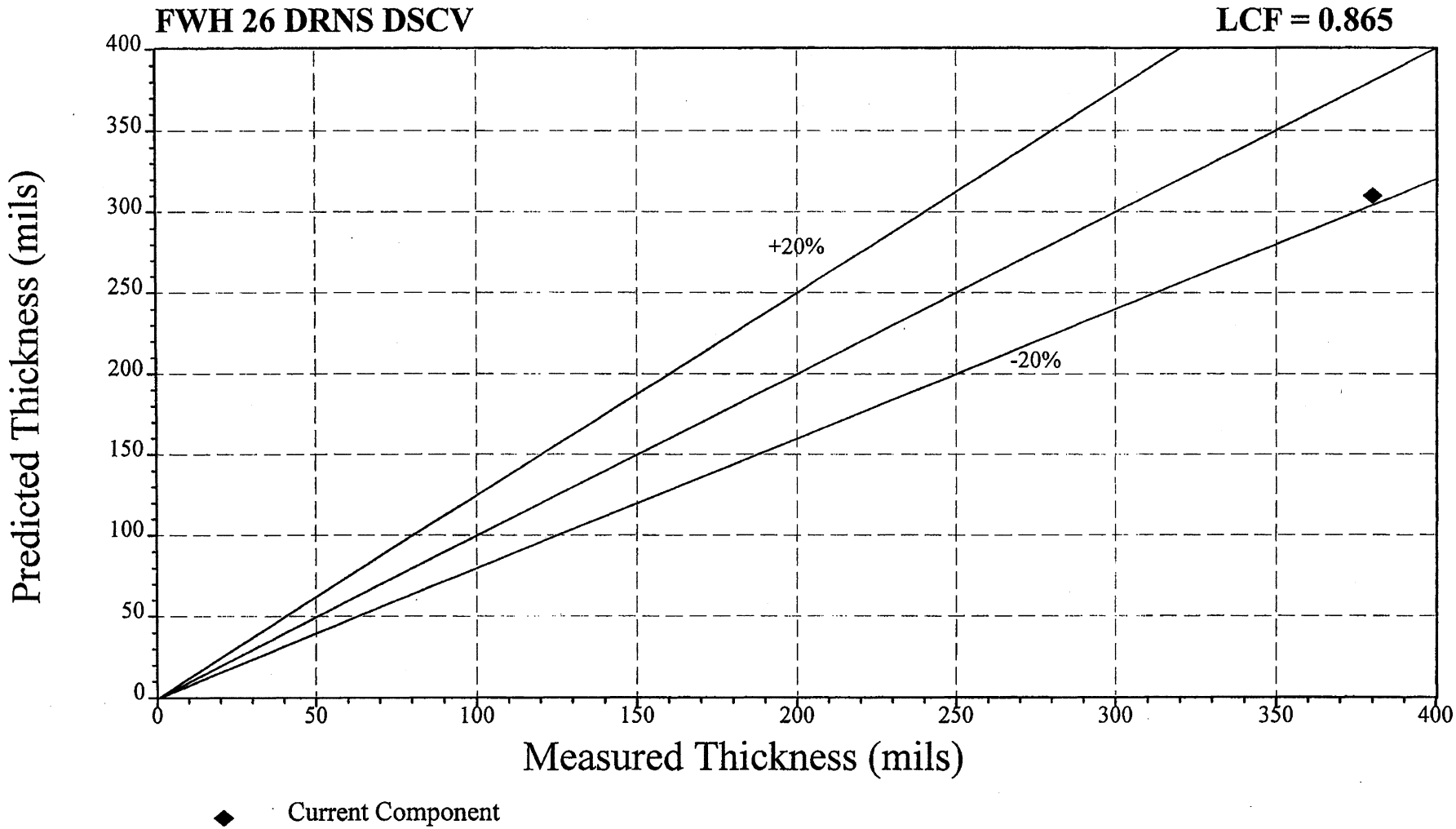

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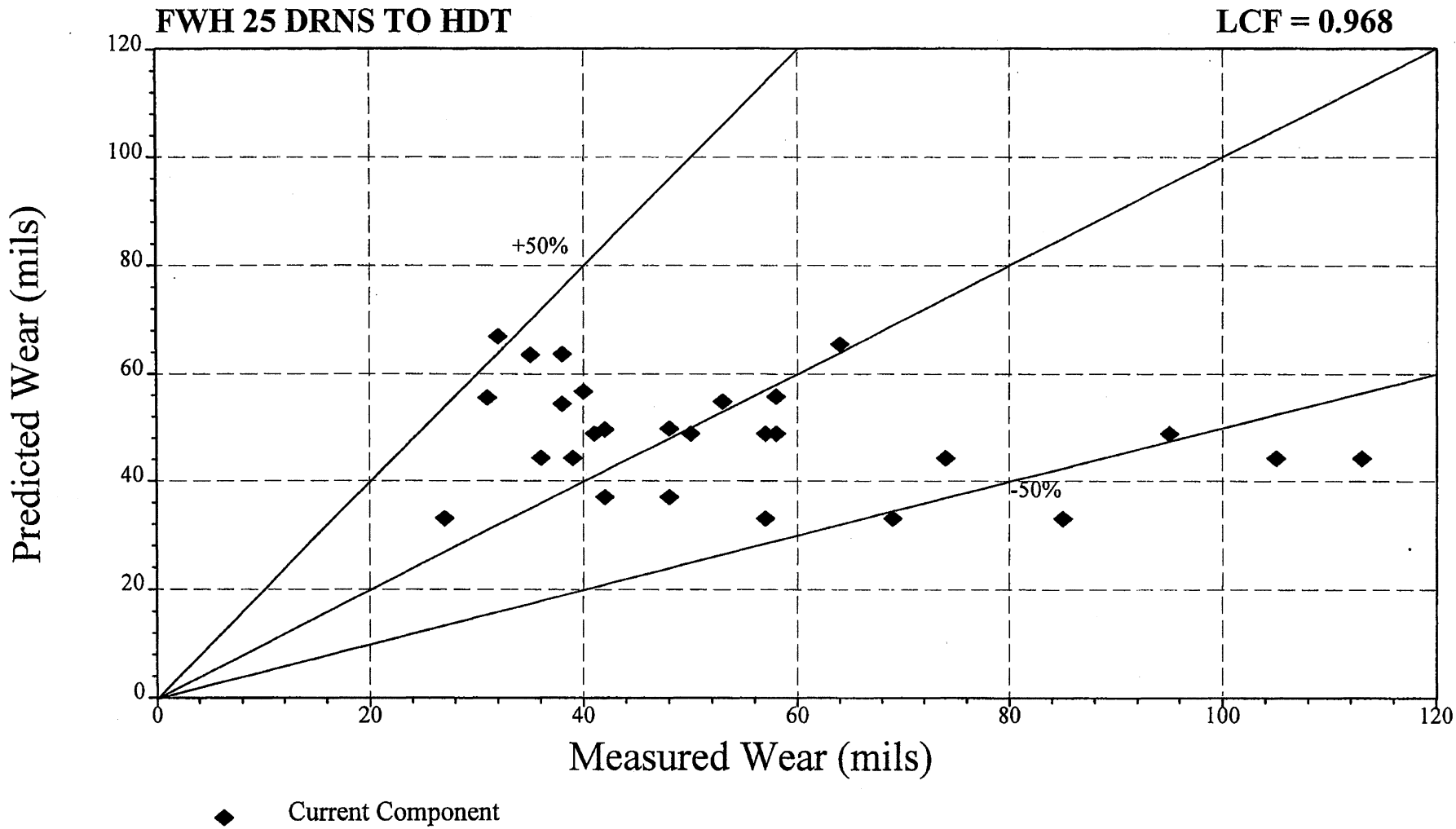

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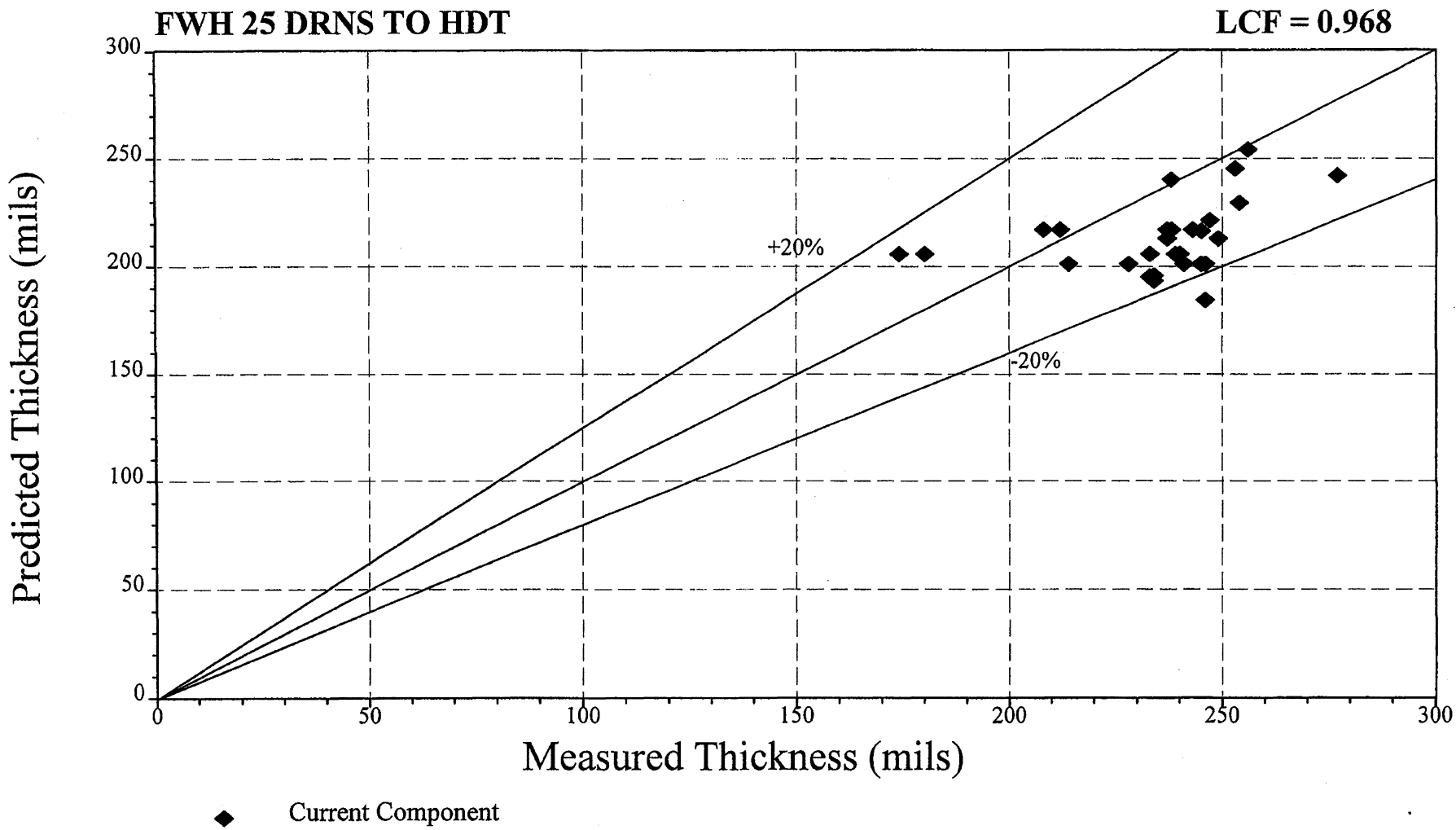

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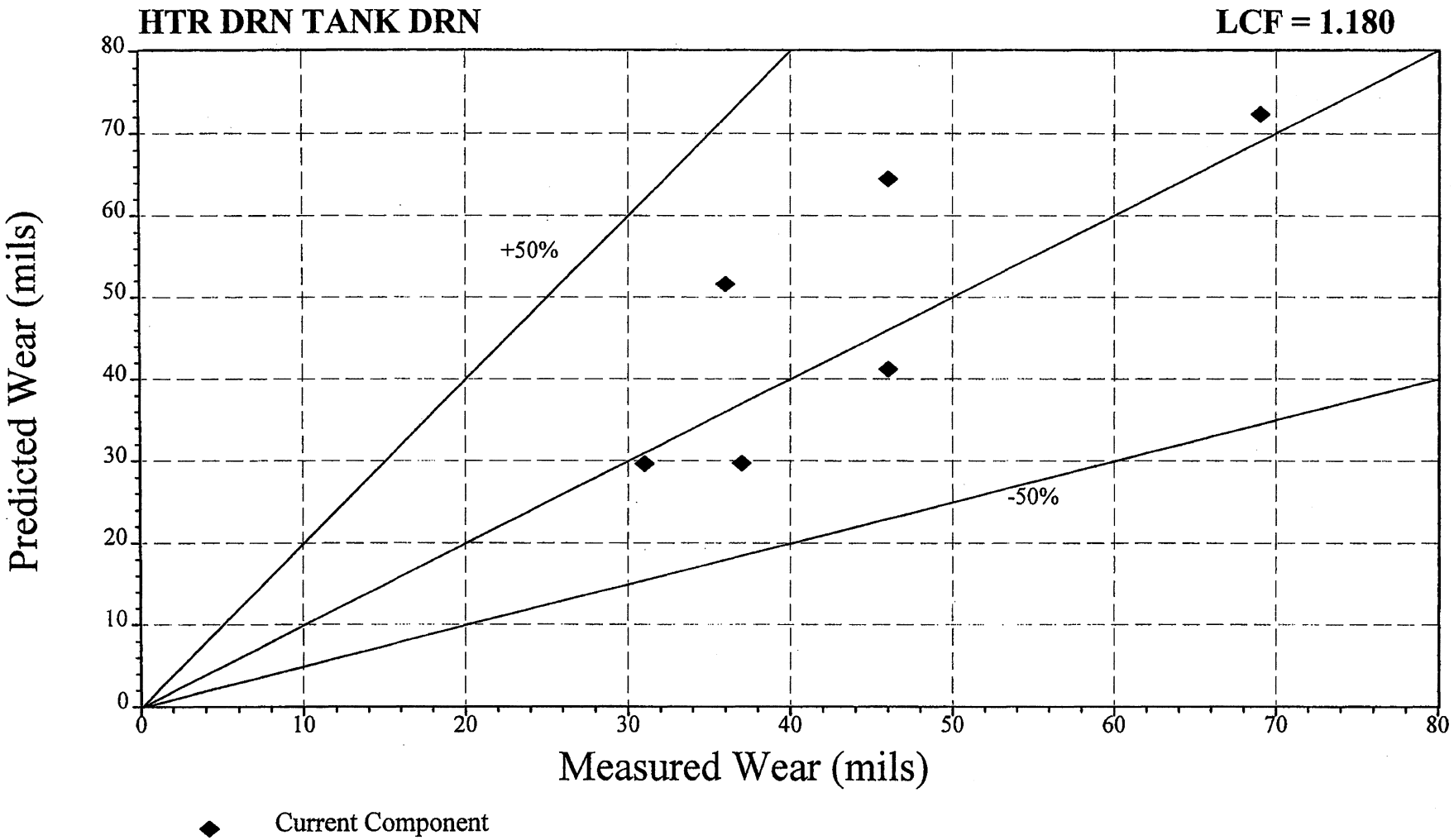

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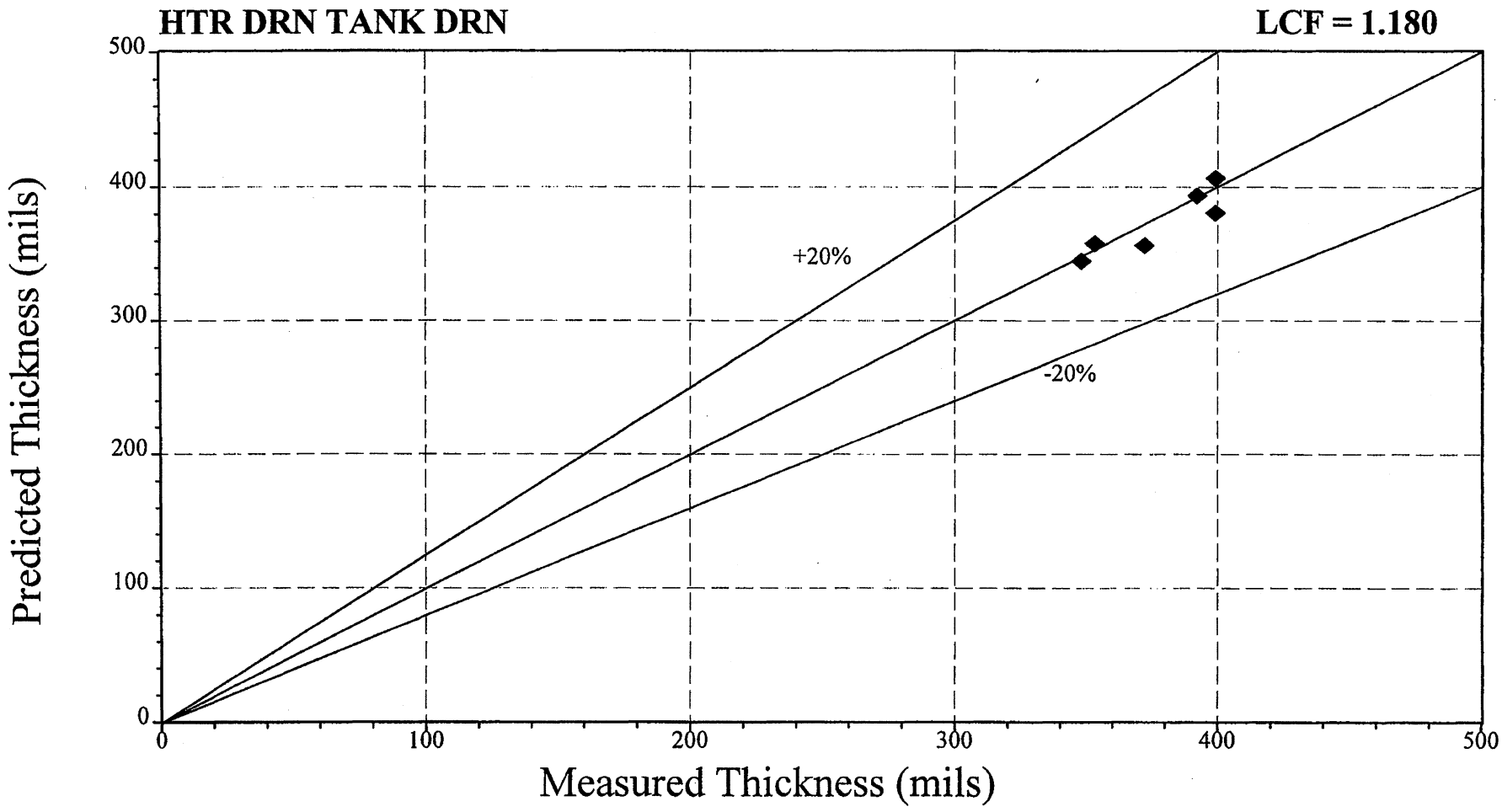

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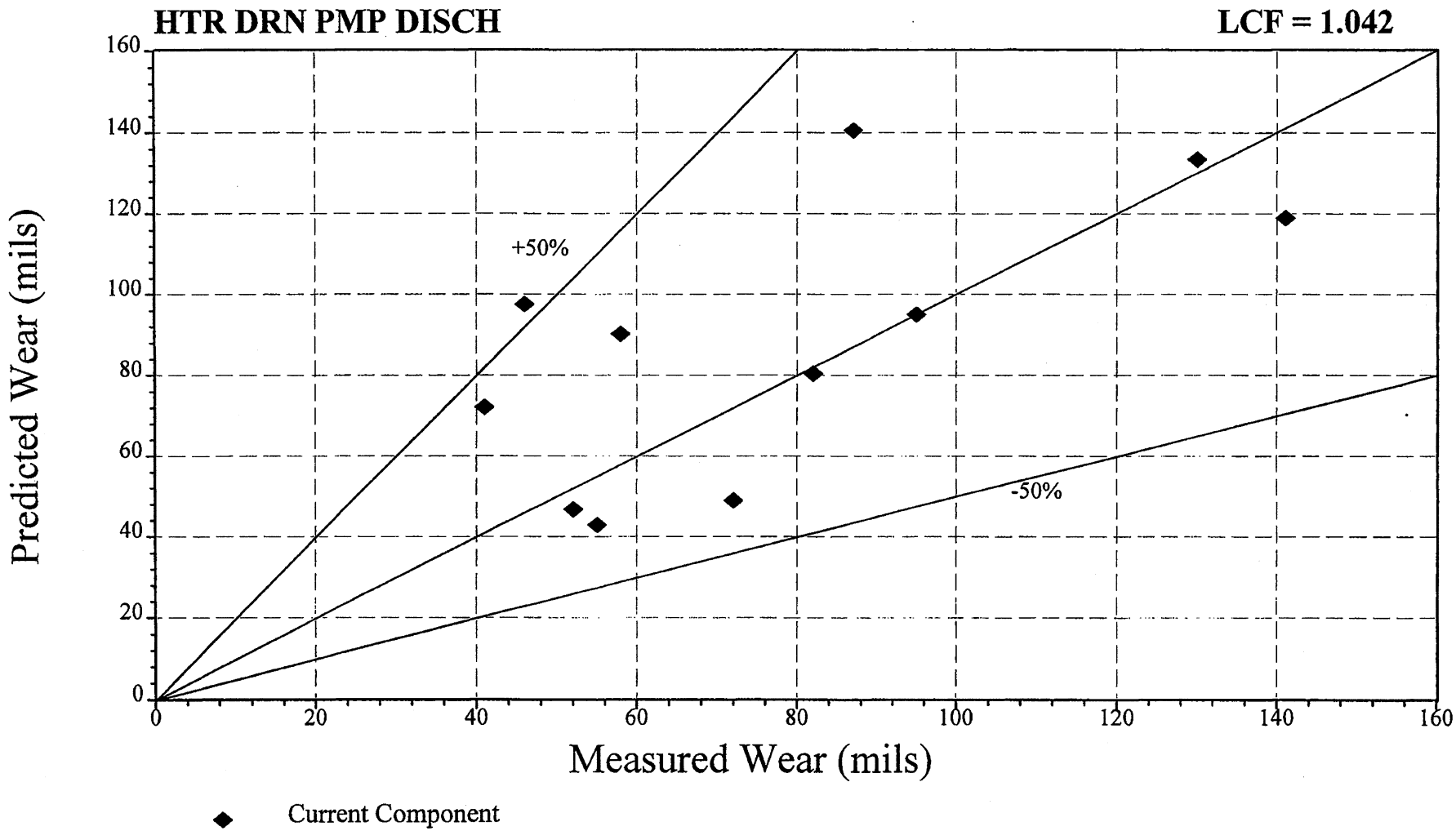

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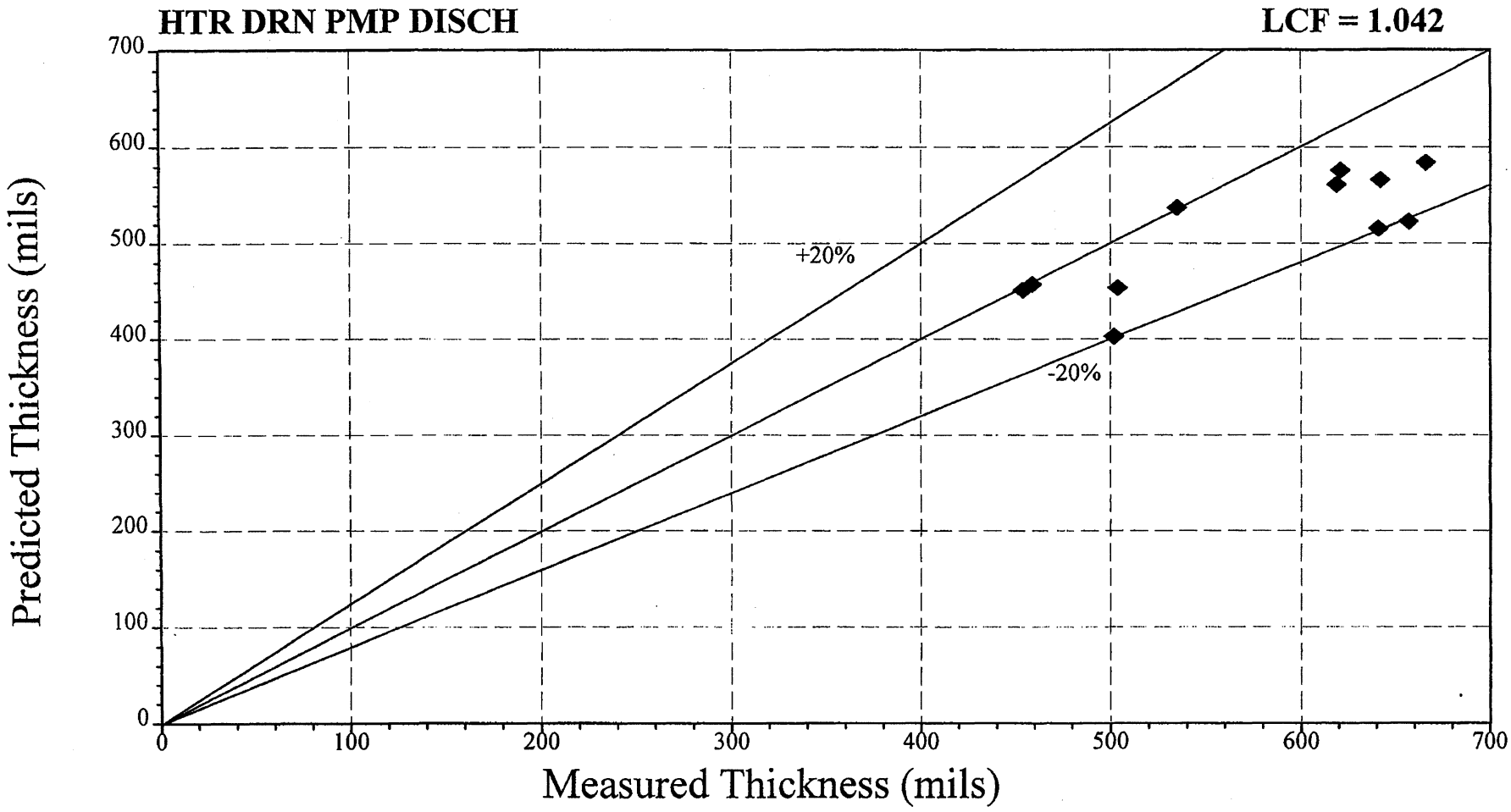

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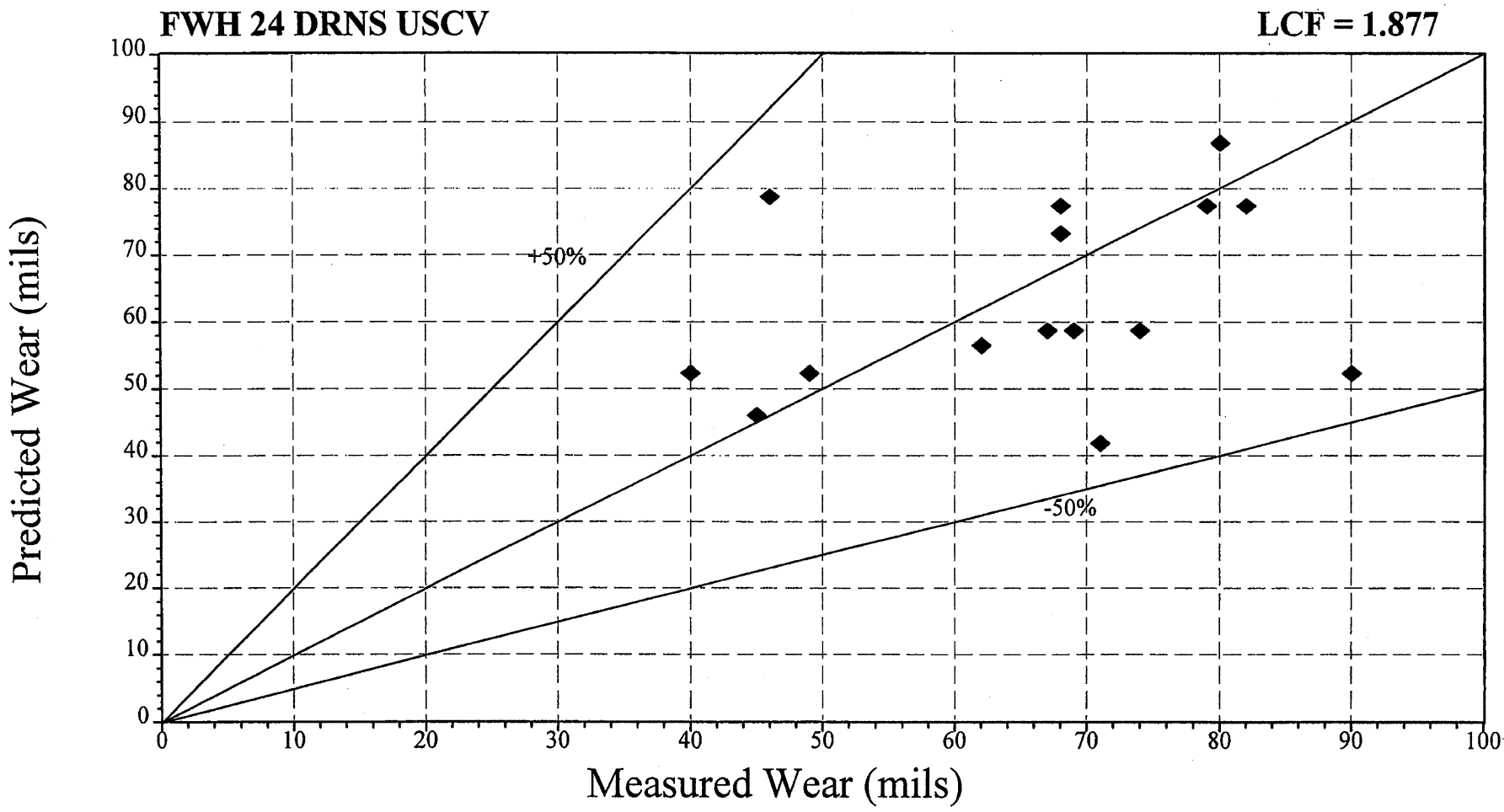

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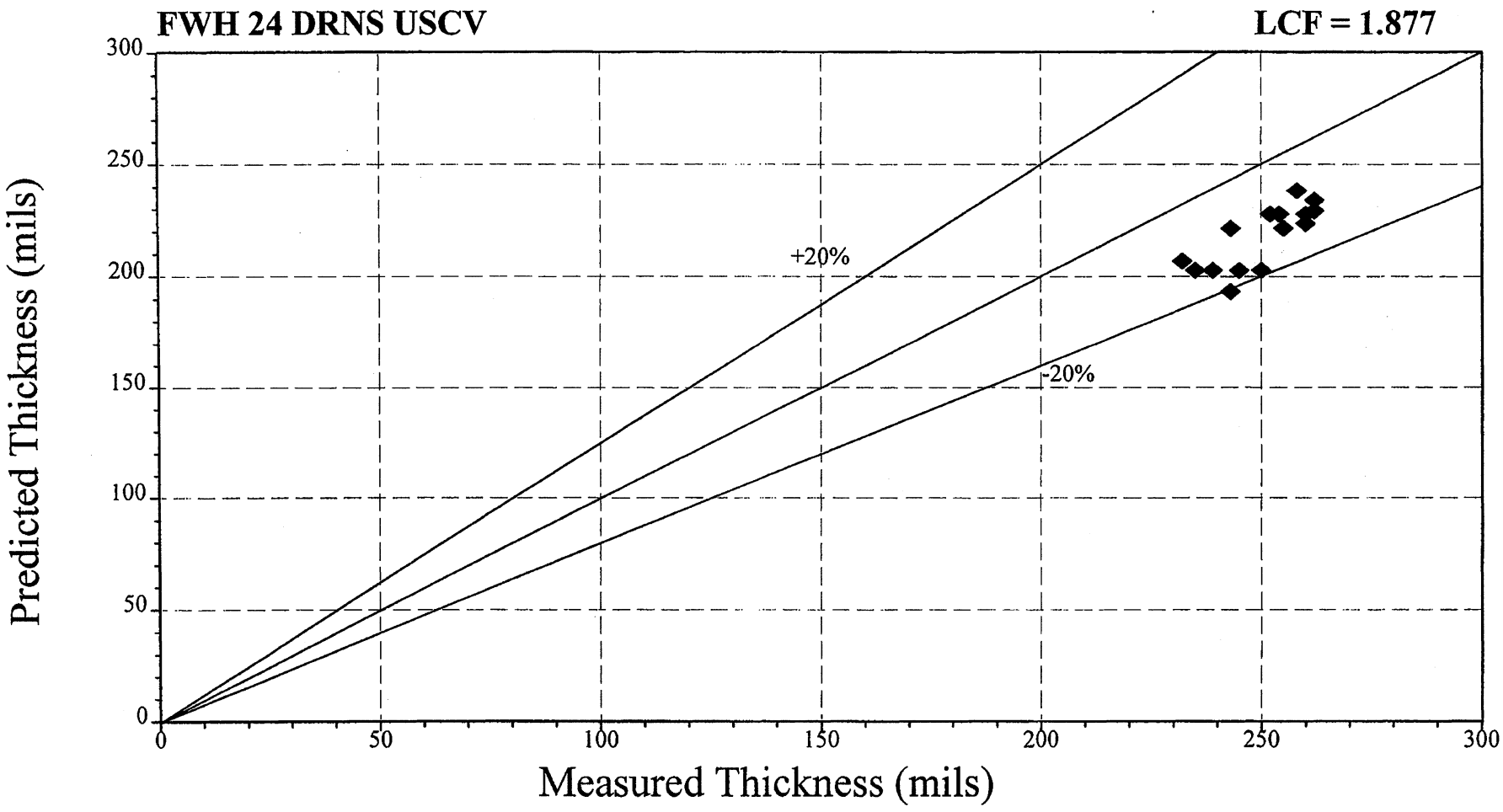

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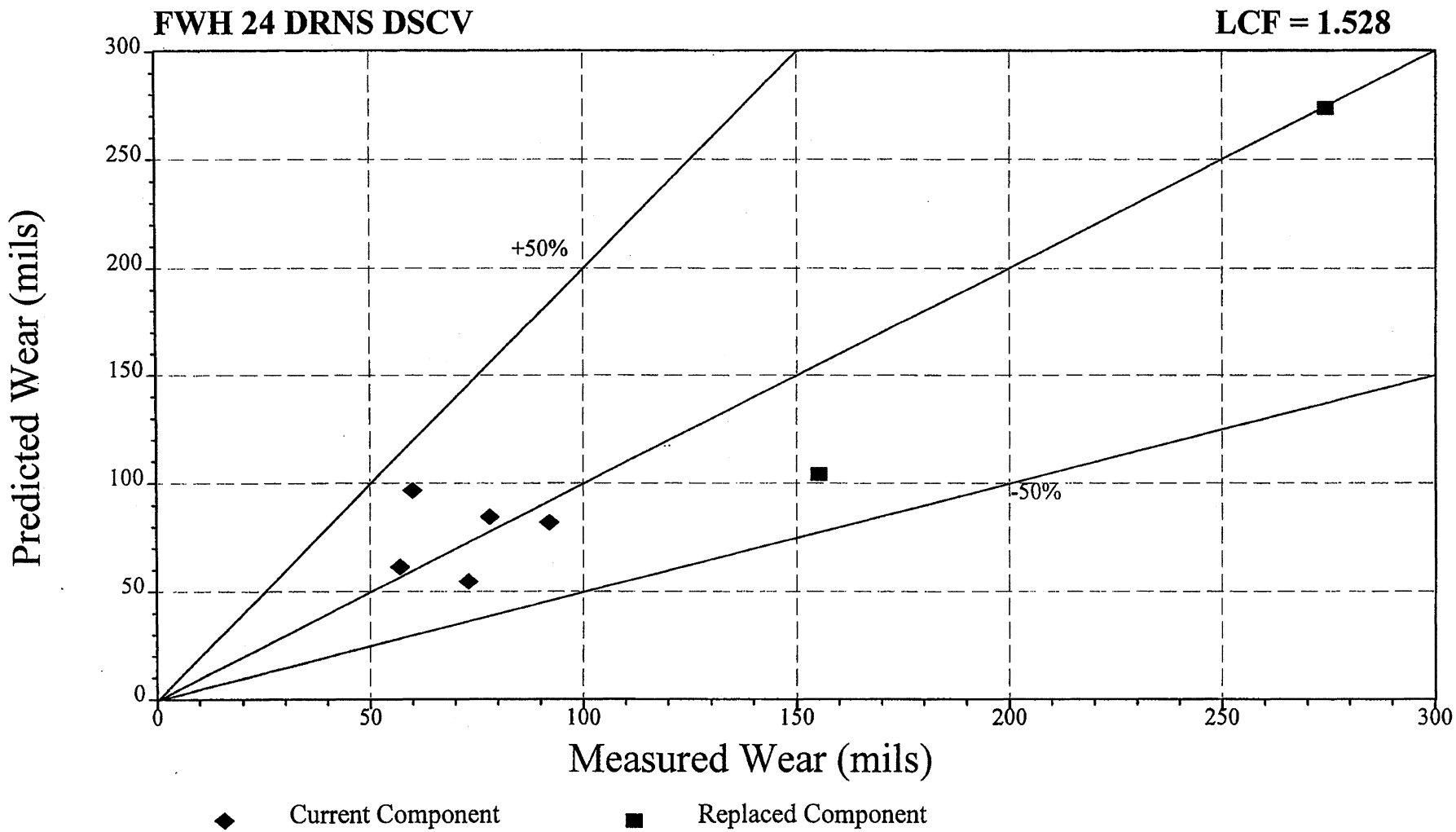

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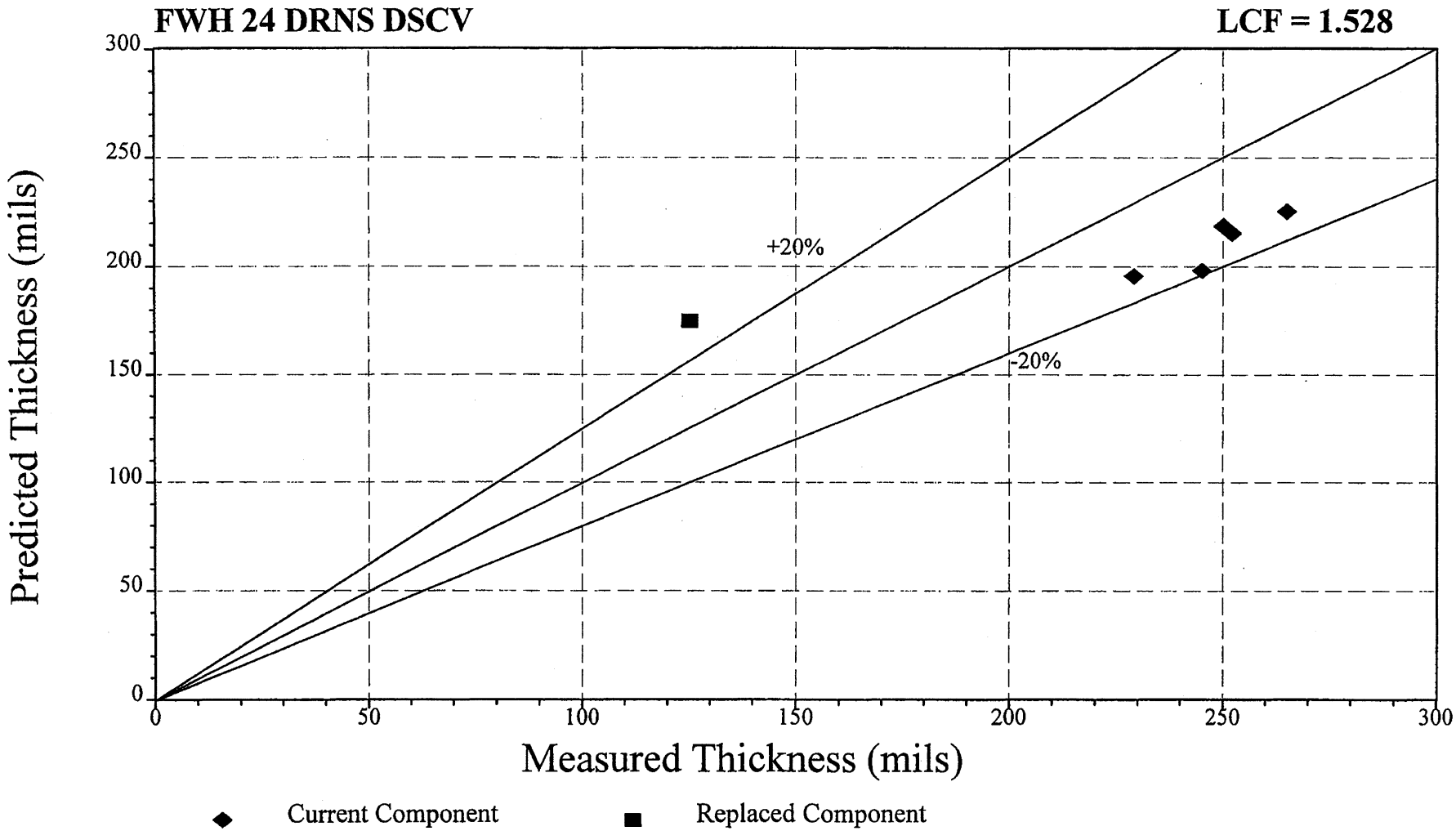

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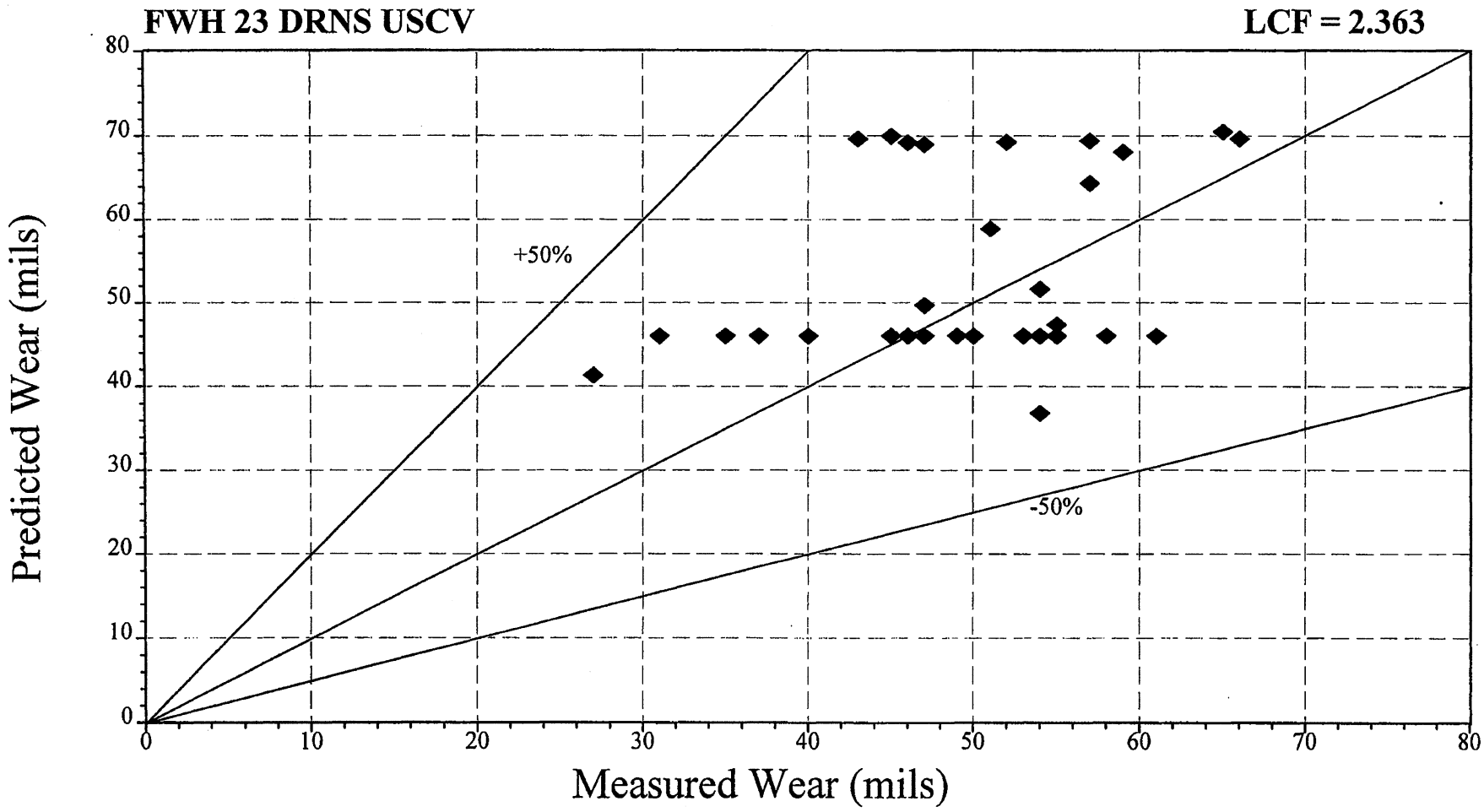

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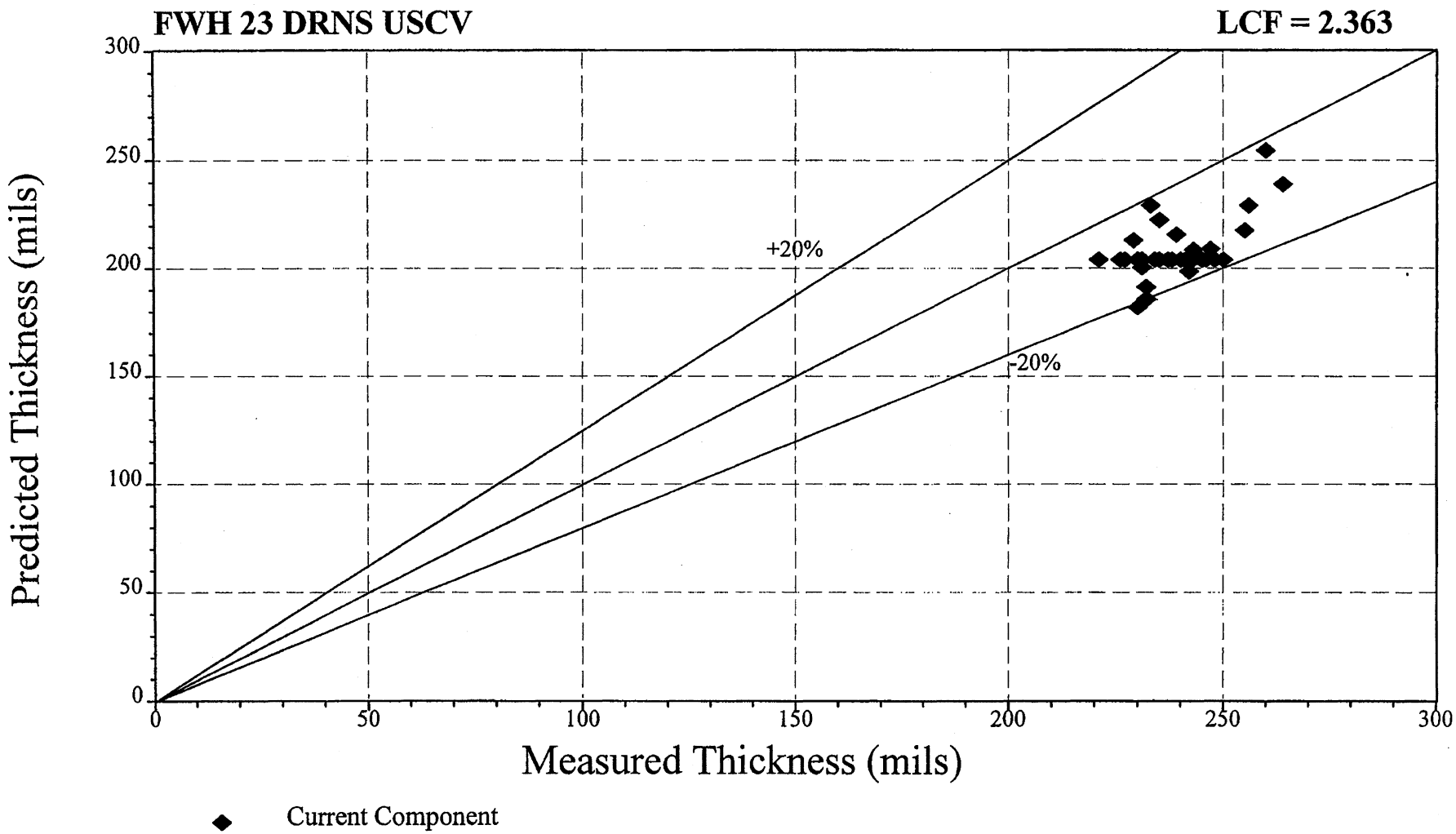

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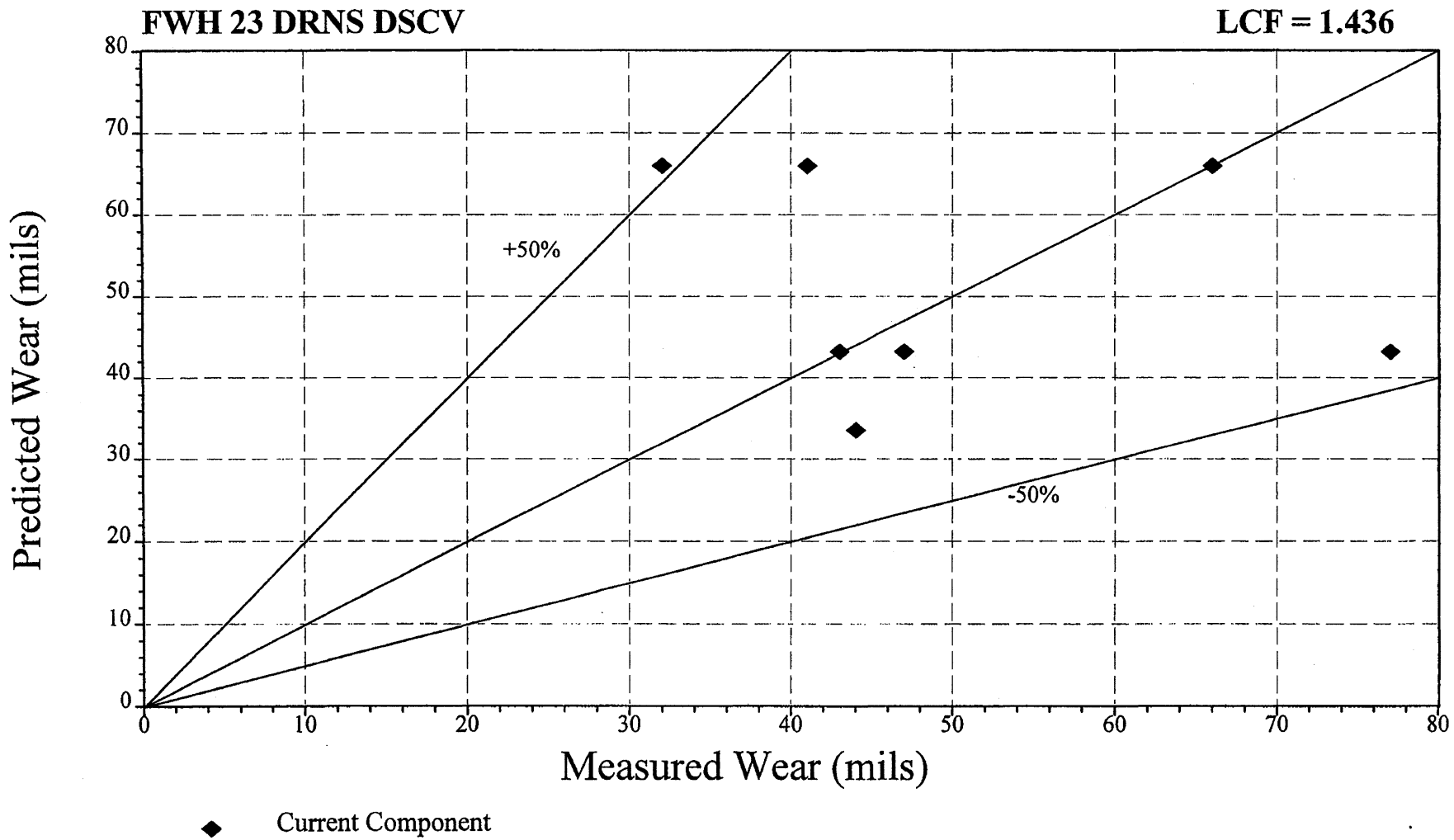

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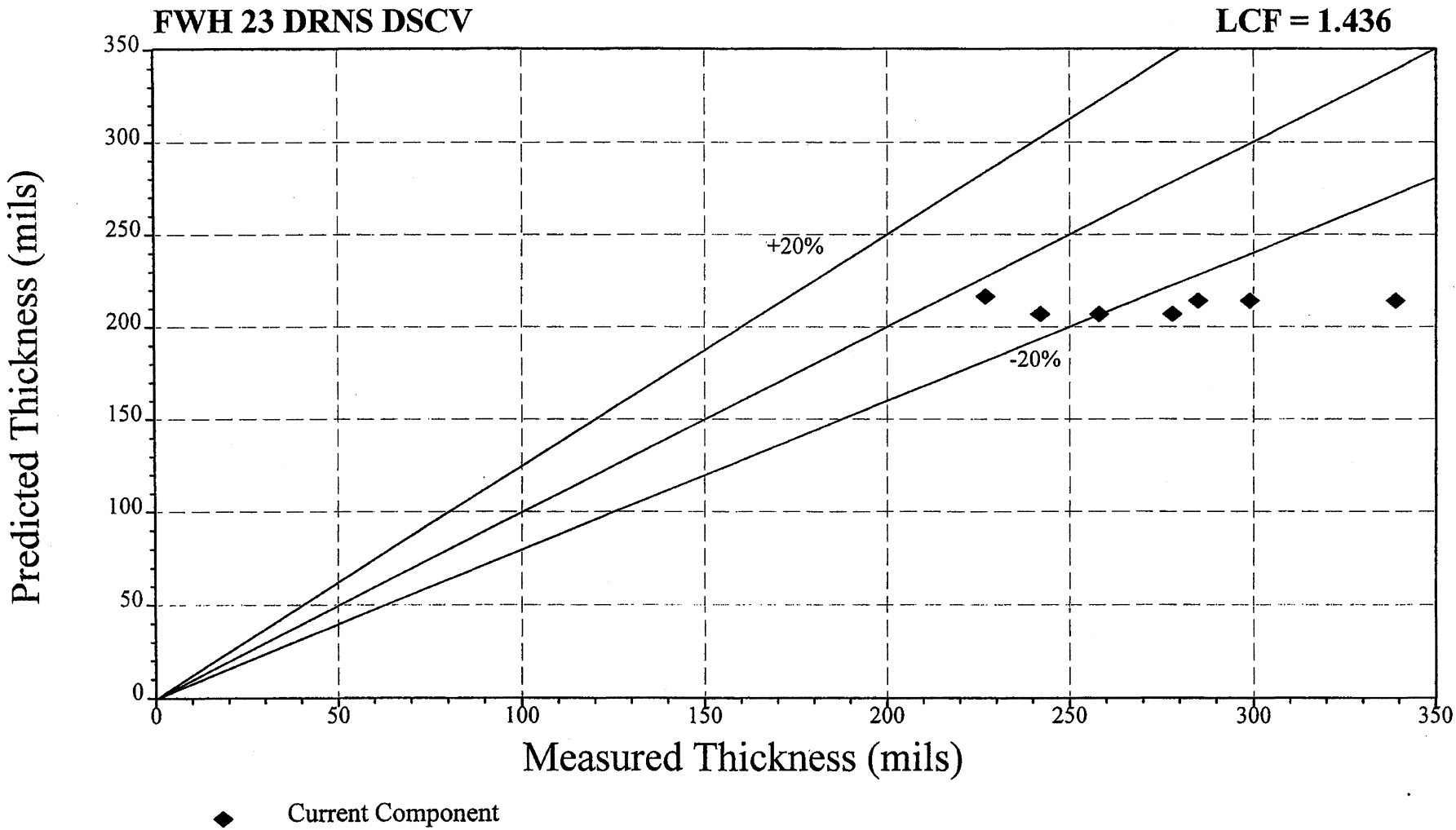

Indian Point Unit 2
CHECWORKS FAC Model

Calculation No. 050714b-01
Revision 0
Issued For-Use

July 5, 2005

prepared for:

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1. Introduction

Flow-Accelerated Corrosion (FAC) is a form of material degradation that results in thinning of the inside pipe wall in carbon steel piping and fittings under certain flow and chemistry conditions. Undetected FAC-induced wall thinning may cause a pipe to leak or rupture, potentially causing injury to plant personnel and/or plant shutdown. For these reasons, and in response to regulatory requirements, Indian Point 2 Nuclear Power Plant (IP2) has developed and implemented a program to monitor and mitigate FAC-induced wall thinning in high energy, large-bore piping systems [7.1].

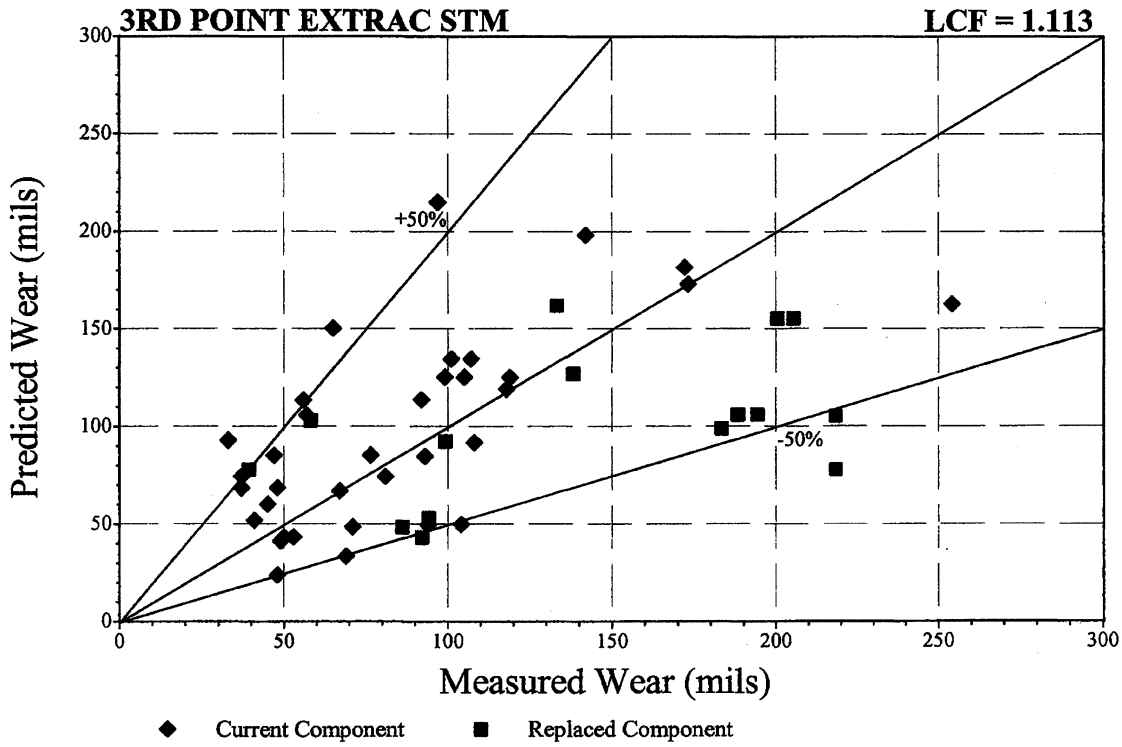
This report uses plant design and operation information to document the CHECWORKS model for IP2. It documents the CHECWORKS Pass 1 analysis to generate a wear rate prediction for every piping component modeled in CHECWORKS. Component inspection data through the Refuel Outage 16 was imported to the model where available. A Pass 2 analysis was performed on all lines to provide wear predictions calibrated to the inspection data, as well as remaining lives based upon measured wear rates for inspected components. The results of these analyses can be used to select components for inspection in order to mitigate pipe deterioration due to FAC.

Appendix I

Pass 2 Wear Rate Analysis Reports

Table of Contents

Comparison of Wear Predictions



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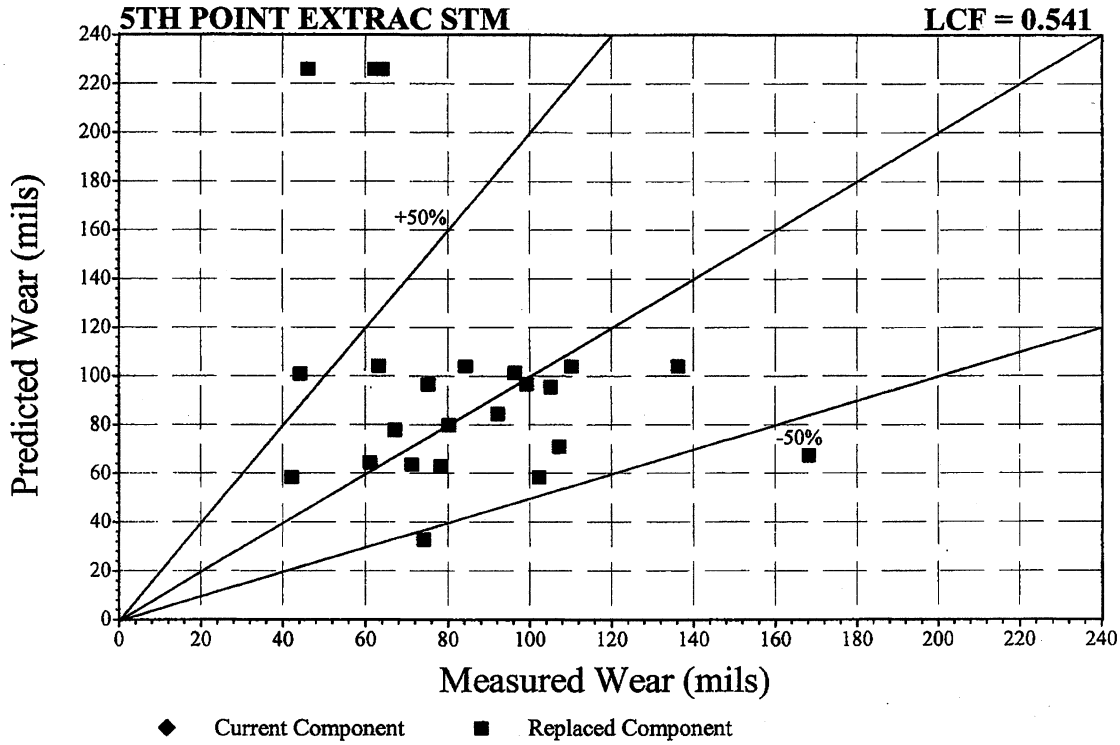


Company: ENTERGY NUCLEAR NORTHEAST
Plant: INDIAN POINT
Unit: 2
DB Name: IP2

Report Date: 02-MAY-2005 Time: 14:32:33
Analysis Date: 02-MAY-2005 Time: 13:39:21
CHECWORKS FAC Version 1.0G (Build 75)

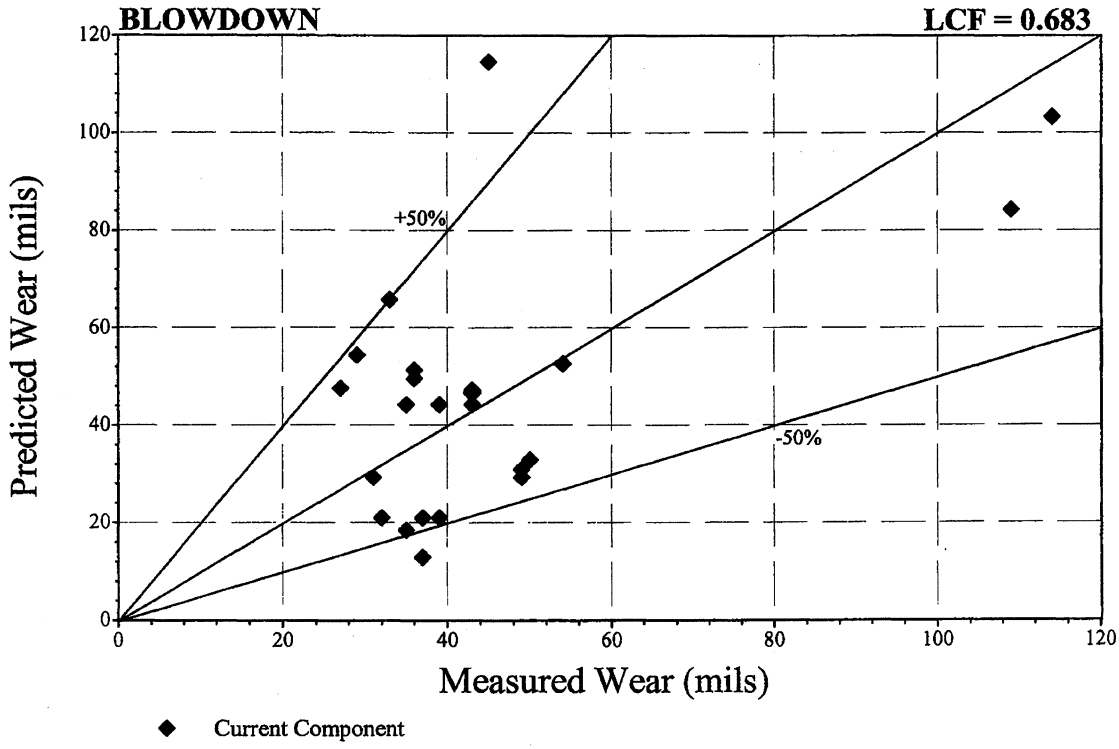
****
*** Wear Rate Analysis: Wear Rates/Input Data Report ***
****

Run Name: BLOWDOWN
Ending Period: REFUEL 17
Total Plant Operating Hours: 193776
WRA Data Option: NFA->HBD->ARD->COMP
Line Correction Factor: 0.683

Duty Factor (Global): 1.000
Exclude Measure Wear: No

Component Name	Geom. Code	Average Wear Rate (mils/year)	Current Wear Rate (mils/year)	Temp. (F)	Velocity (ft/s)	Steam Quality	Diameter (in)
===>Grouped by Line: SG51-1-CONT PEN to SGBFTK, Sorted by Average Wear Rate.							
MS46-Valve-MS-71-A	20	19.341	5.658	511.5	15.718	0.0000	1.315
MS46-VALVE-HCV-5046	24	6.421	1.878	511.5	3.826	0.0000	2.375
MS46-VALVE-PCV-1214	22	6.421	1.878	511.5	3.826	0.0000	2.375
MS46-VALVE-MS-131-A	22	6.421	1.878	511.5	3.826	0.0000	2.375
MS46-VALVE-PCV-1214A	22	6.421	1.878	511.5	3.826	0.0000	2.375
MS46-1	2	4.751	1.390	511.5	3.826	0.0000	2.375
MS46-2	2	4.751	1.390	511.5	3.826	0.0000	2.375
MS46-5	2	4.751	1.390	511.5	3.826	0.0000	2.375
MS46-6-1	1	4.238	1.240	511.5	3.826	0.0000	2.375
MS46-6	1	4.238	1.240	511.5	3.826	0.0000	2.375
MS46-4(S/E)	16	3.981	1.165	511.5	3.826	0.0000	2.375
MS46-7(D/S)	15	3.853	1.127	511.5	3.826	0.0000	2.375
MS46-7(U/S)	15	3.853	1.127	511.5	3.826	0.0000	2.375
MS46-2R(S/E)	18	3.596	1.052	511.5	3.826	0.0000	2.375
MS46-2P-3	52	3.458	1.012	511.5	4.145	0.0000	2.375
MS46-1P US	52	3.404	0.996	511.5	4.083	0.0000	2.375
MS46-1P DS	52	3.377	0.988	511.5	4.048	0.0000	2.375
MS46-6P US	52	3.210	0.939	511.5	3.833	0.0000	2.375
MS46-1P-1	52	3.210	0.939	511.5	3.826	0.0000	2.375
MS46-6P1	52	3.210	0.939	511.5	3.833	0.0000	2.375
MS46-5P	52	3.210	0.939	511.5	3.826	0.0000	2.375
MS46-3FE	6	3.037	0.888	511.5	1.709	0.0000	3.500
MS46-2P	58	2.825	0.826	511.5	3.826	0.0000	2.375
MS46-2P-1	58	2.825	0.826	511.5	3.826	0.0000	2.375
MS46-6-1P	58	2.825	0.826	511.5	3.826	0.0000	2.375
MS46-4P DS	66	2.568	0.751	511.5	3.833	0.0000	2.375
MS46-4P US	66	2.568	0.751	511.5	3.833	0.0000	2.375
MS46-3	3	2.126	0.622	511.5	1.709	0.0000	3.500
MS46-2R(L/E)	18	1.822	0.533	511.5	1.709	0.0000	3.500
MS46-4(L/E)	16	1.552	0.454	511.5	1.750	0.0000	3.500
MS46-2P-2	68	1.518	0.444	511.5	1.709	0.0000	3.500
MS46-3P	53	1.518	0.444	511.5	1.706	0.0000	3.500
MS46-4P-1 US	56	0.607	0.178	511.5	1.709	0.0000	3.500
MS46-4P-1 DS	56	0.607	0.178	511.5	1.709	0.0000	3.500
MS46-7R(S/E)	7	0.024	0.007	511.5	15.718	0.0000	1.315
MS46-7P2	67	0.015	0.004	511.5	15.718	0.0000	1.315
MS46-7R(L/E)	7	0.009	0.003	511.5	3.826	0.0000	2.375
===>Grouped by Line: SG52-1-CONT PEN to SGBFTK, Sorted by Average Wear Rate.							
MS45-VALVE-MS-71-B	20	19.341	5.658	511.5	15.718	0.0000	1.315
MS45-VALVE-PCV-1215	22	6.421	1.878	511.5	3.826	0.0000	2.375
MS45-VALVE-MS-131-B	22	6.421	1.878	511.5	3.826	0.0000	2.375
MS45-VALVE-HCV-5047	22	6.421	1.878	511.5	3.826	0.0000	2.375
MS45-VALVE-PCV-1215A	22	6.421	1.878	511.5	3.826	0.0000	2.375
MS45-3FE	6	5.186	1.517	511.5	3.040	0.0000	3.500
MS45-1	2	4.751	1.390	511.5	3.826	0.0000	2.375
MS45-6	2	4.751	1.390	511.5	3.826	0.0000	2.375
MS45-2	2	4.751	1.390	511.5	3.826	0.0000	2.375
MS45-5(S/E)	16	3.981	1.165	511.5	3.826	0.0000	2.375
MS45-7(D/S)	15	3.853	1.127	511.5	3.826	0.0000	2.375
MS45-7(U/S)	15	3.853	1.127	511.5	3.826	0.0000	2.375
MS45-2R(S/E)	18	3.596	1.052	511.5	3.826	0.0000	2.375
MS45-1P-1	52	3.431	1.004	511.5	4.110	0.0000	2.375
MS45-1P	52	3.210	0.939	511.5	3.833	0.0000	2.375

Comparison of Wear Predictions



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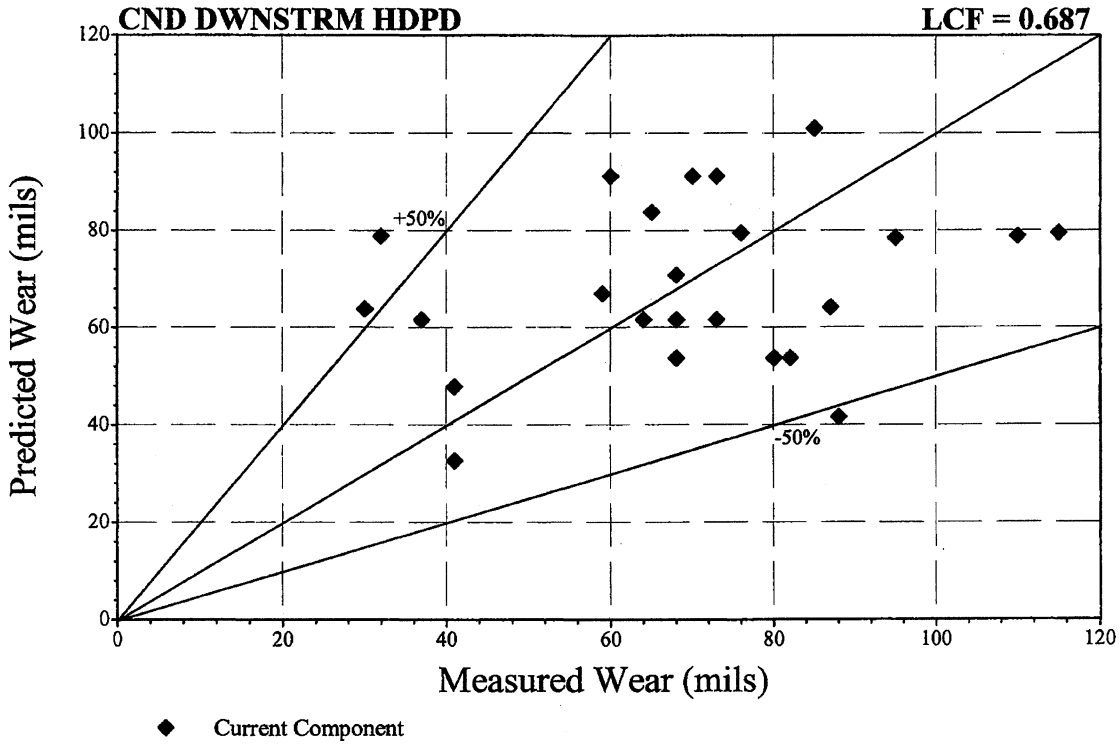

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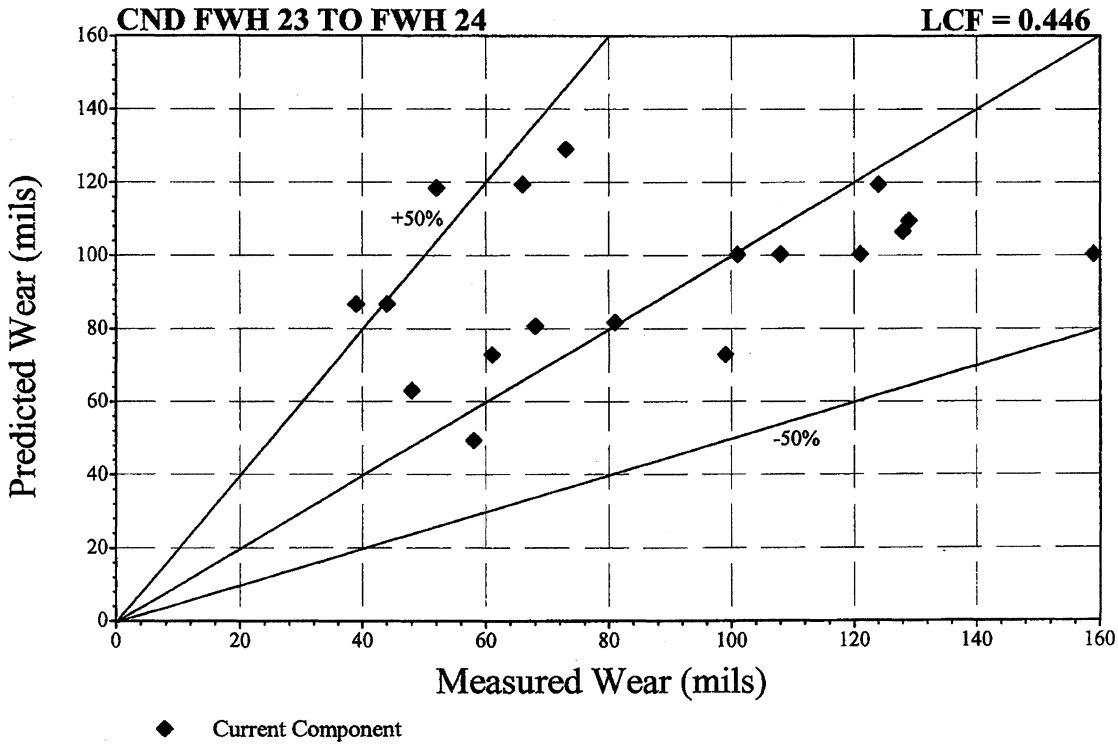

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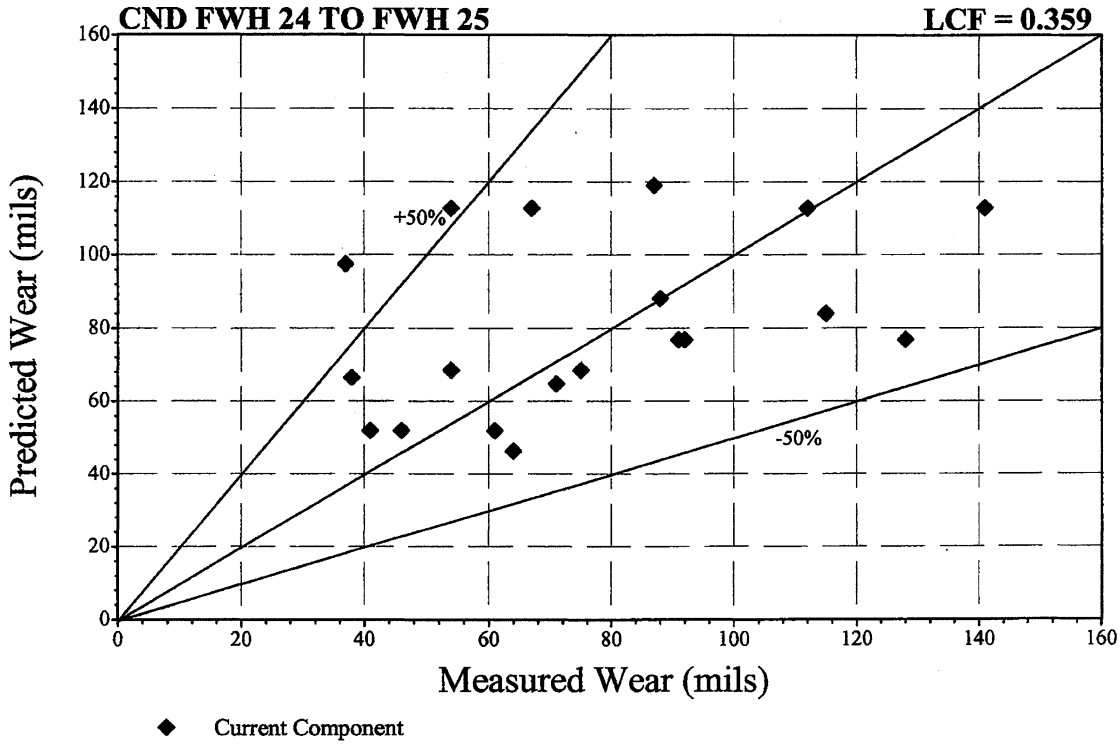

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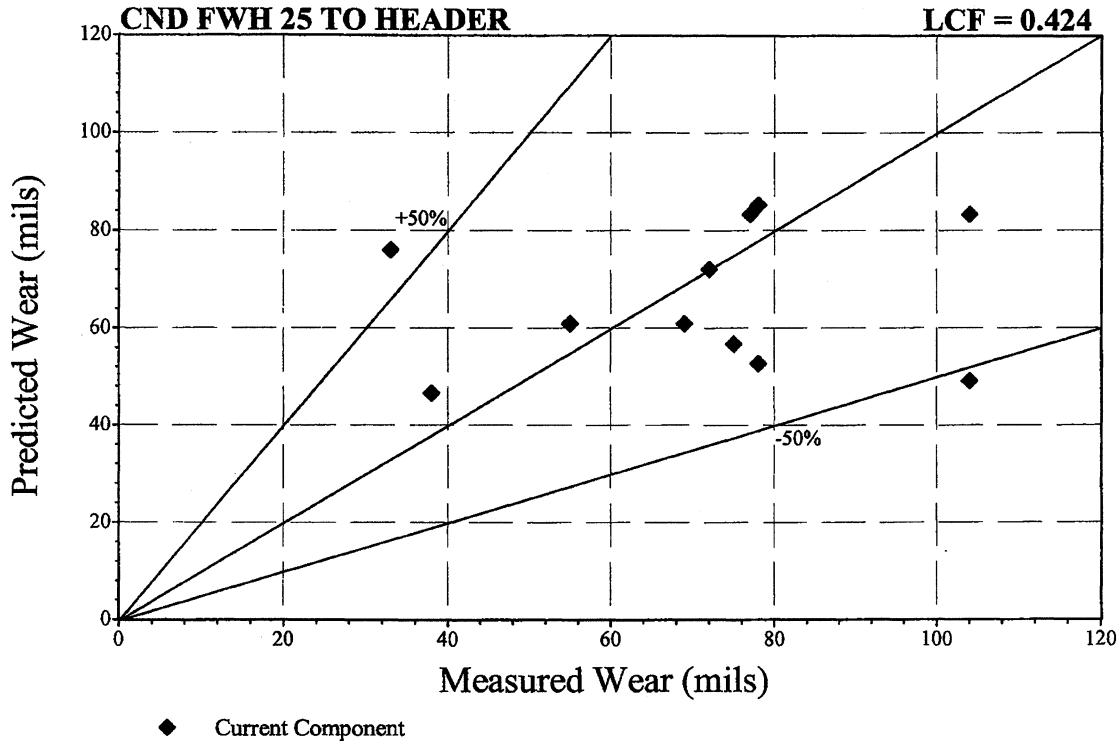

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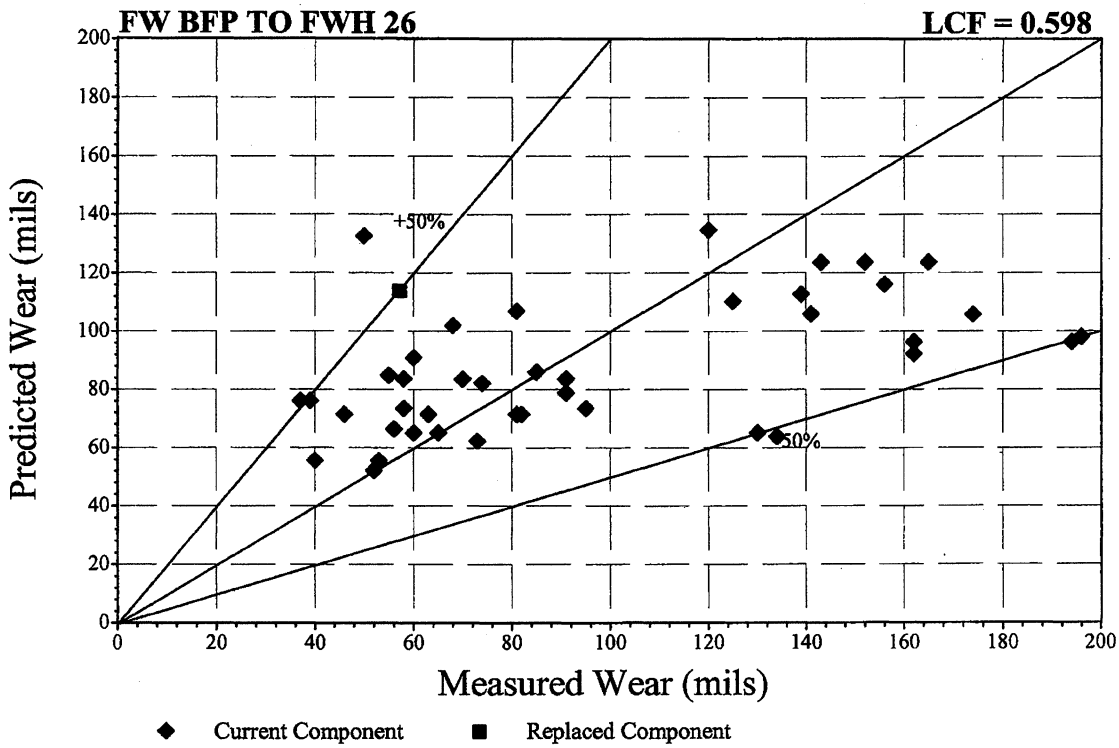

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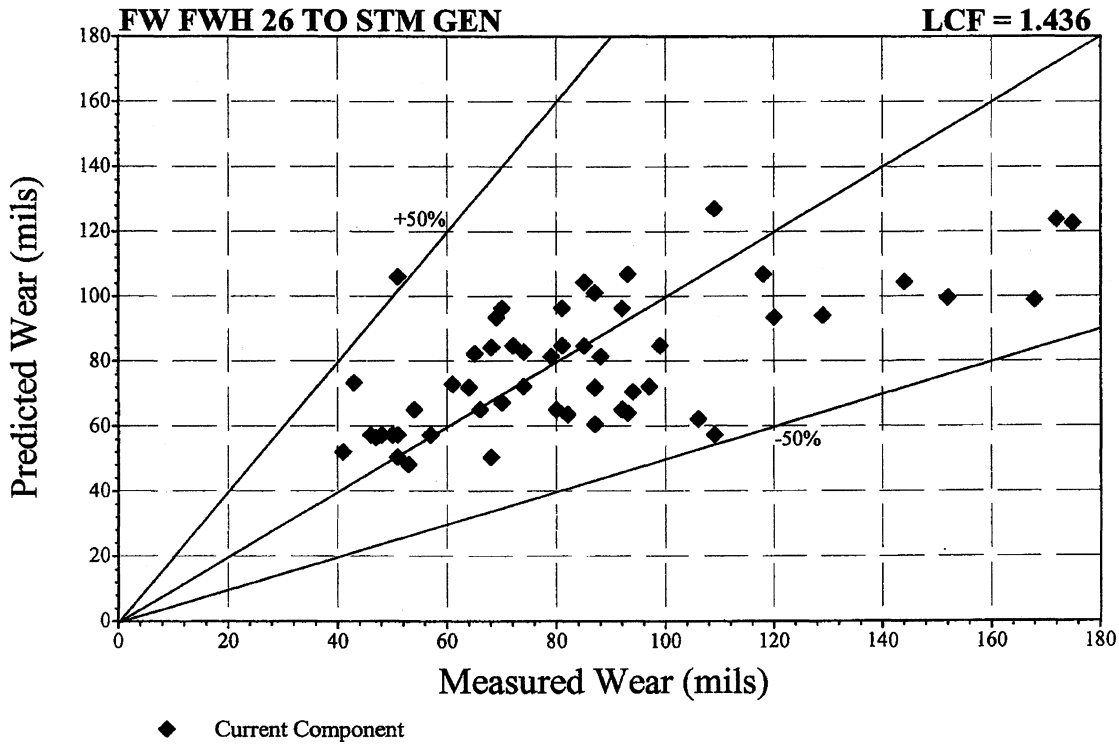

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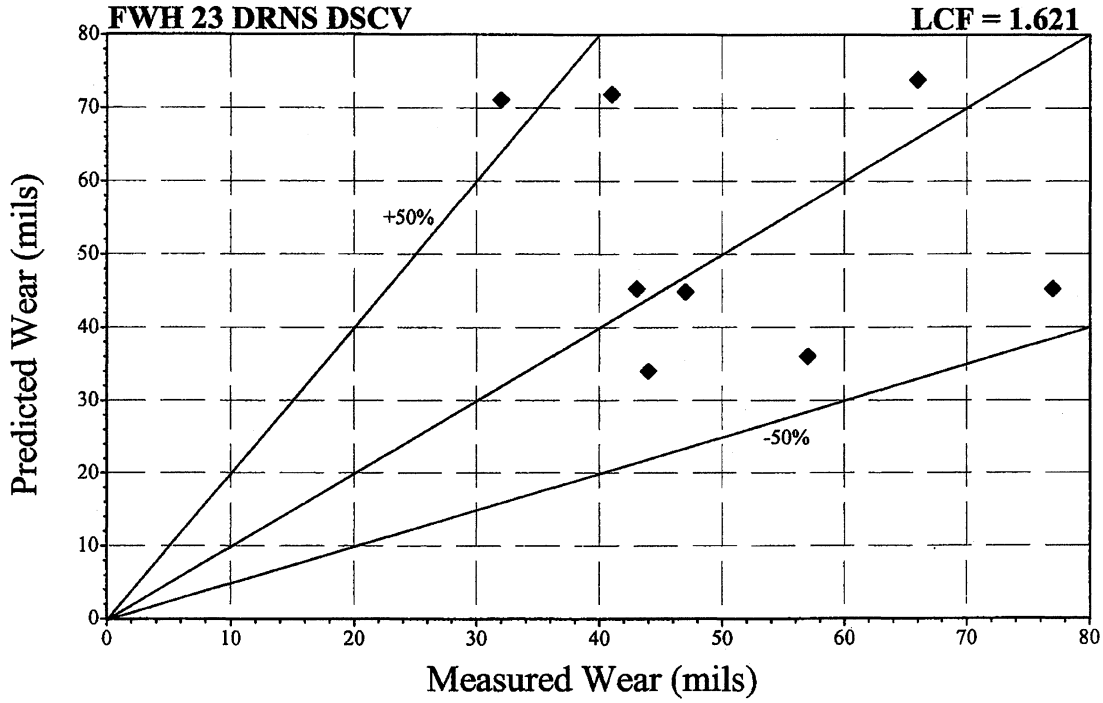

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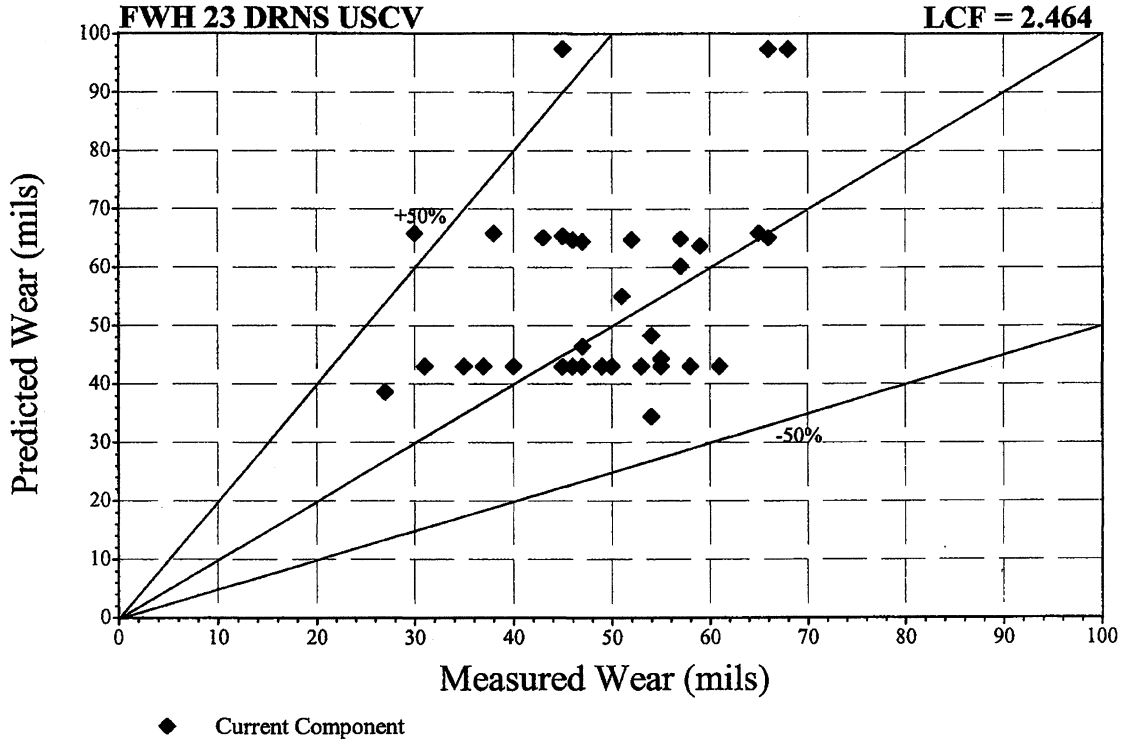

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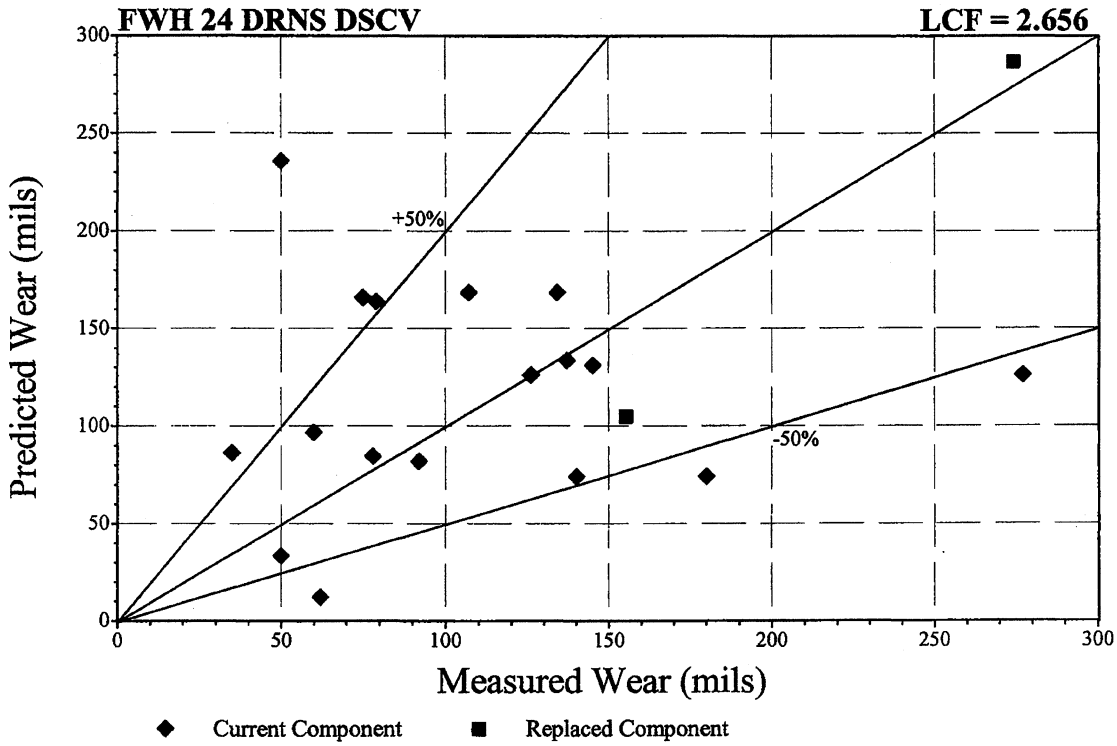

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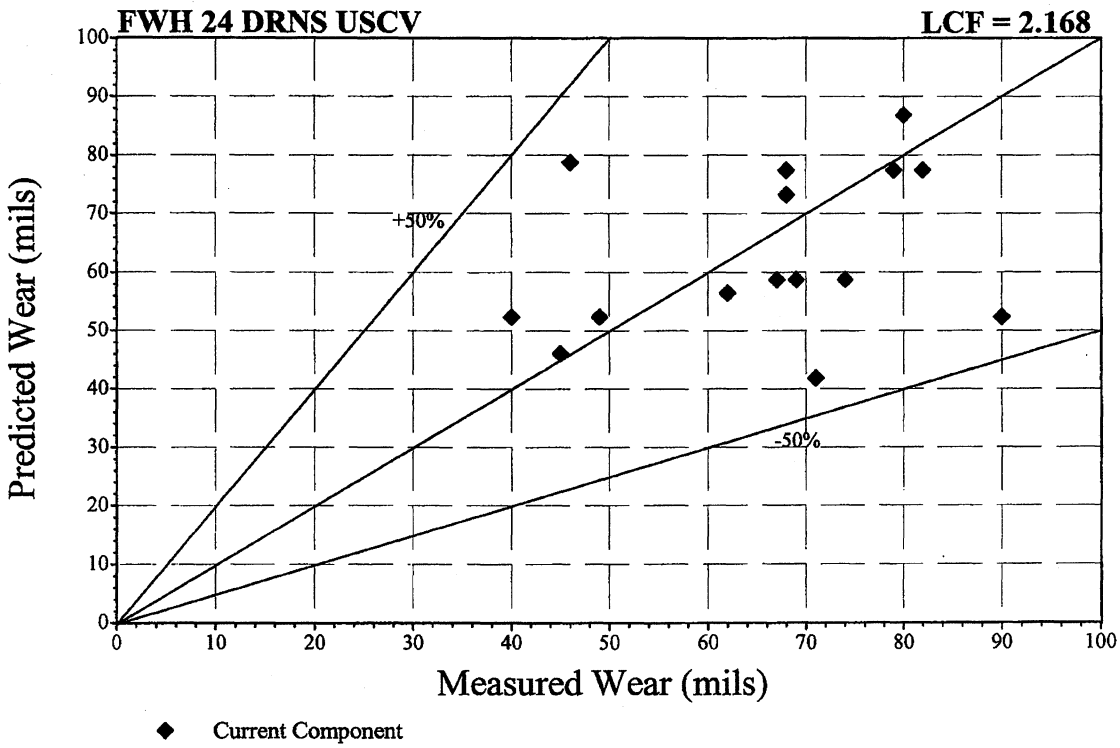

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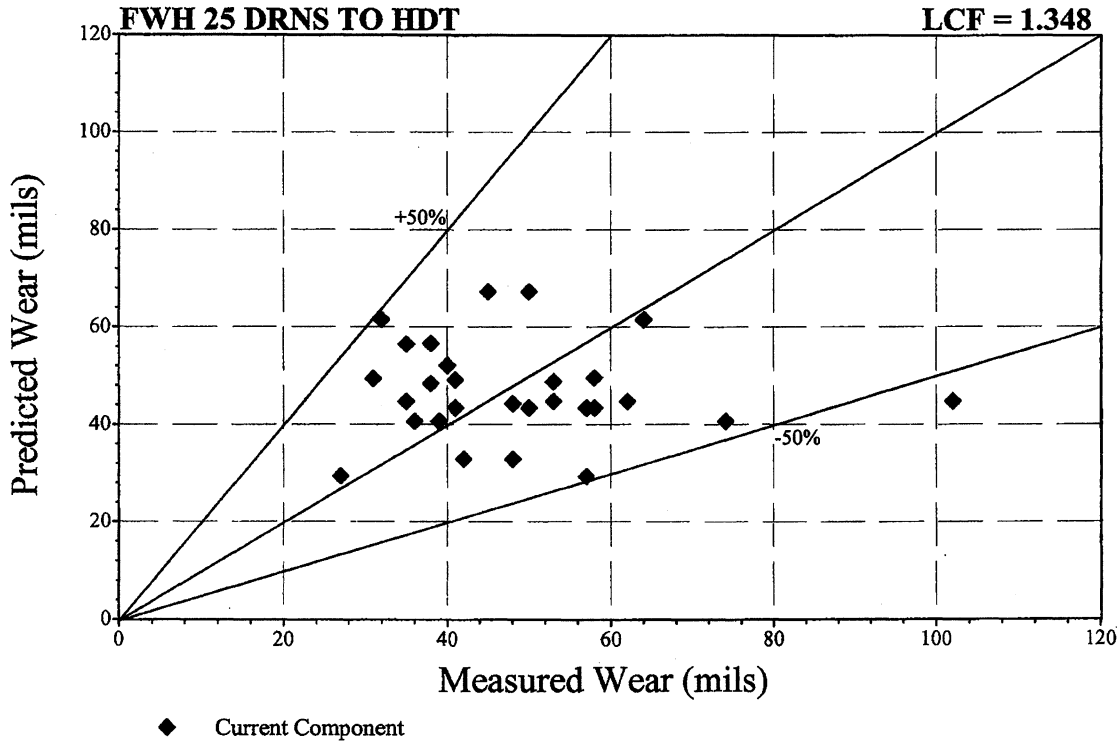

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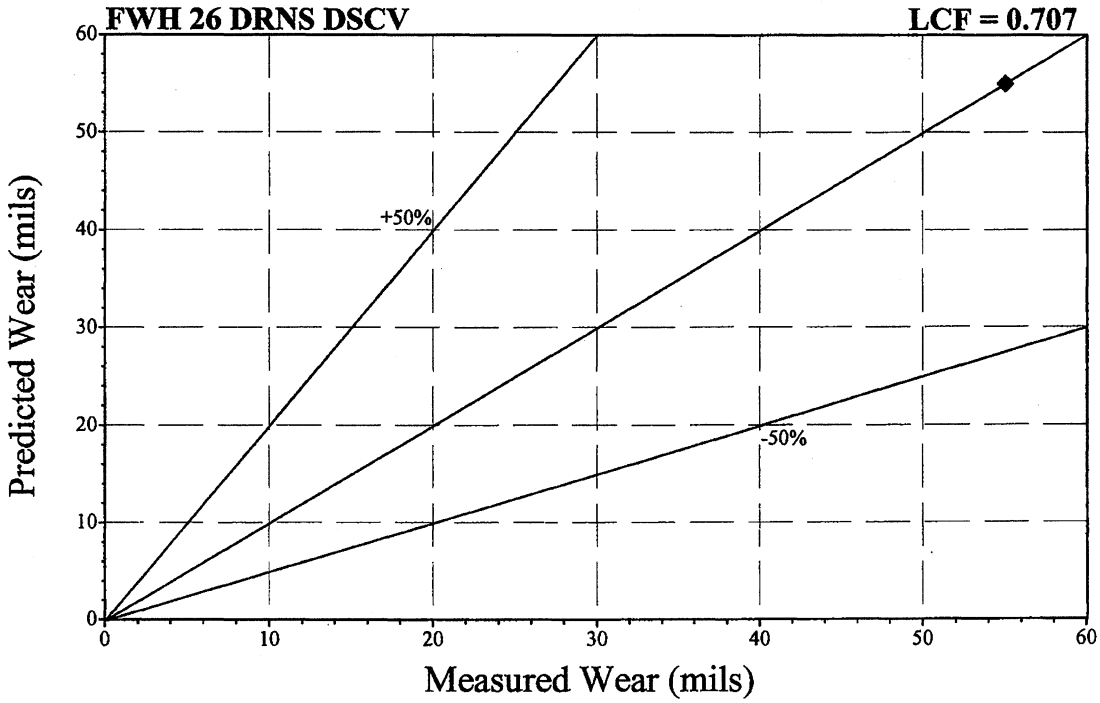

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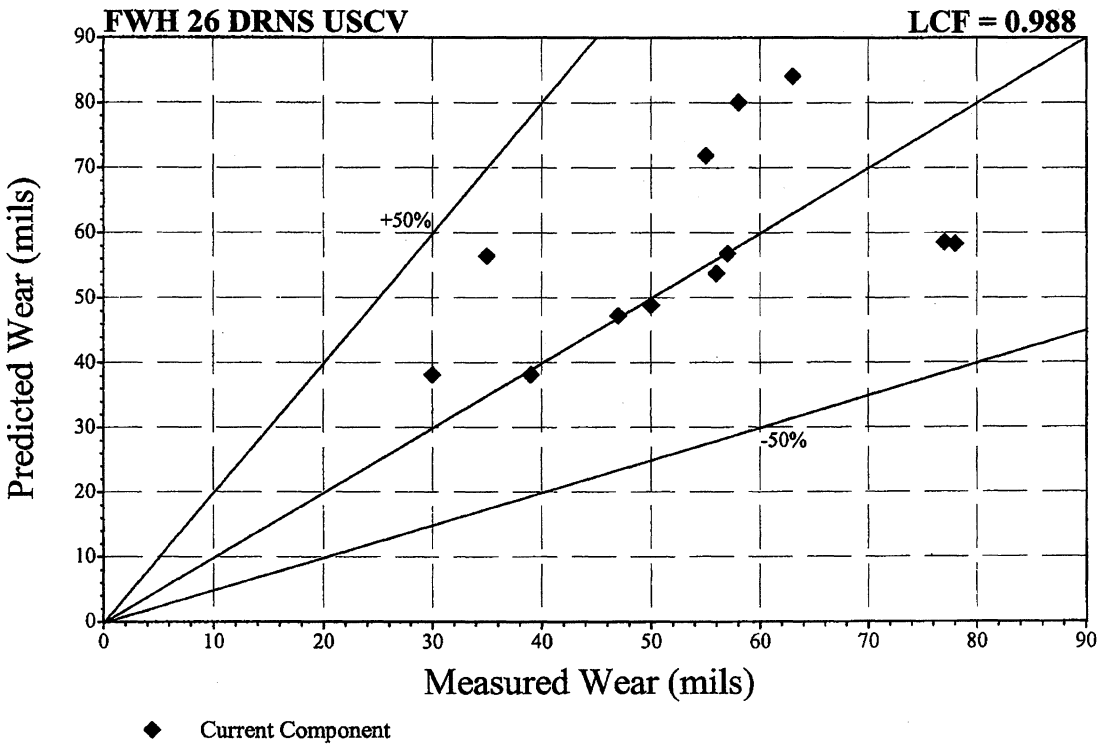

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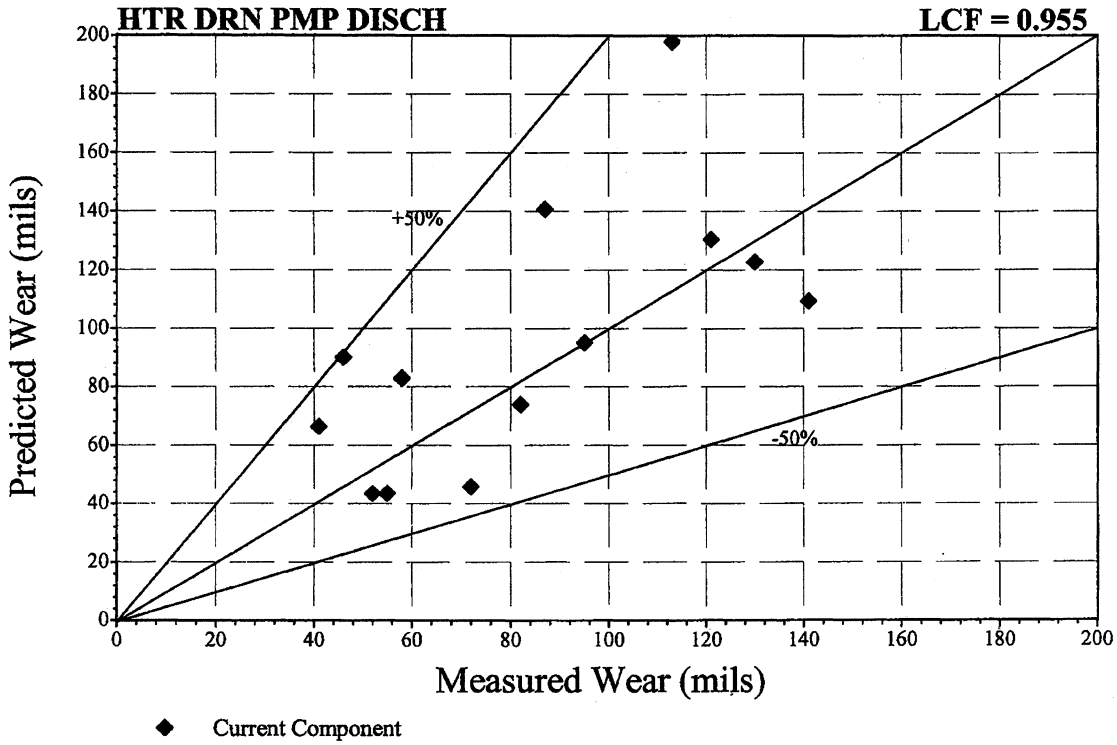

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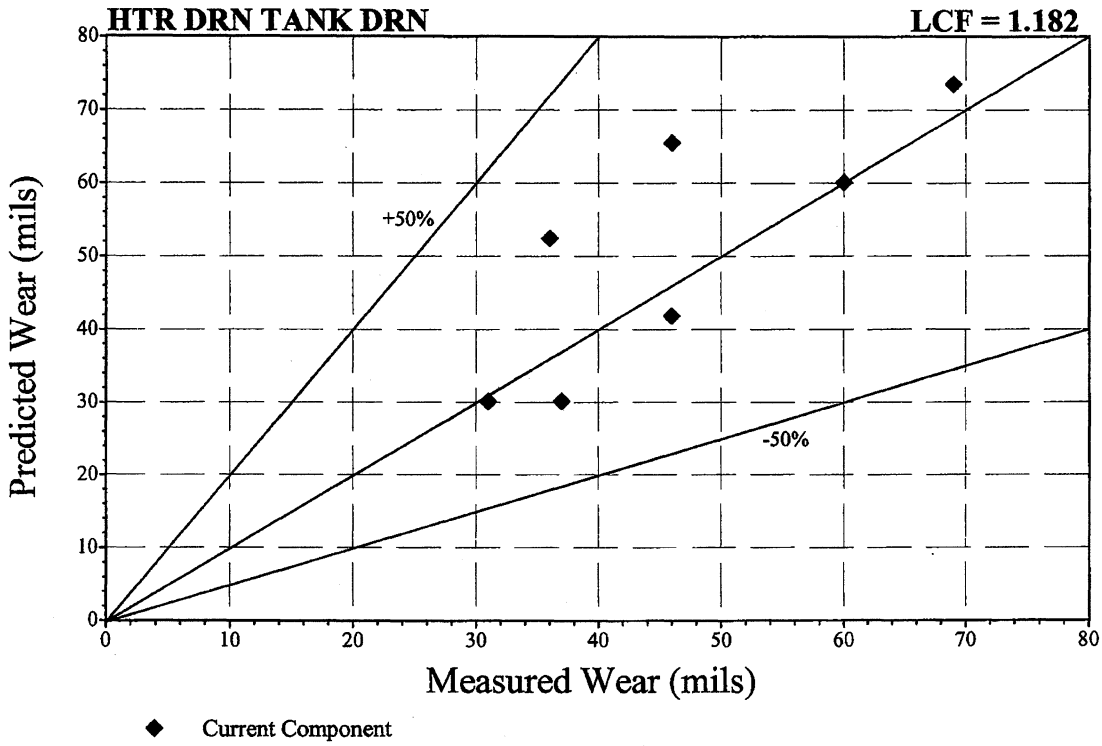

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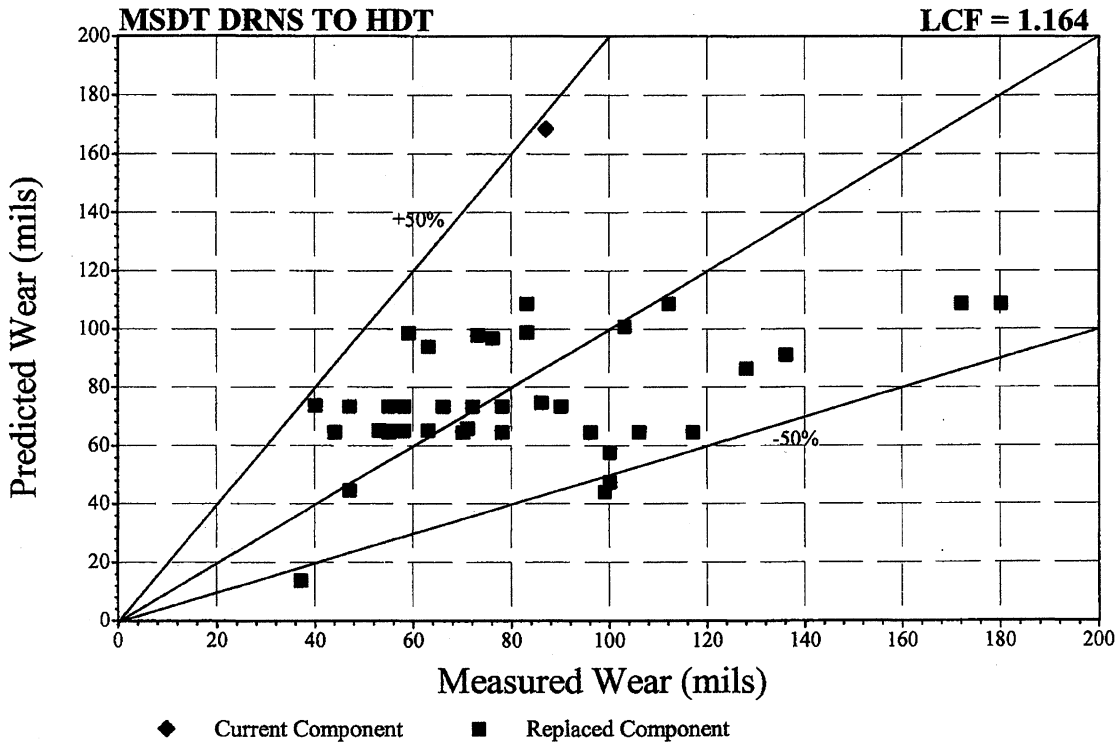

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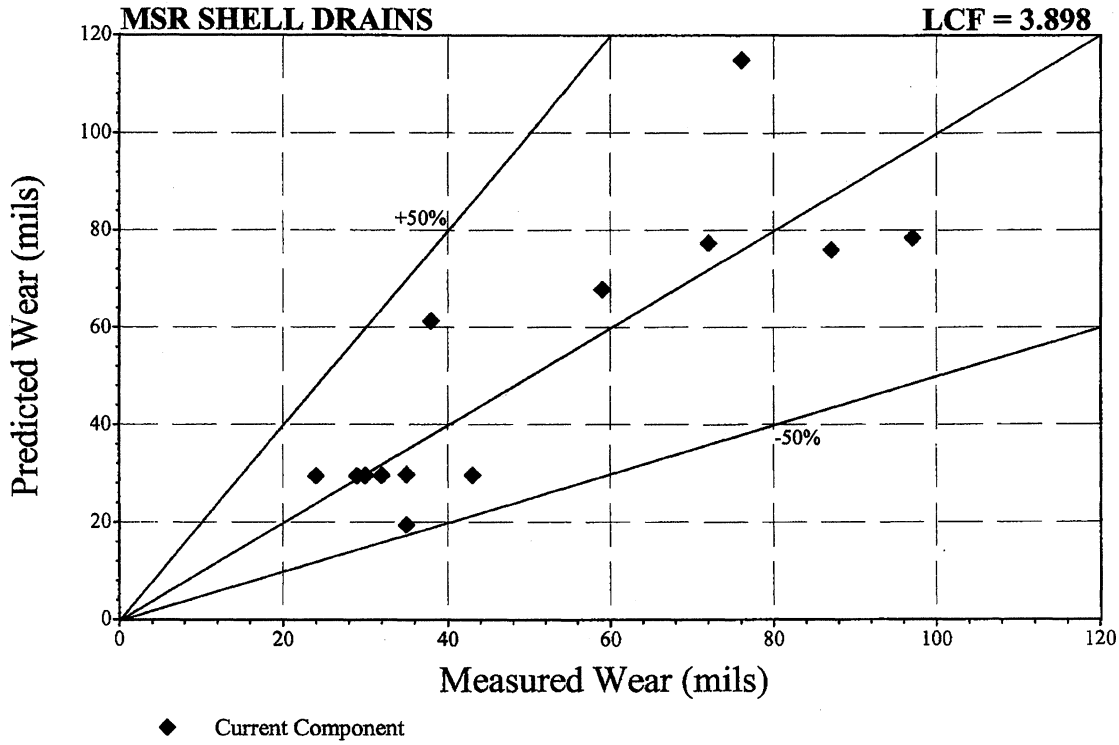

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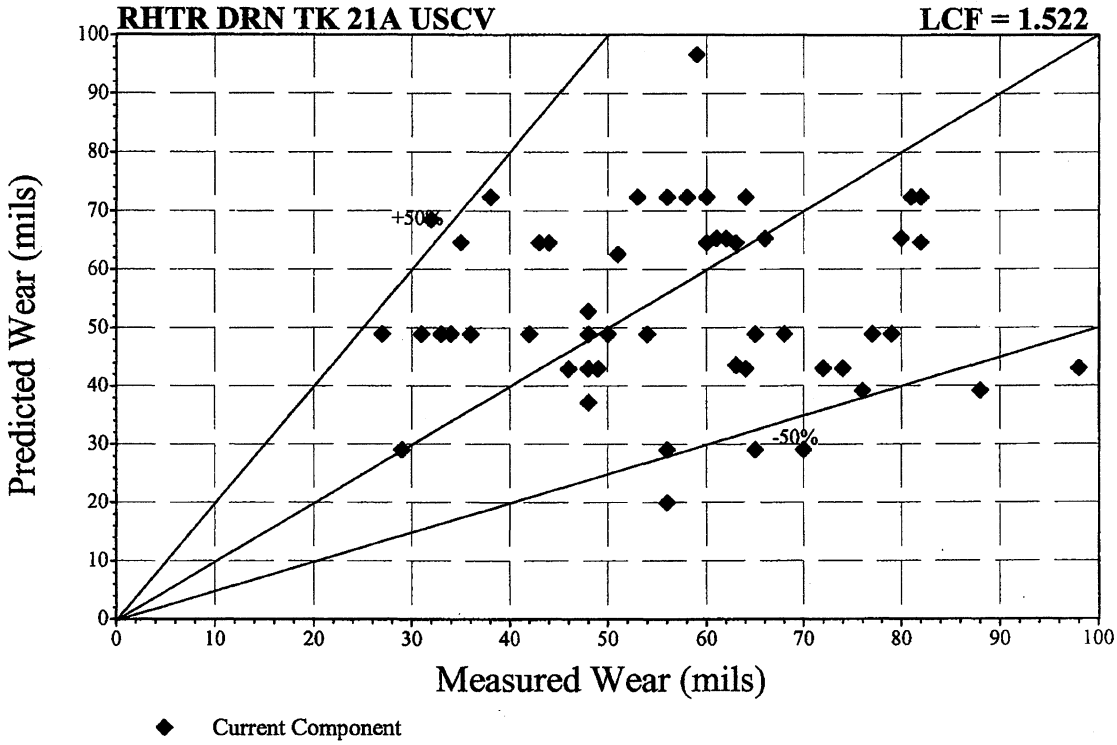

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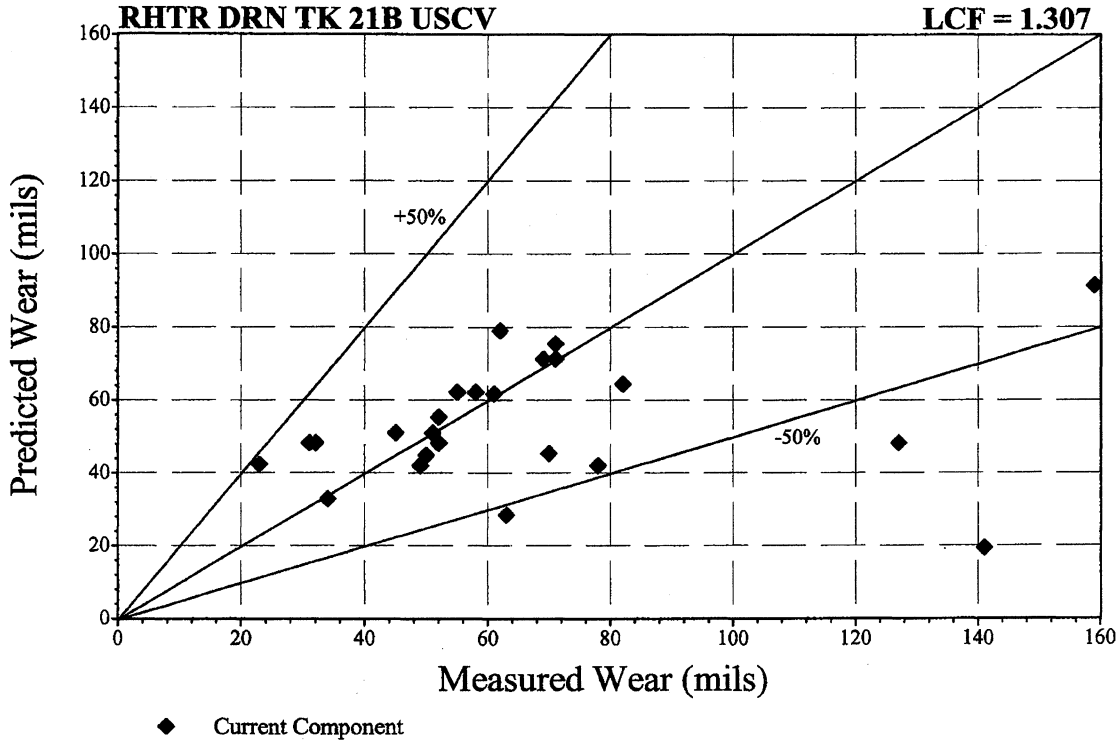

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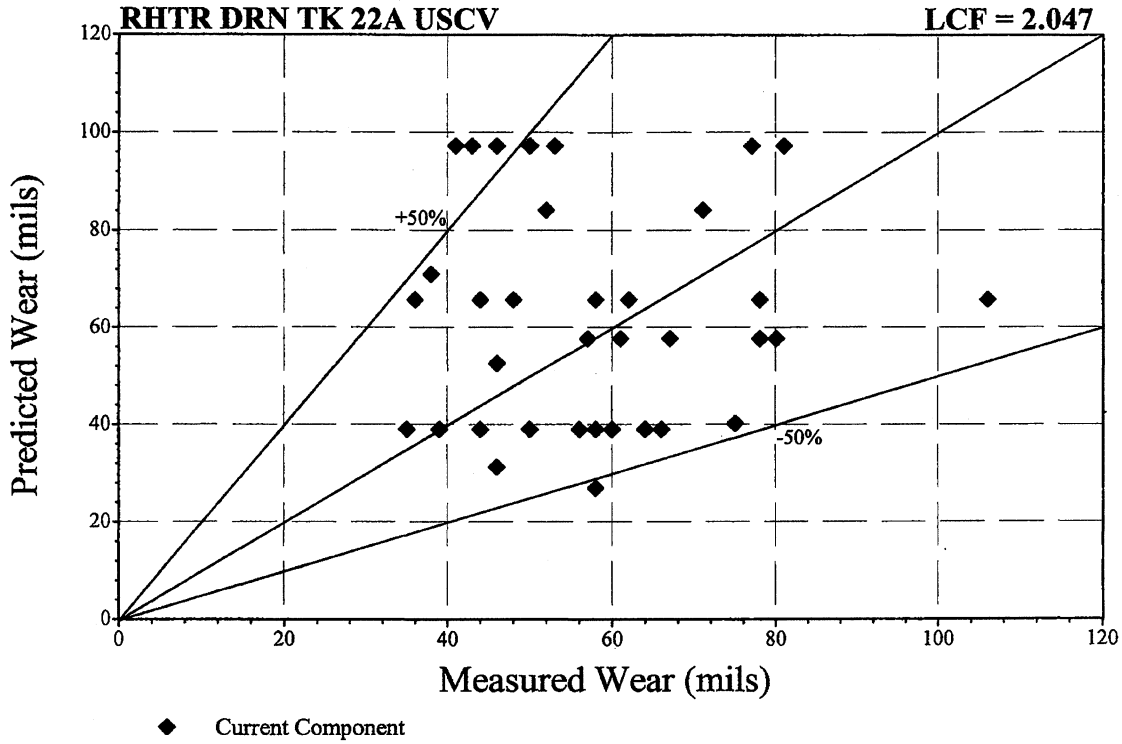

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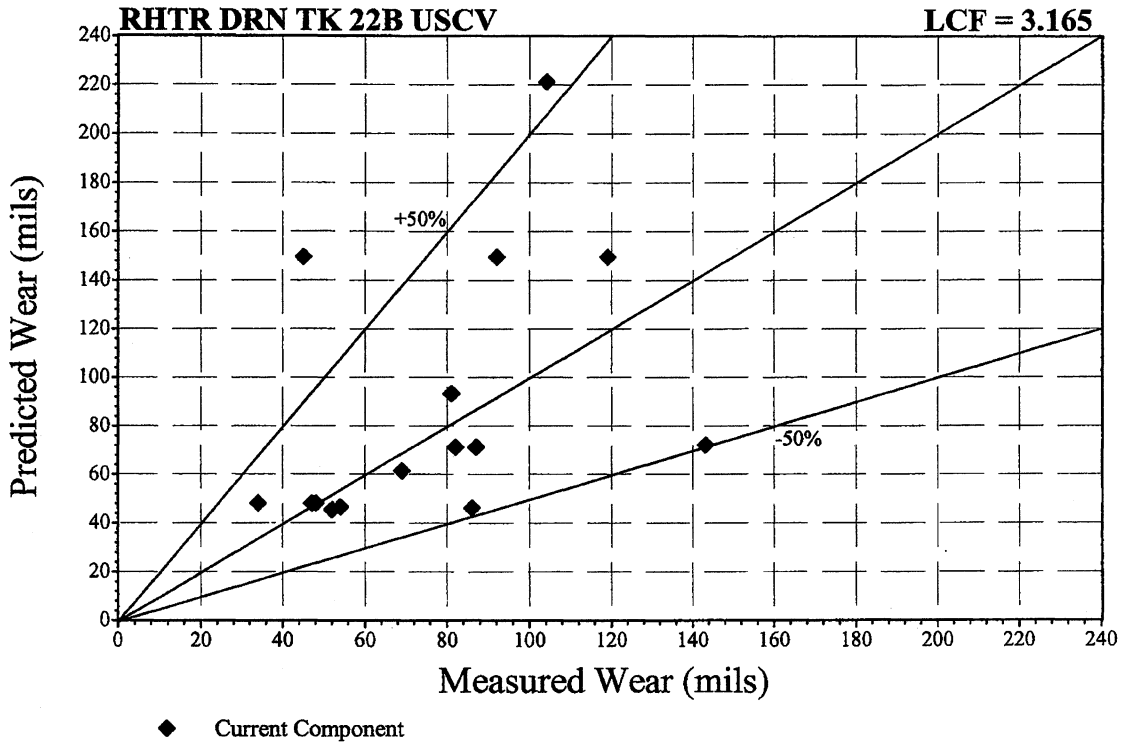

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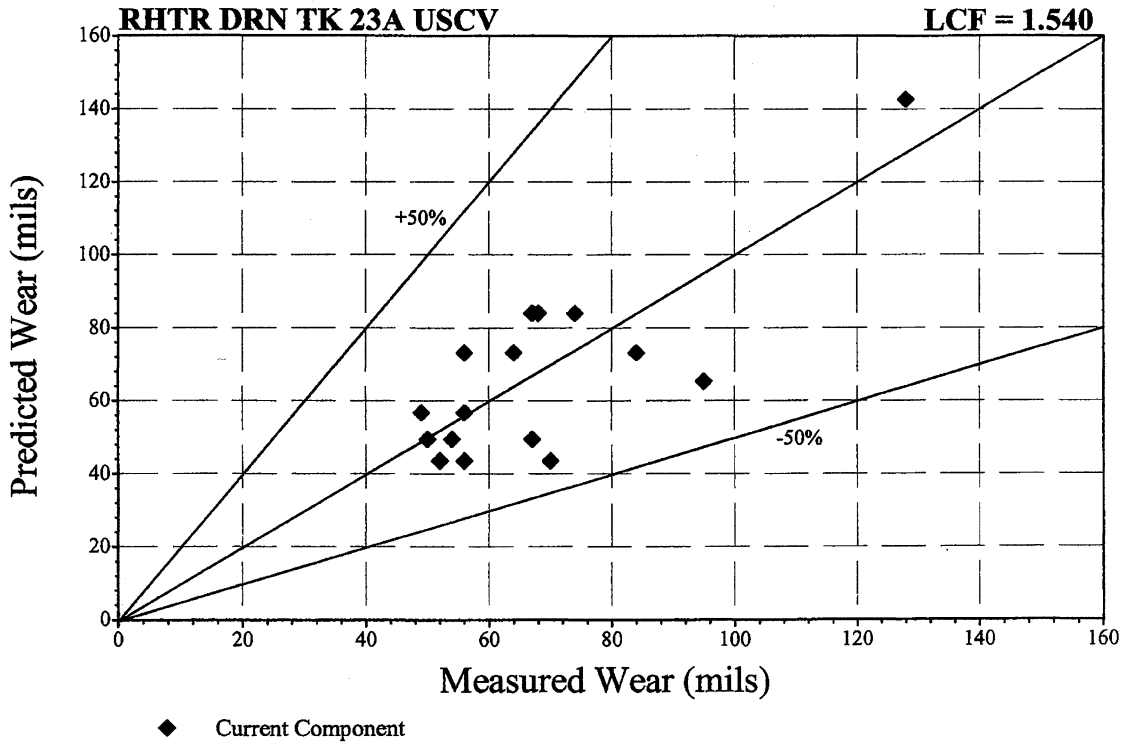

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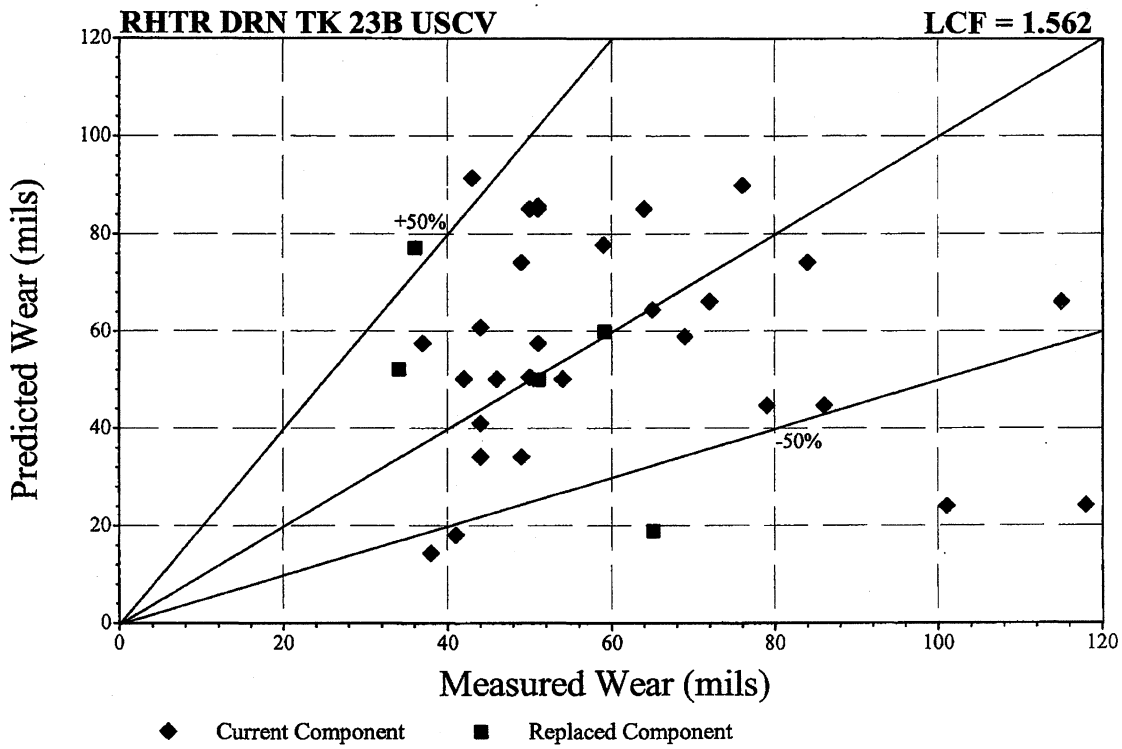

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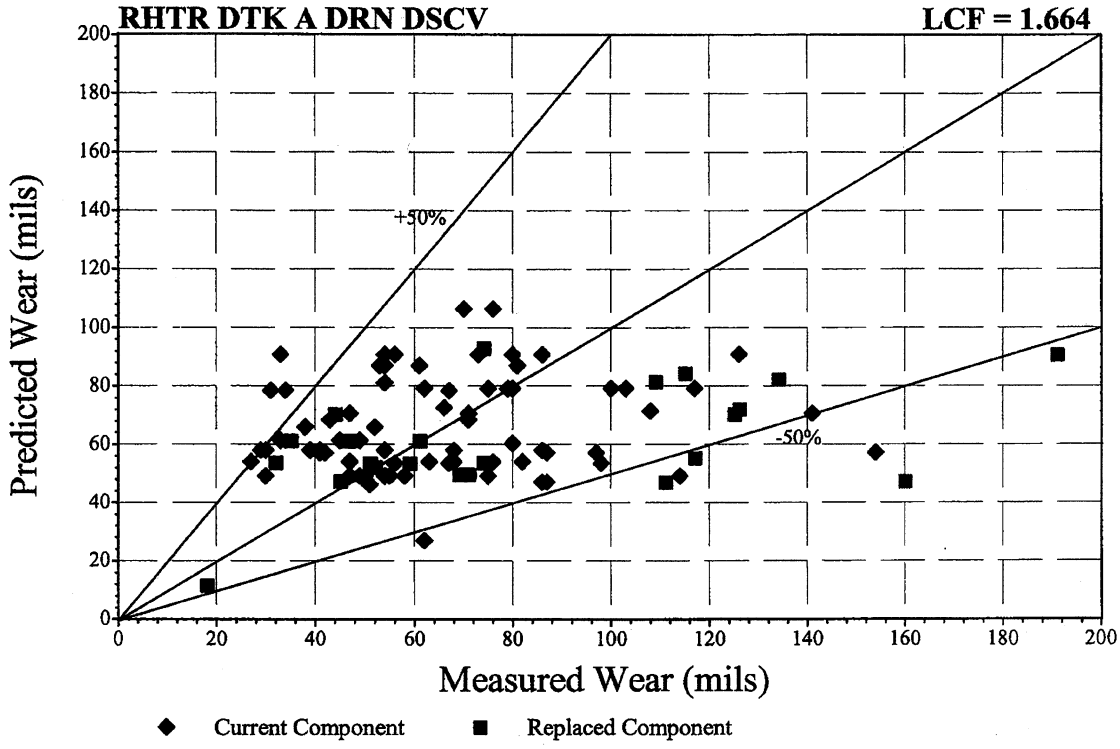

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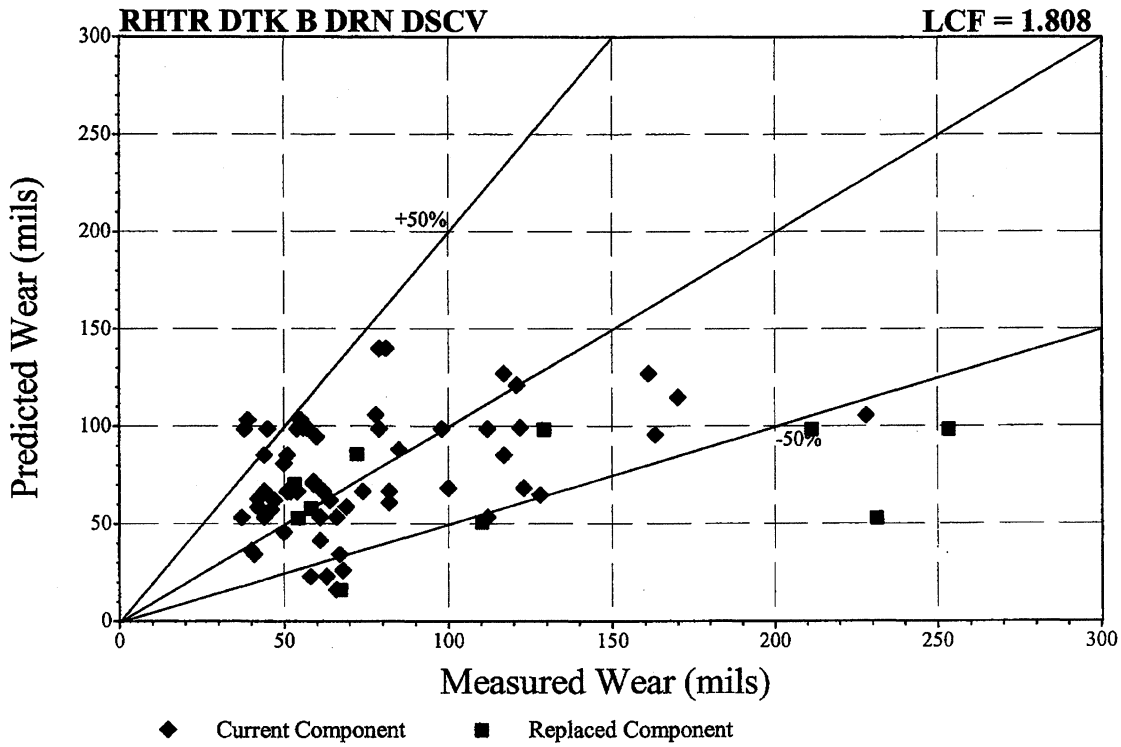

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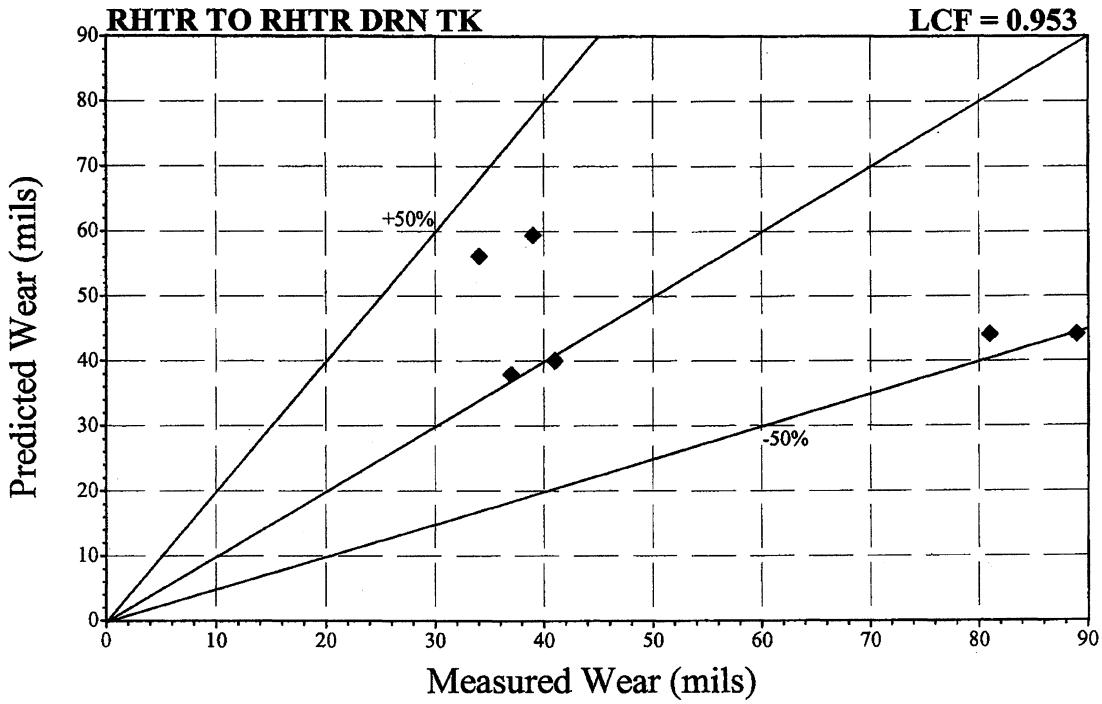

Indian Point Unit 2
CHECWORKS FAC Model

Calculation No. 050714b-01
Revision 1
Issued For-Use

September 12, 2006

prepared for:

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1. Introduction

Flow-Accelerated Corrosion (FAC) is a form of material degradation that results in thinning of the inside pipe wall in carbon steel piping and fittings under certain flow and chemistry conditions. Undetected FAC-induced wall thinning may cause a pipe to leak or rupture, potentially causing injury to plant personnel and/or plant shutdown. For these reasons, and in response to regulatory requirements, Indian Point 2 Nuclear Power Plant (IP2) has developed and implemented a program to monitor and mitigate FAC-induced wall thinning in high energy, large-bore piping systems [7.1].

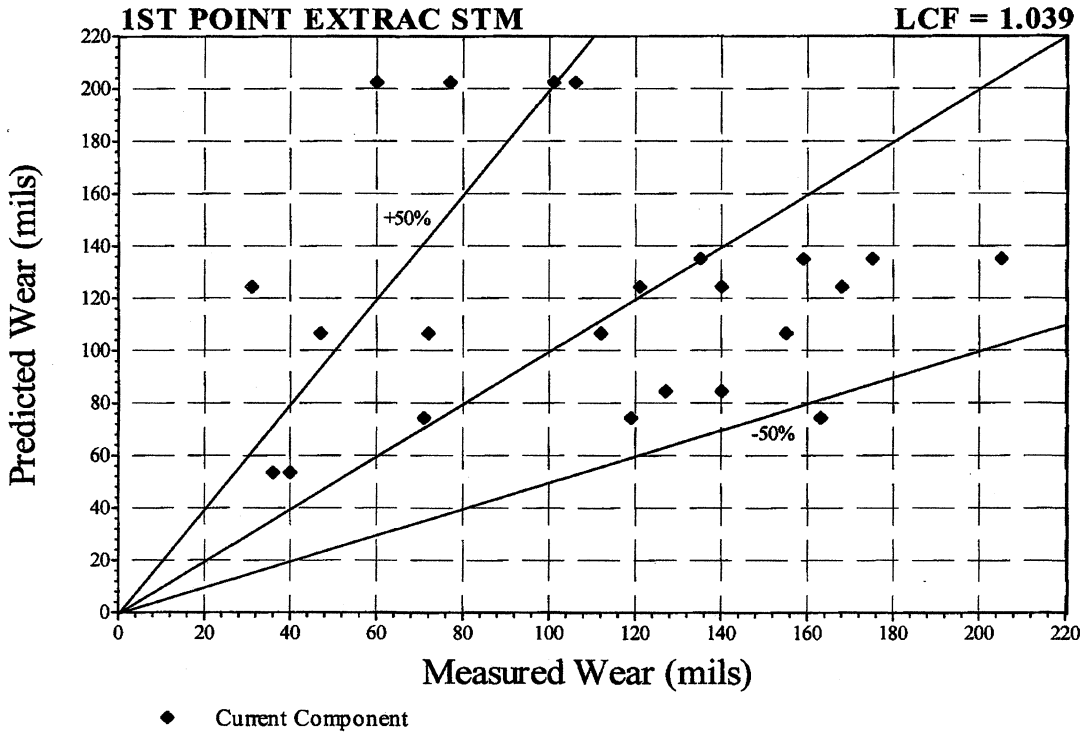
This report uses plant design and operation information to document the CHECWORKS model for IP2. It documents the CHECWORKS Pass 1 analysis to generate a wear rate prediction for every piping component modeled in CHECWORKS. Component inspection data through the Refuel Outage 17 was imported to the model where available. A Pass 2 analysis was performed on all lines to provide wear predictions calibrated to the inspection data, as well as remaining lives based upon measured wear rates for inspected components. The results of these analyses can be used to select components for inspection in order to mitigate pipe deterioration due to FAC.

Appendix I

Pass 2 Wear Rate Analysis Reports

Table of Contents

Comparison of Wear Predictions



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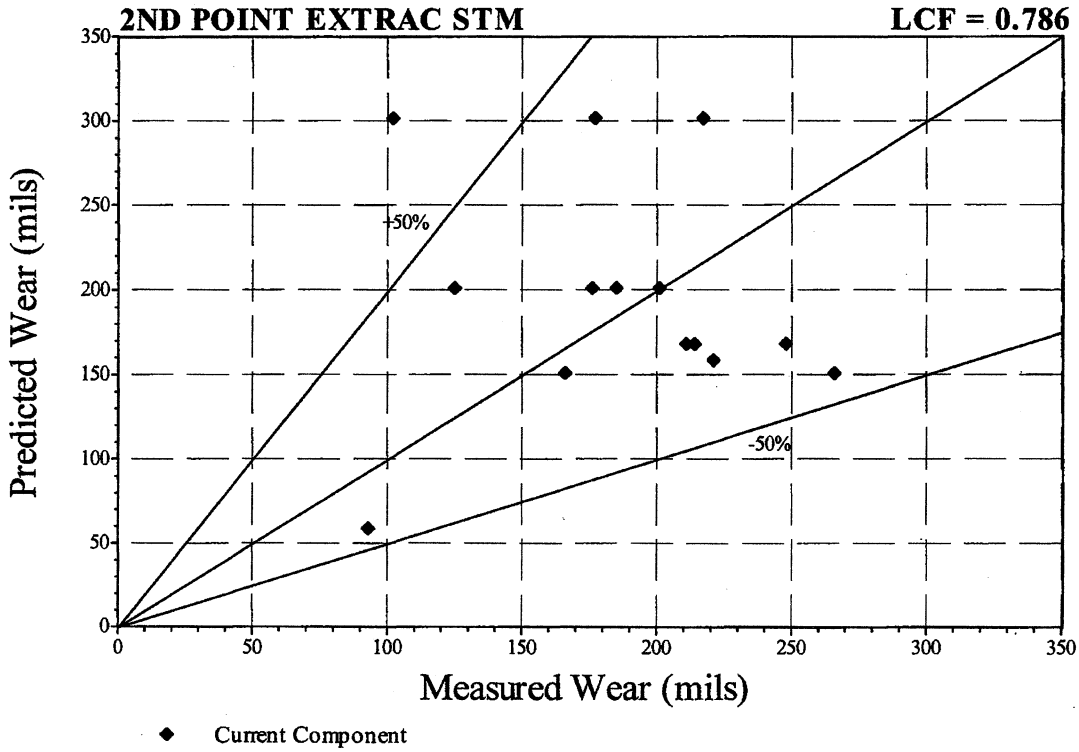

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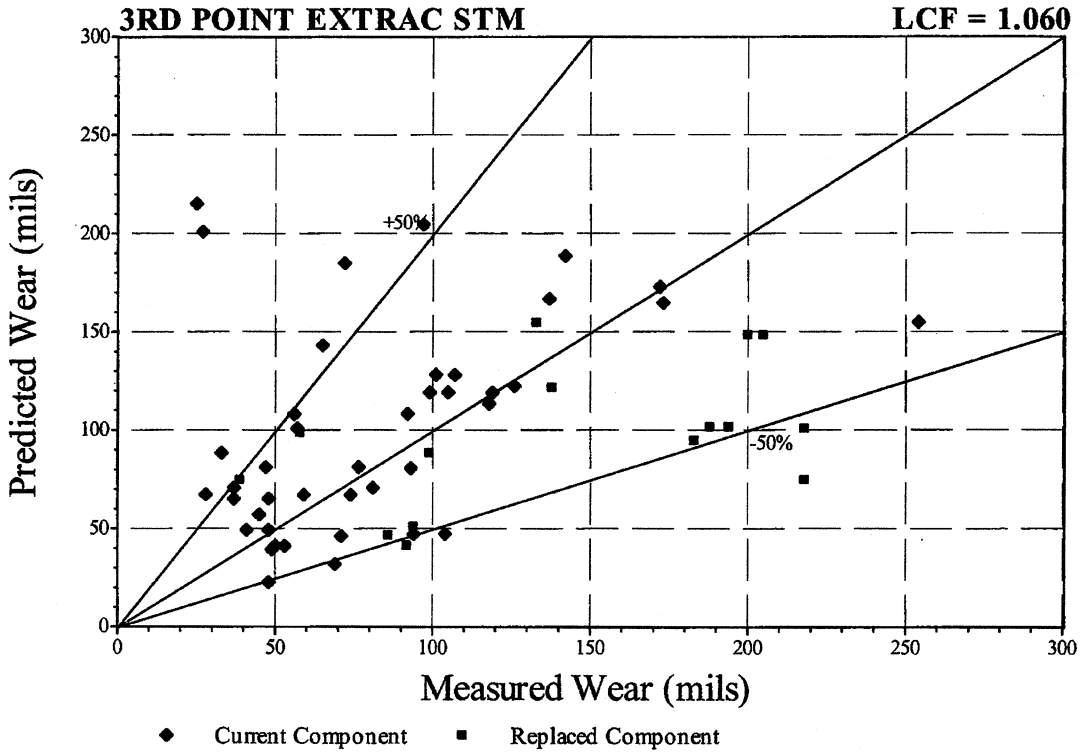

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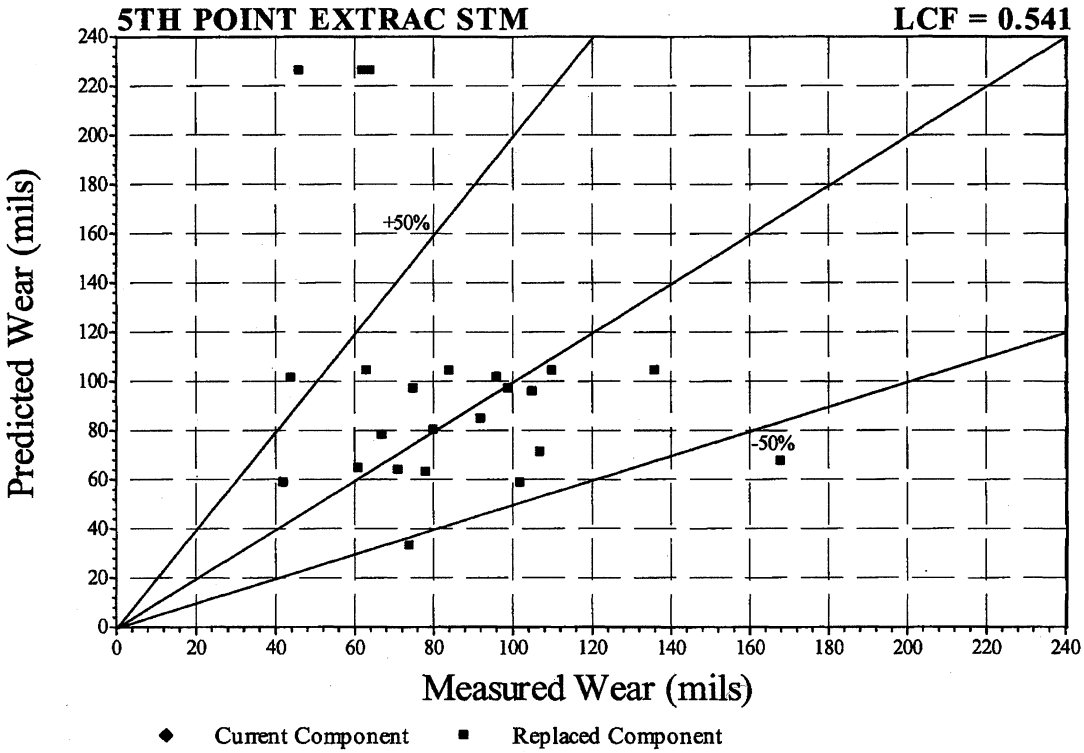

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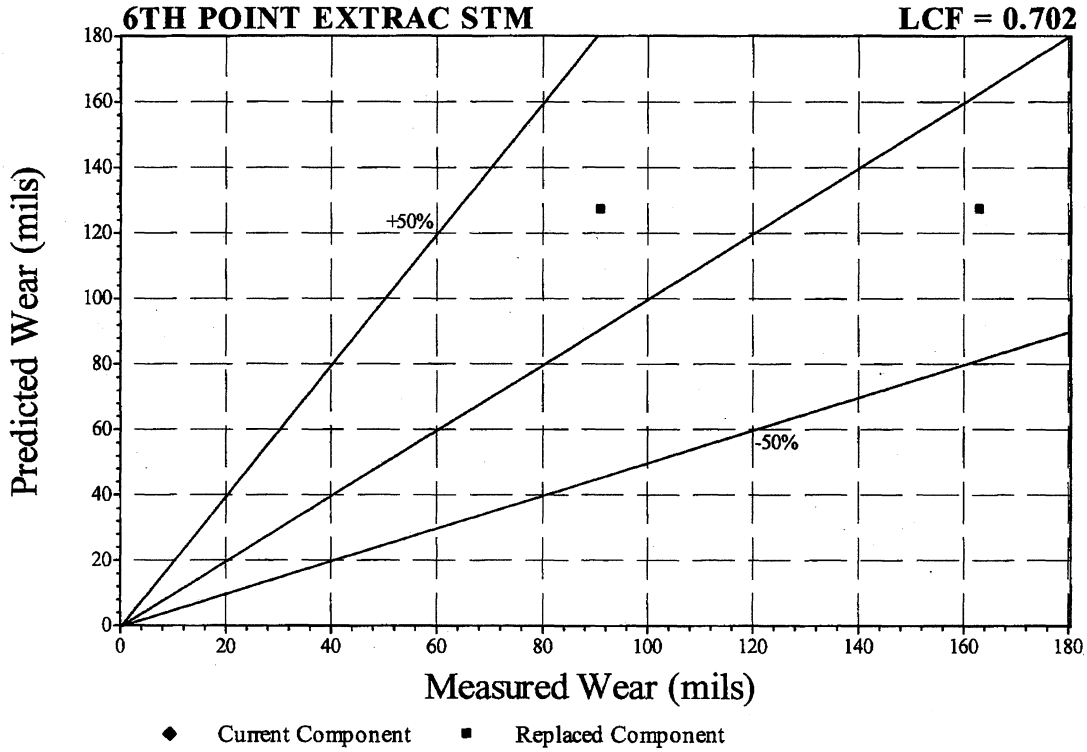

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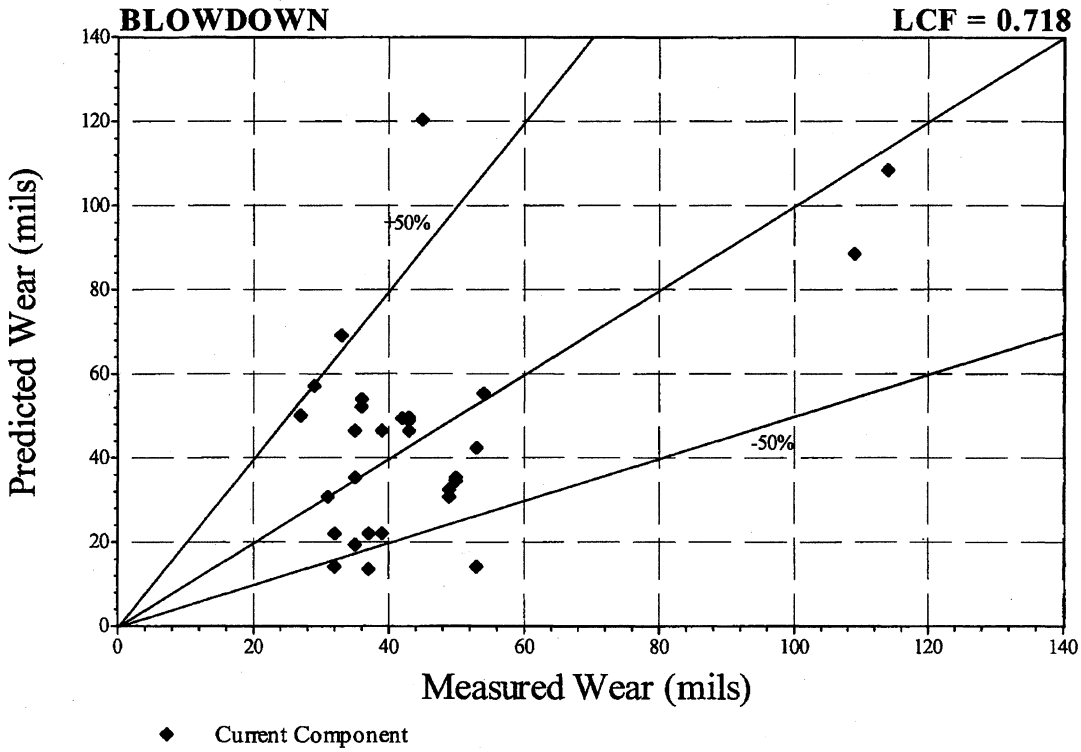

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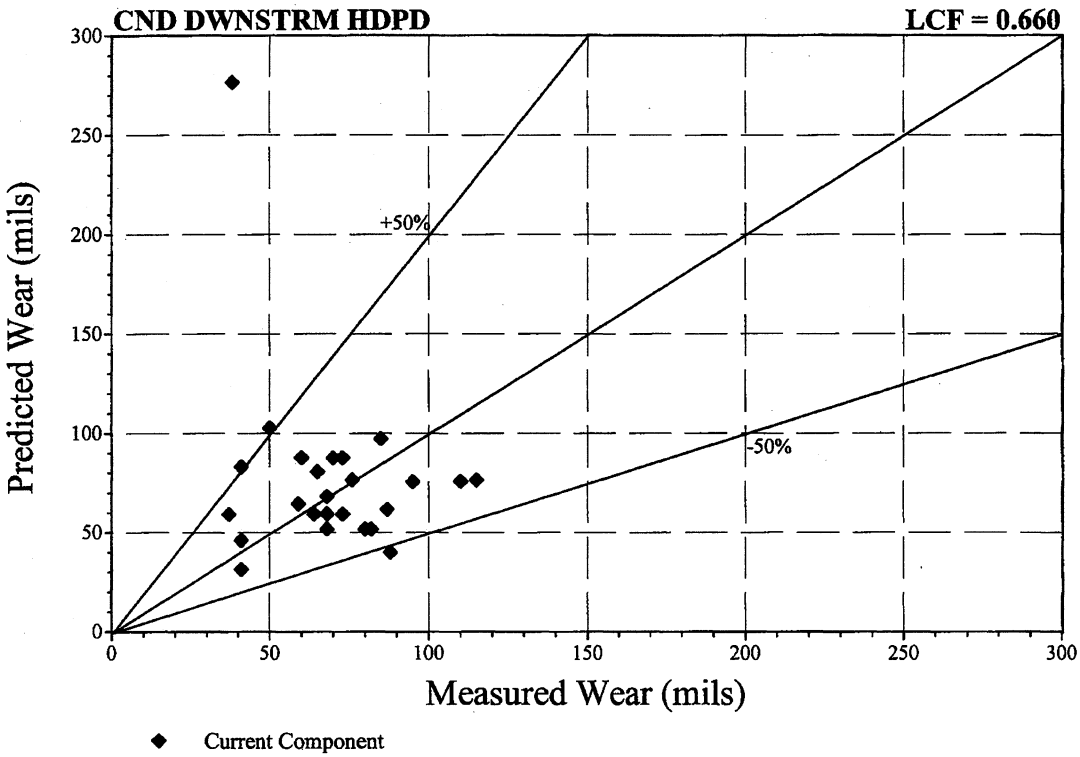

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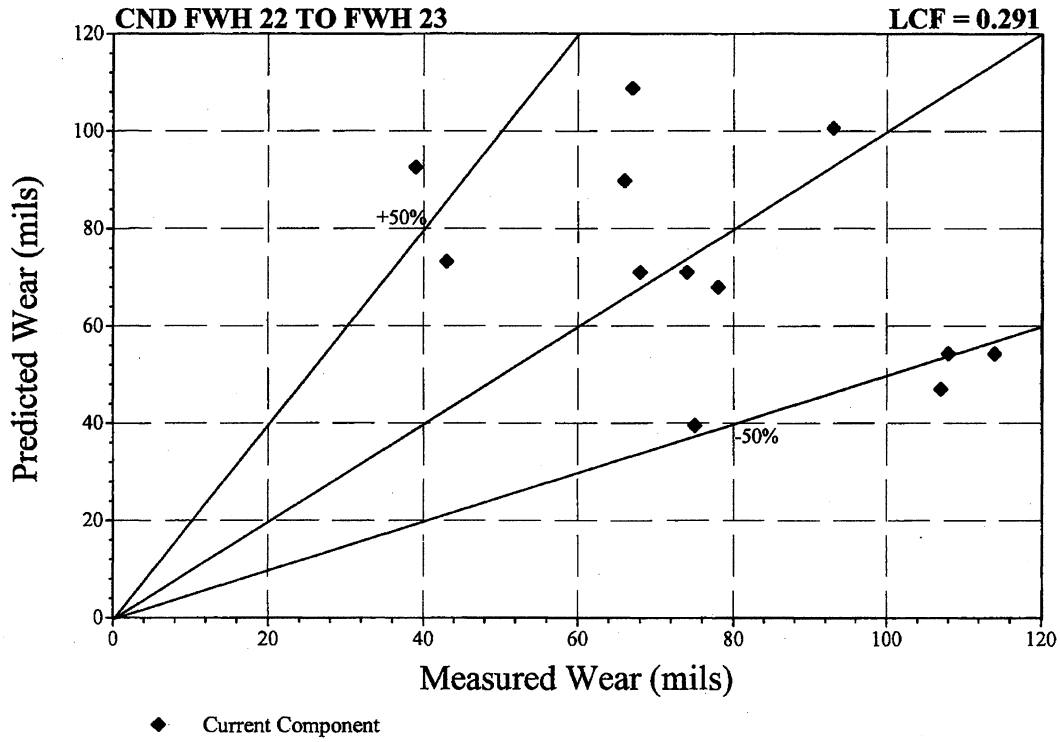

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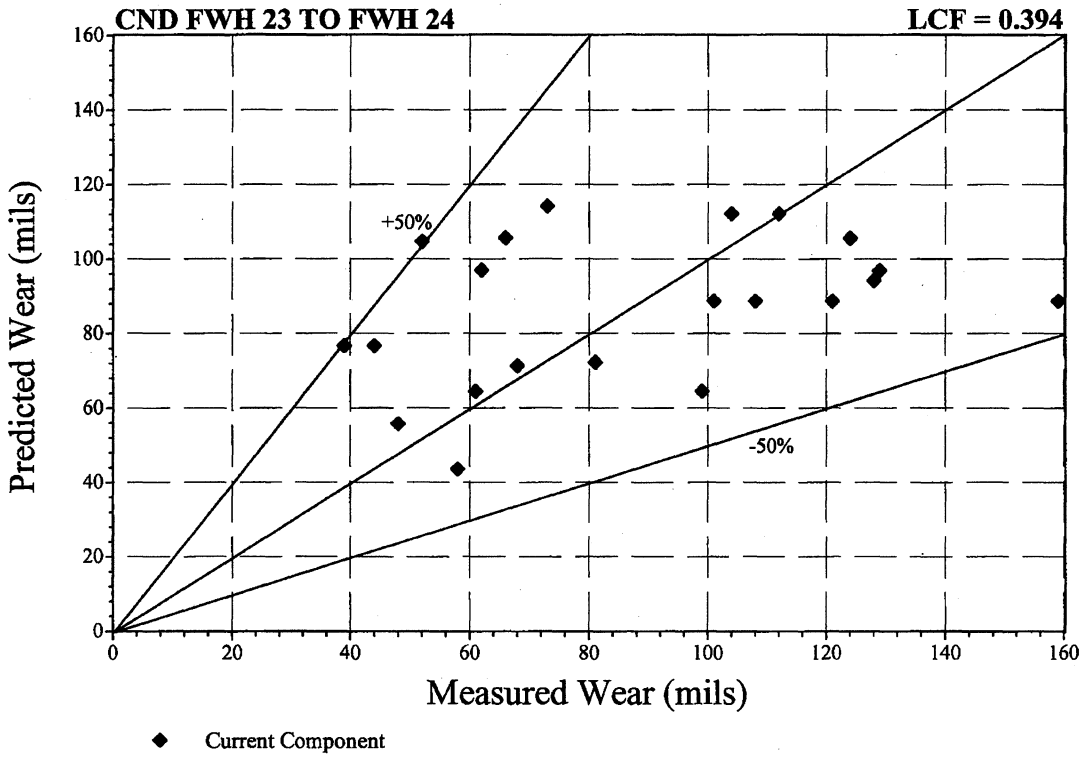

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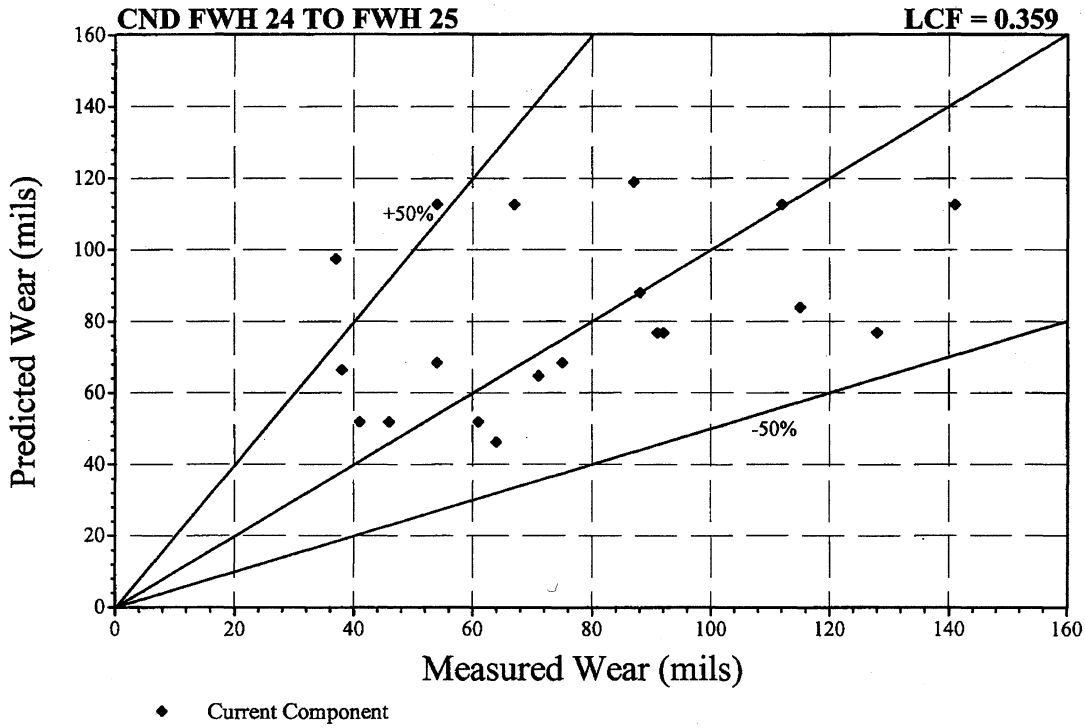

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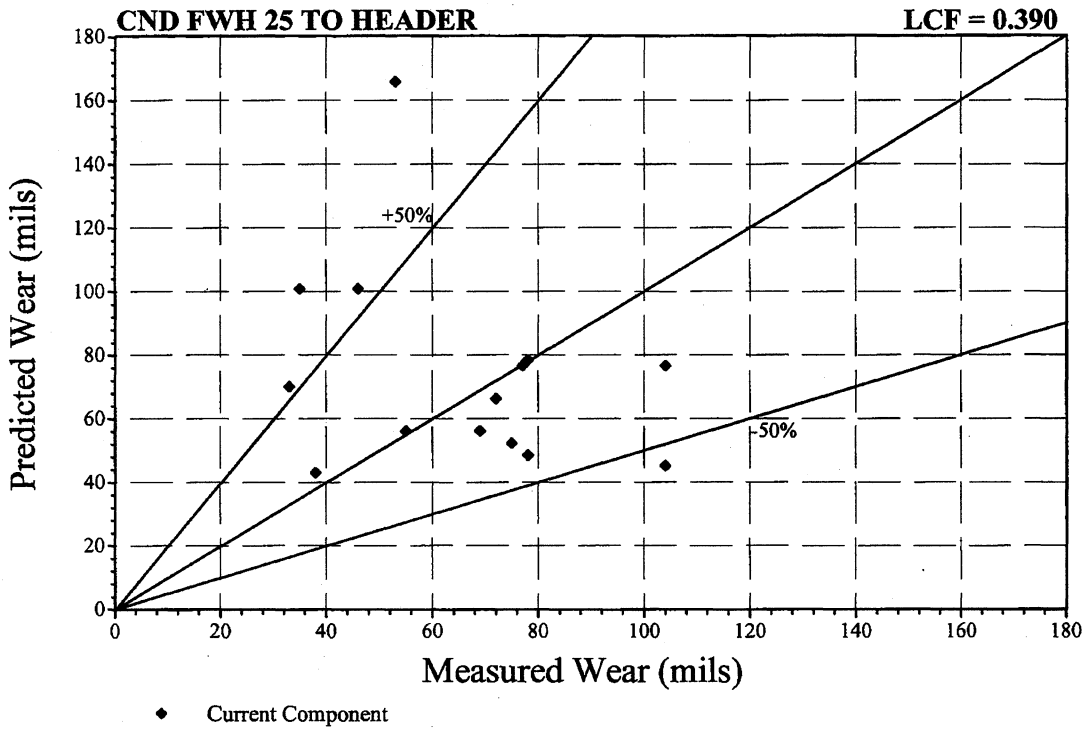

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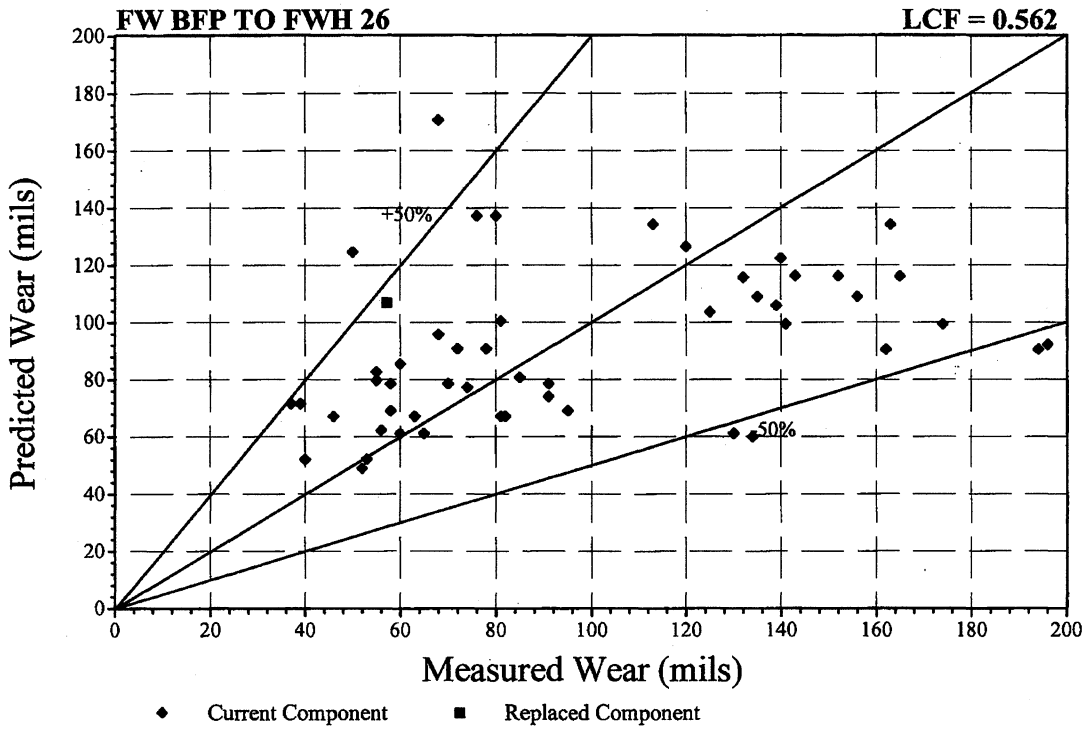

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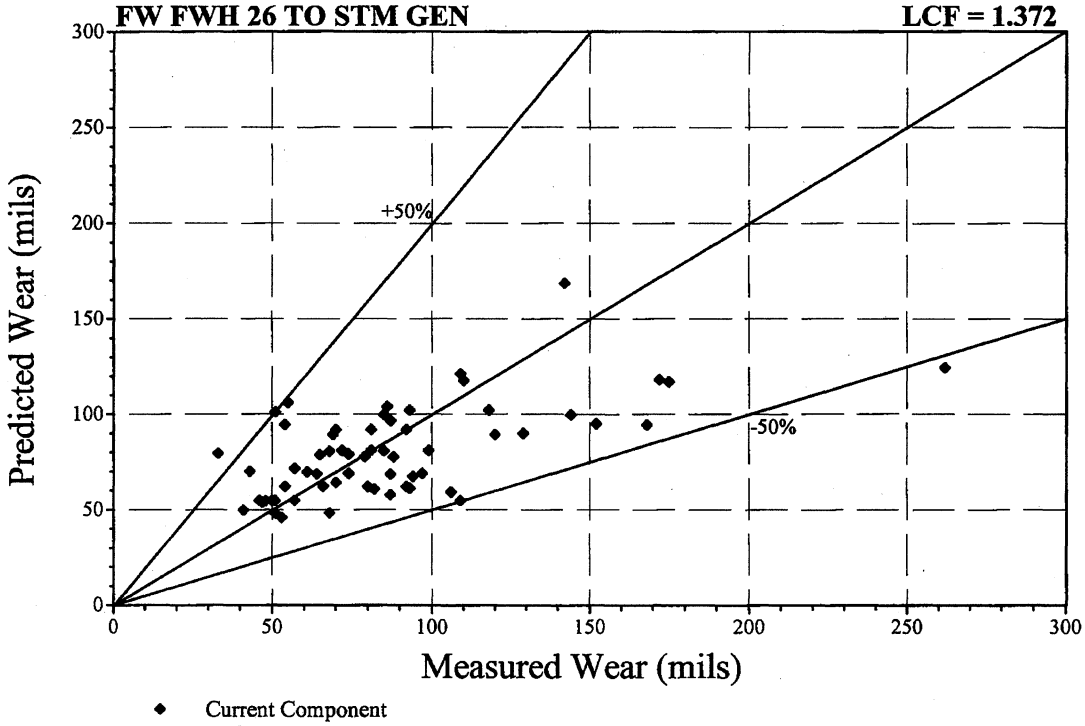

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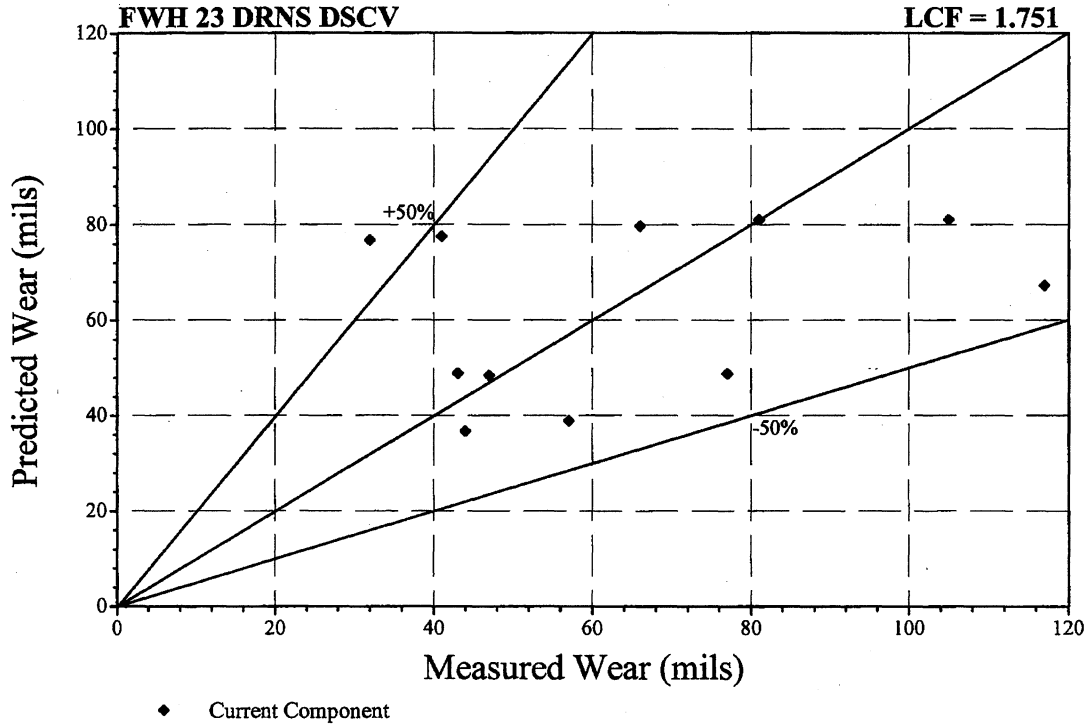

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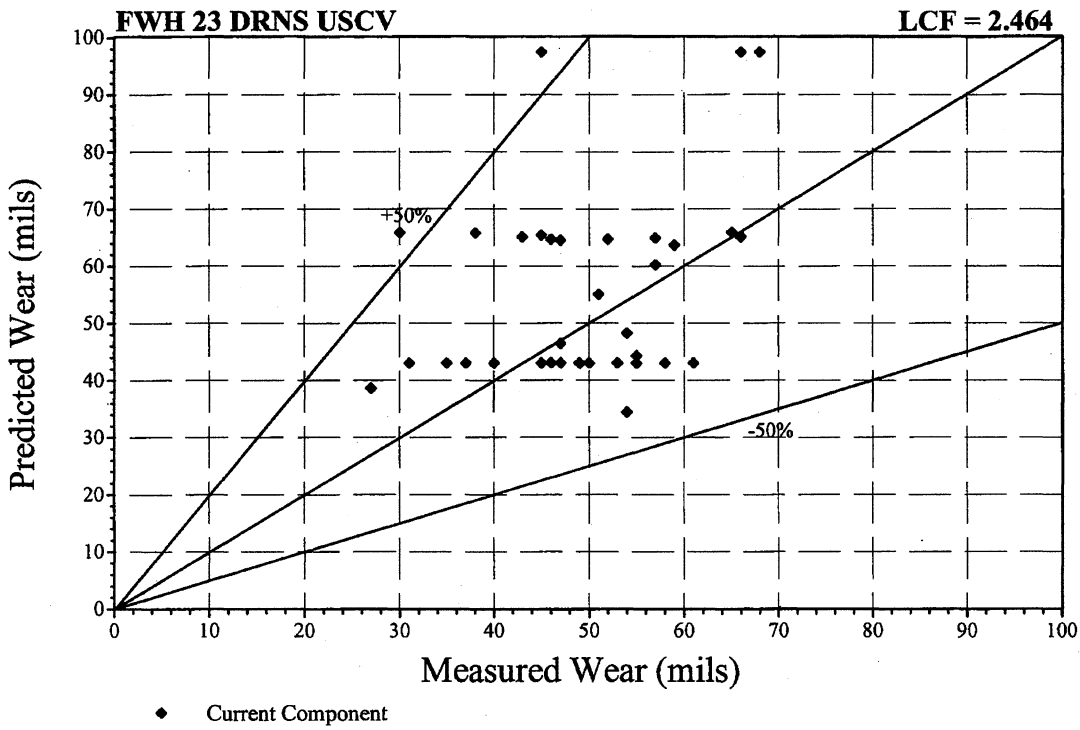
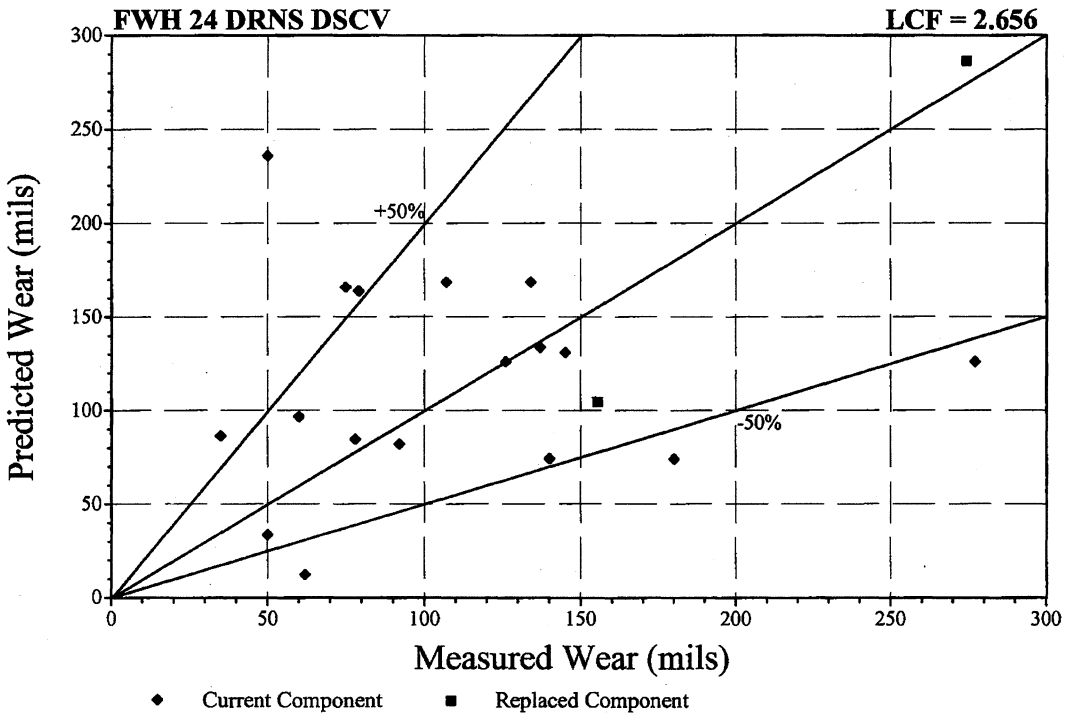
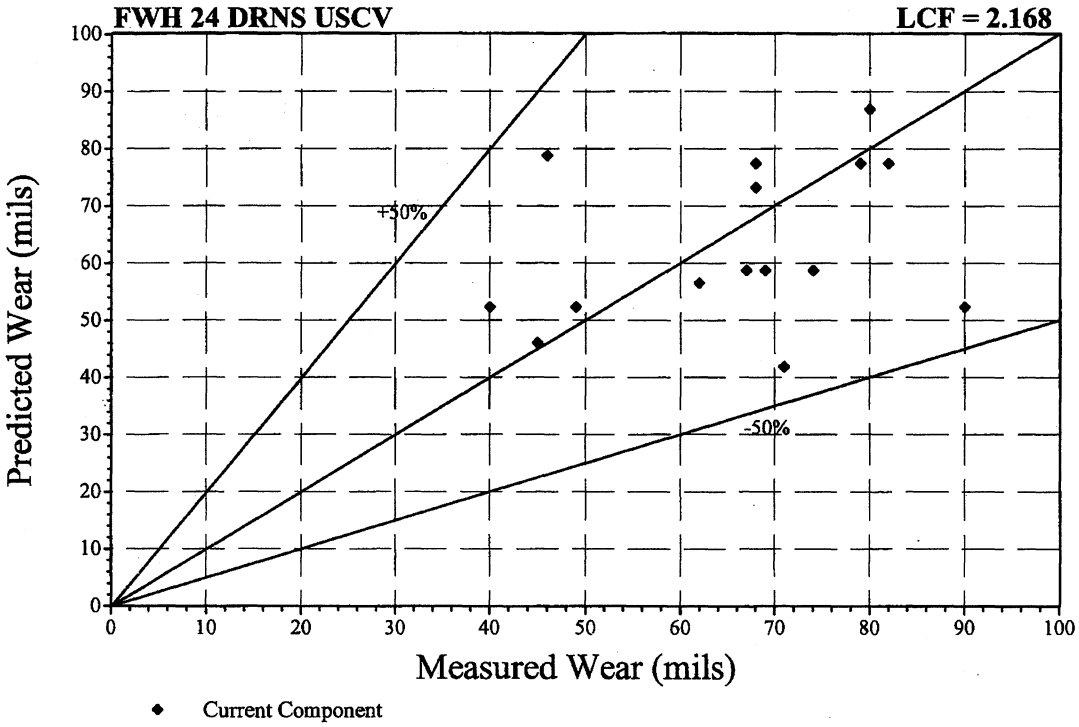


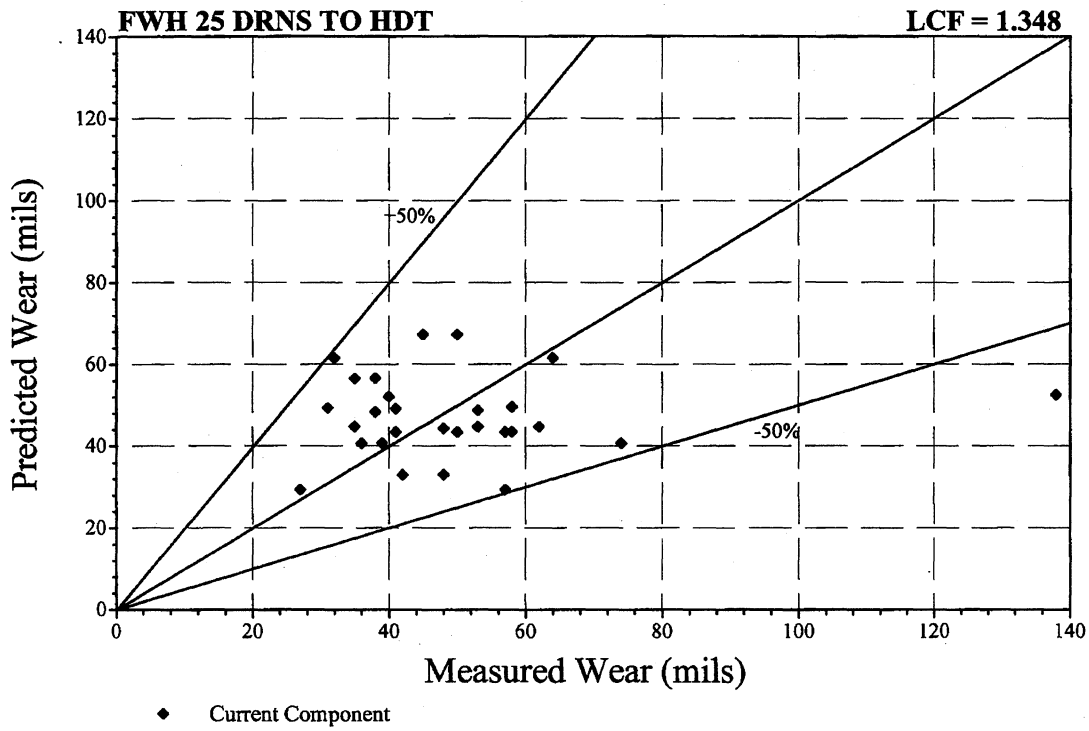
Comparison of Wear Predictions



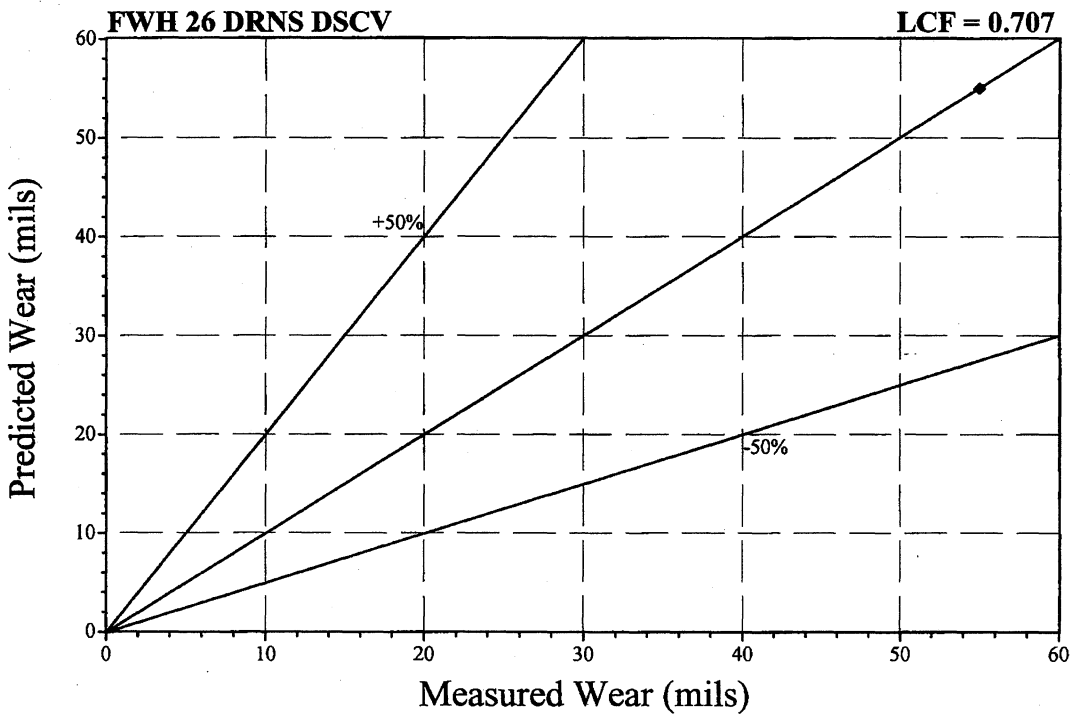
Comparison of Wear Predictions



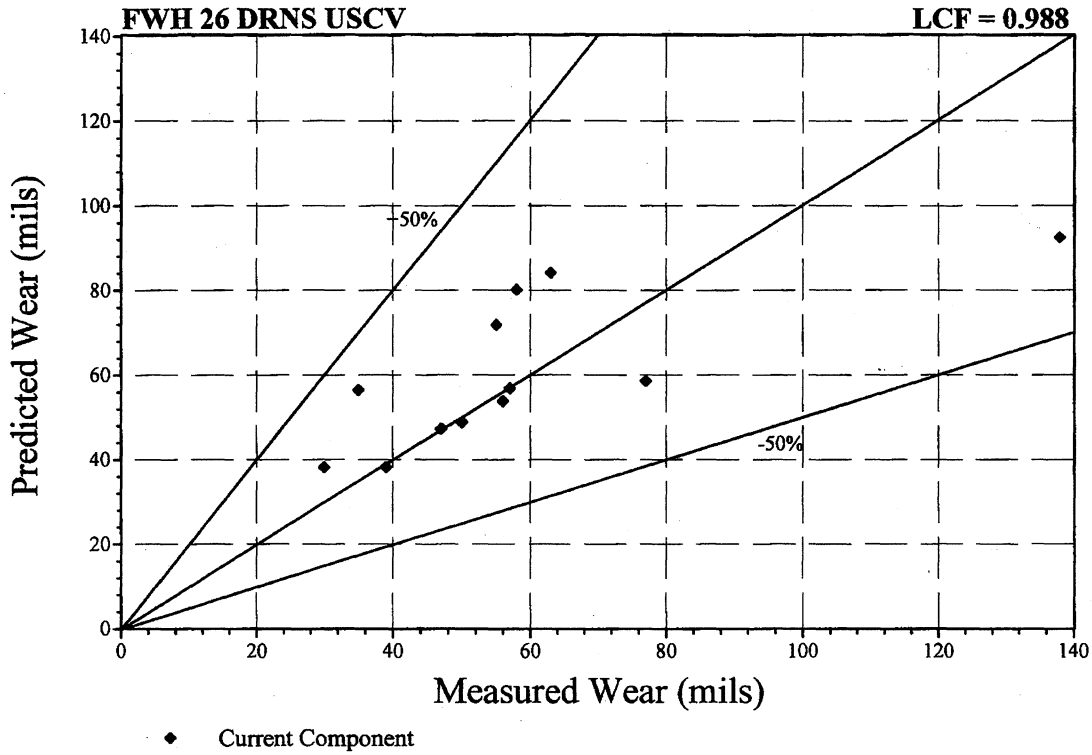
Comparison of Wear Predictions



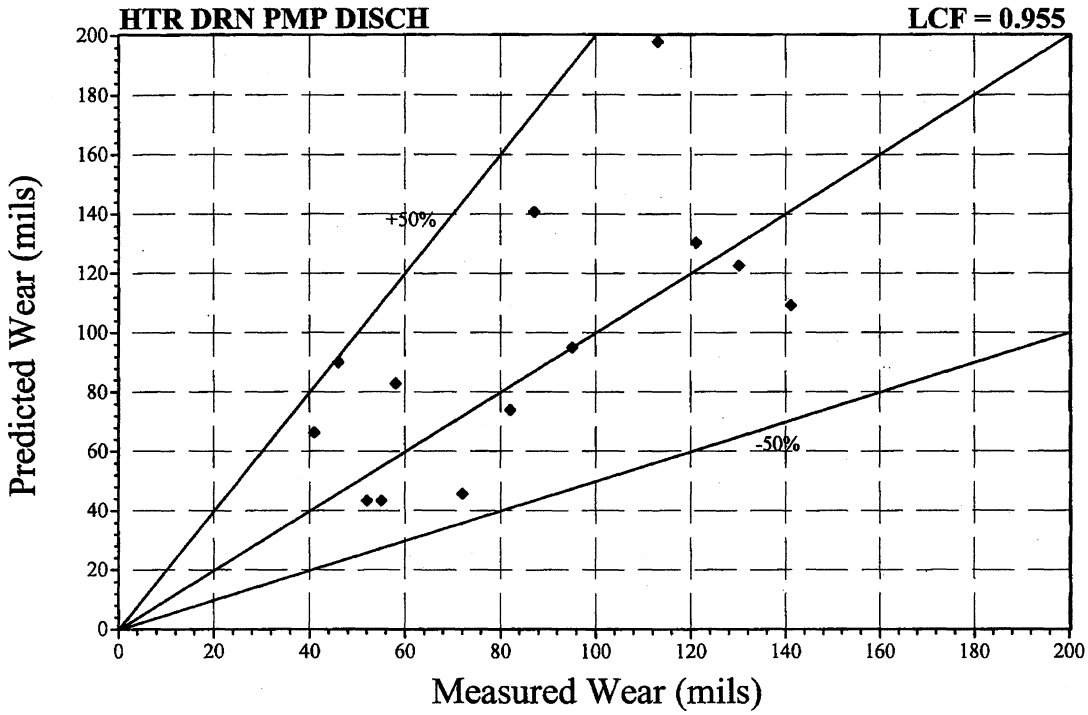
Comparison of Wear Predictions



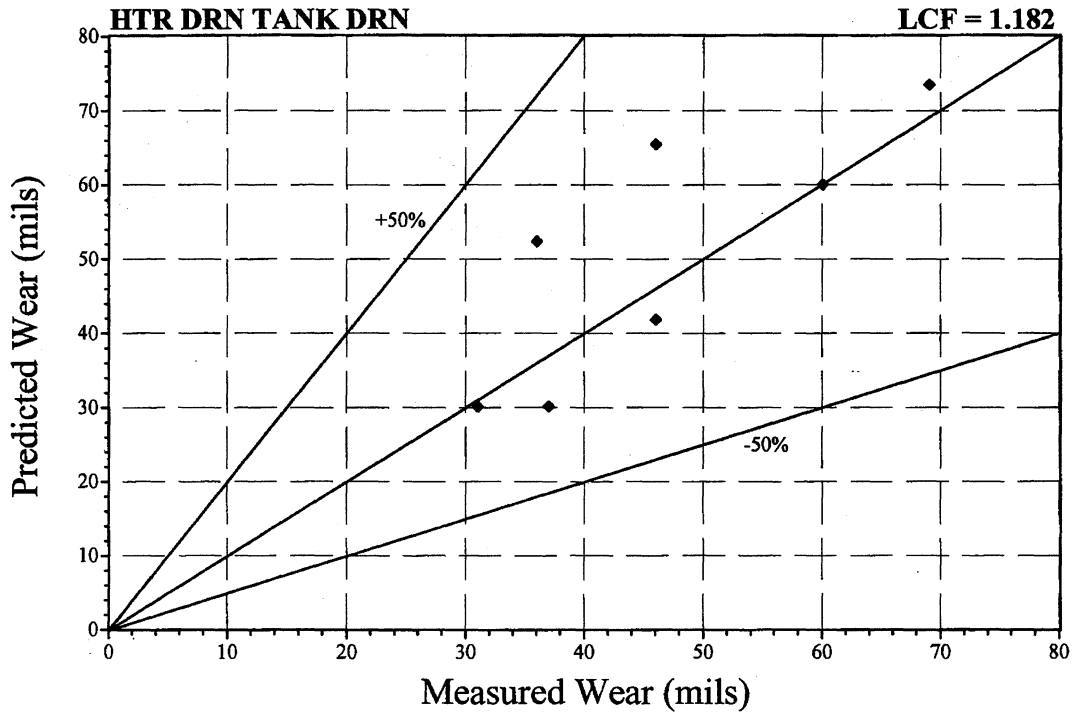
Comparison of Wear Predictions



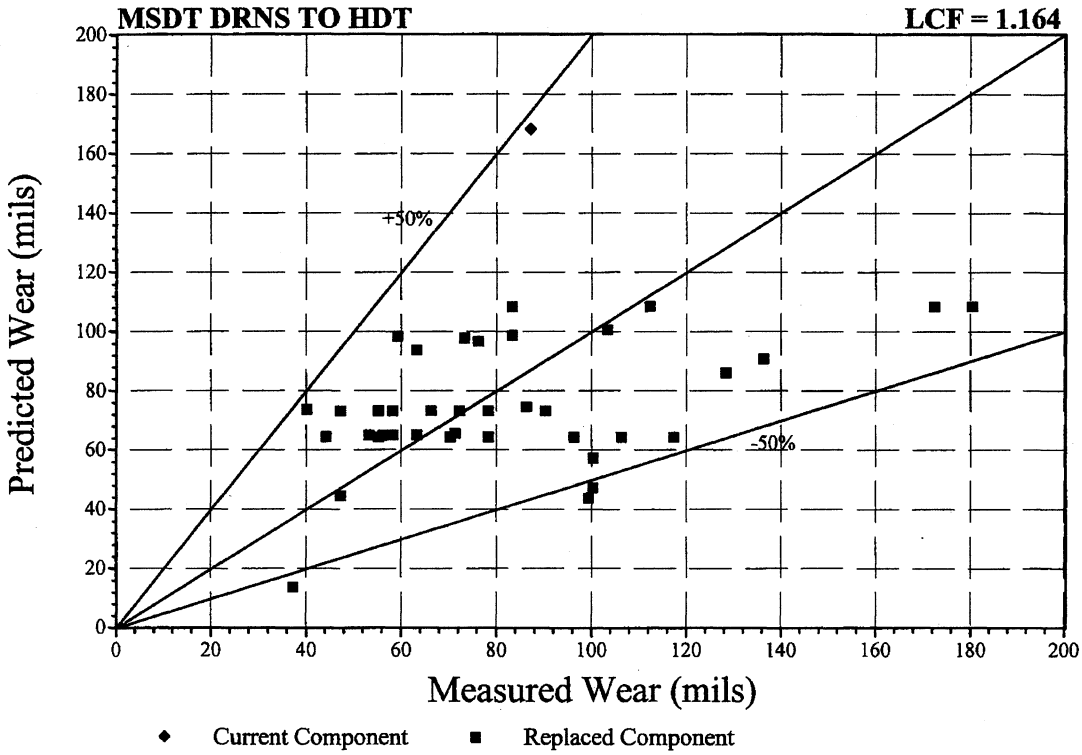
Comparison of Wear Predictions



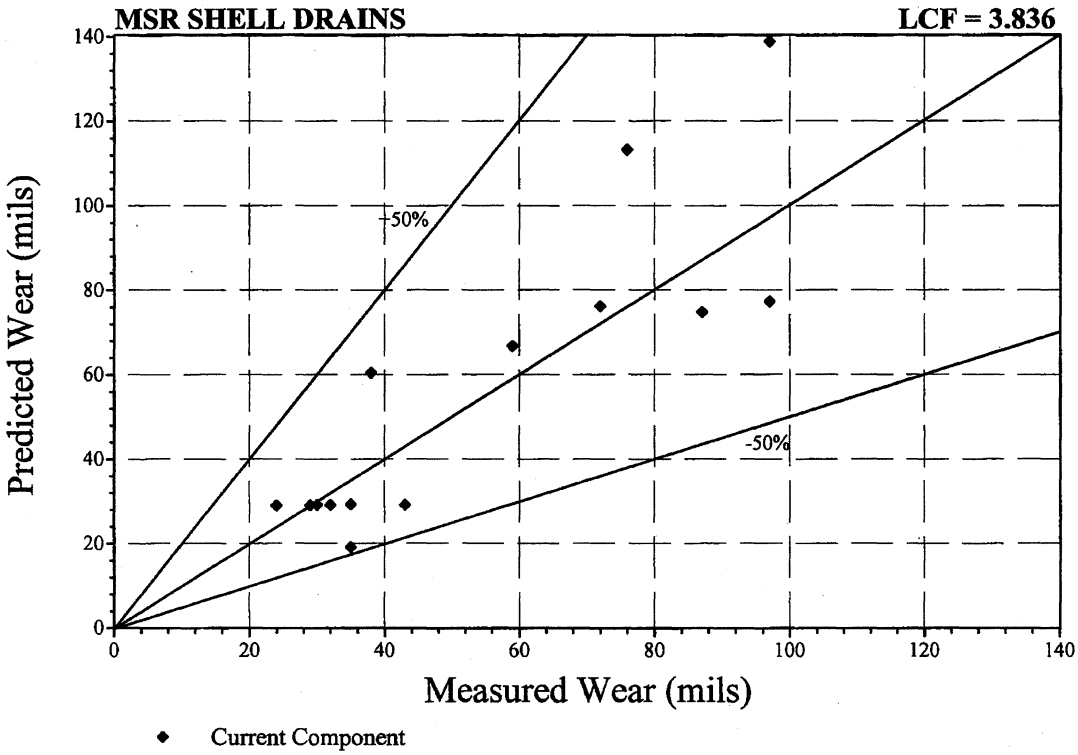
Comparison of Wear Predictions



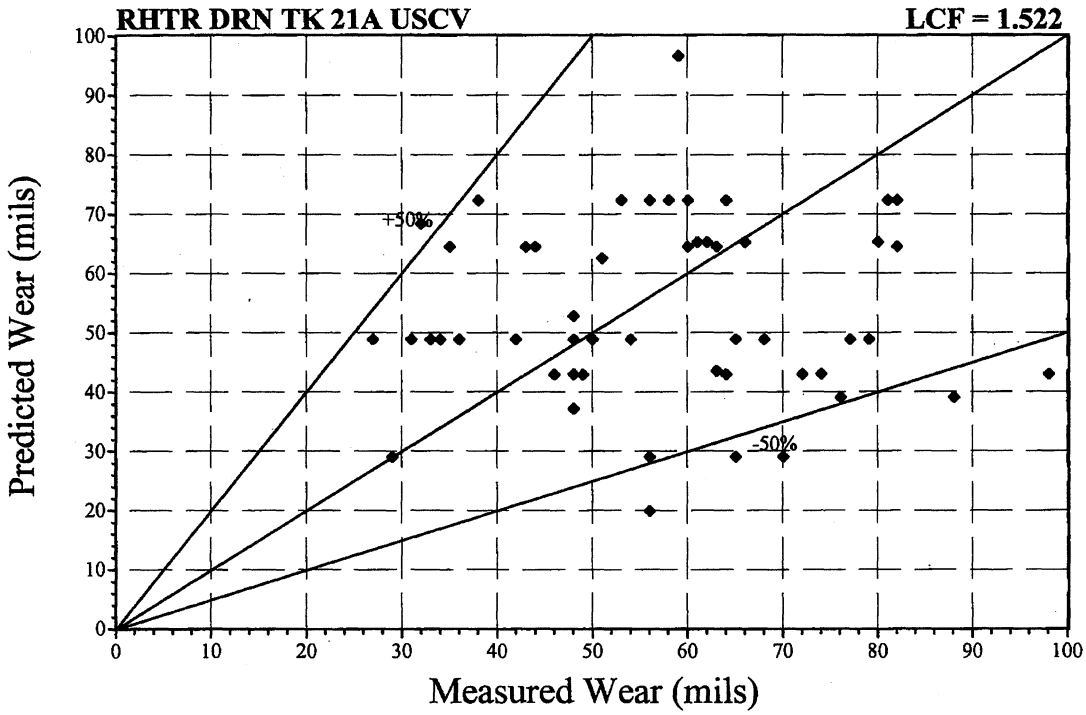
Comparison of Wear Predictions



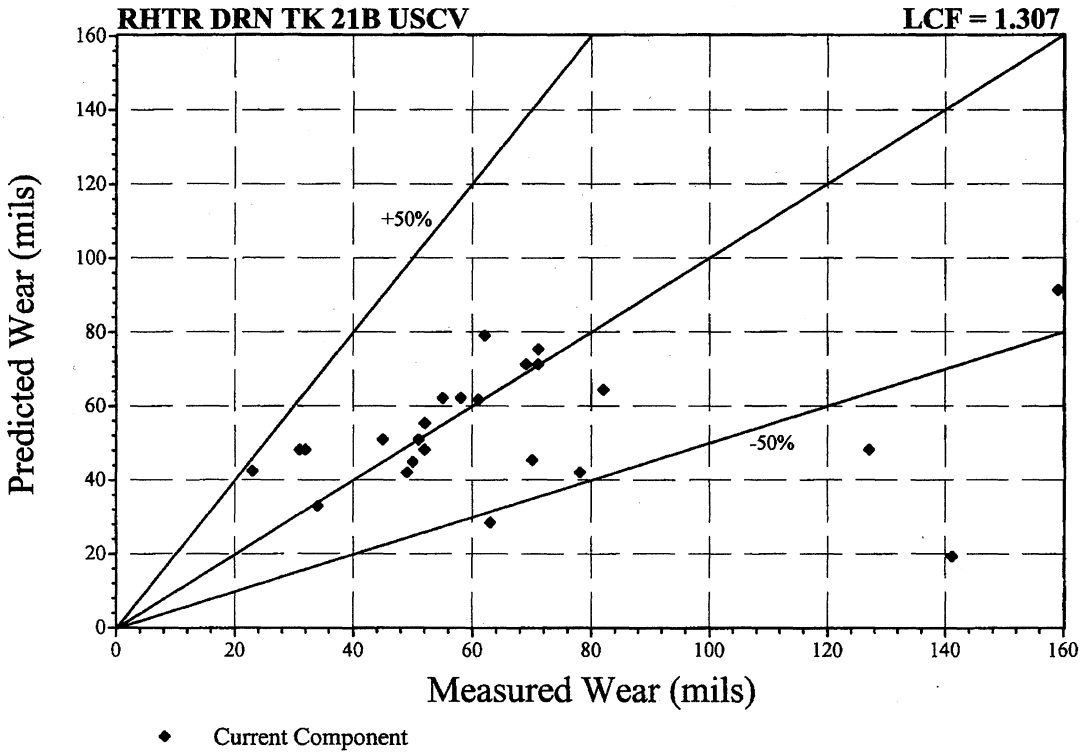
Comparison of Wear Predictions



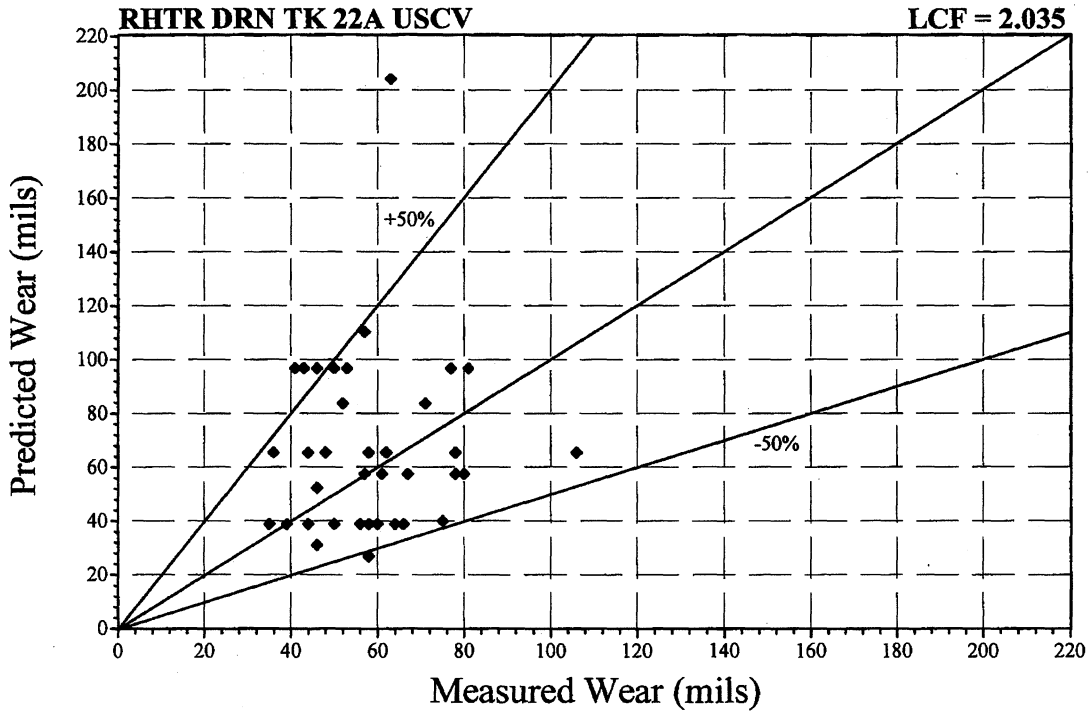
Comparison of Wear Predictions



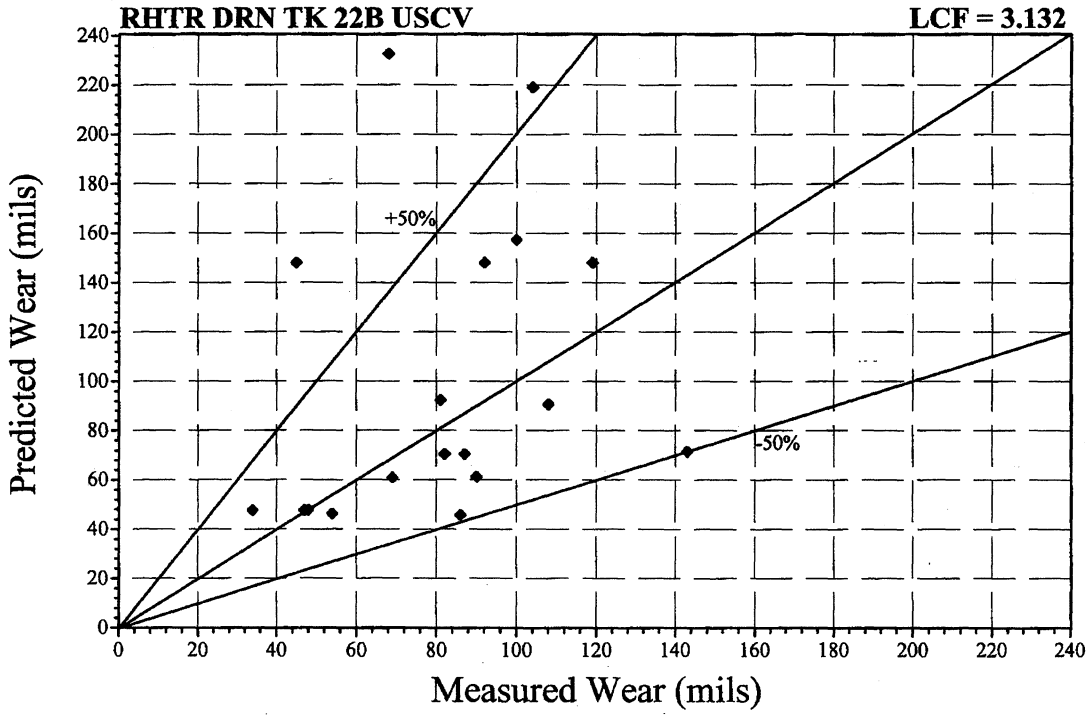
Comparison of Wear Predictions



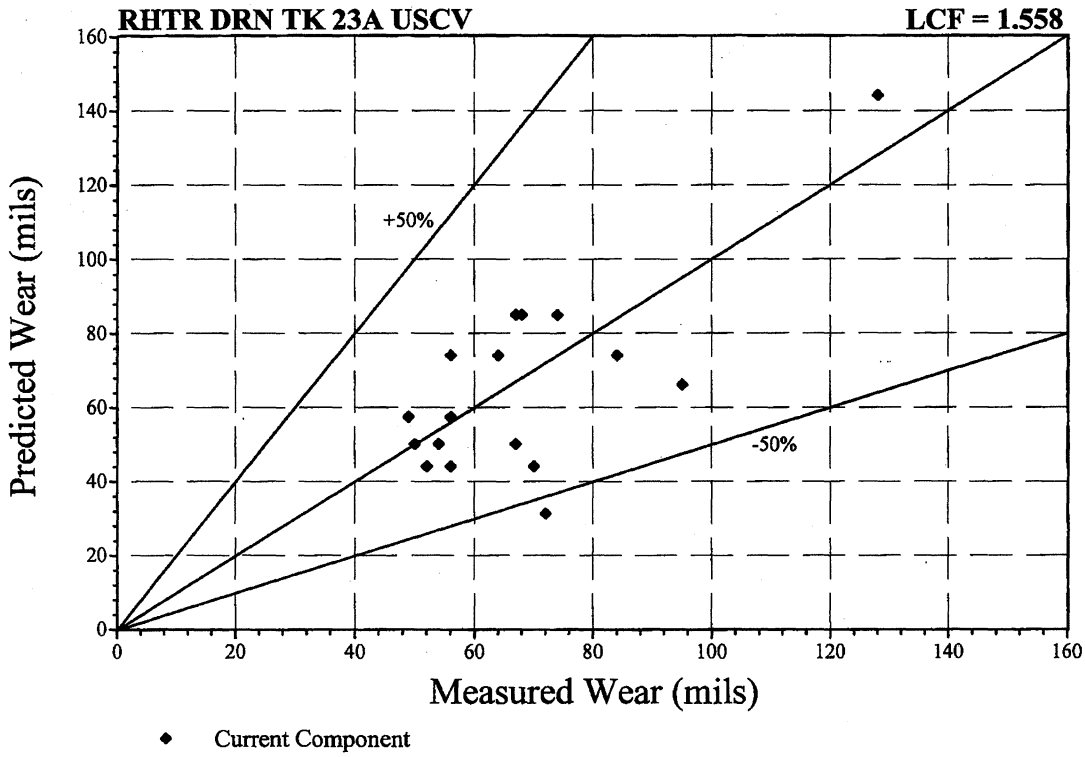
Comparison of Wear Predictions



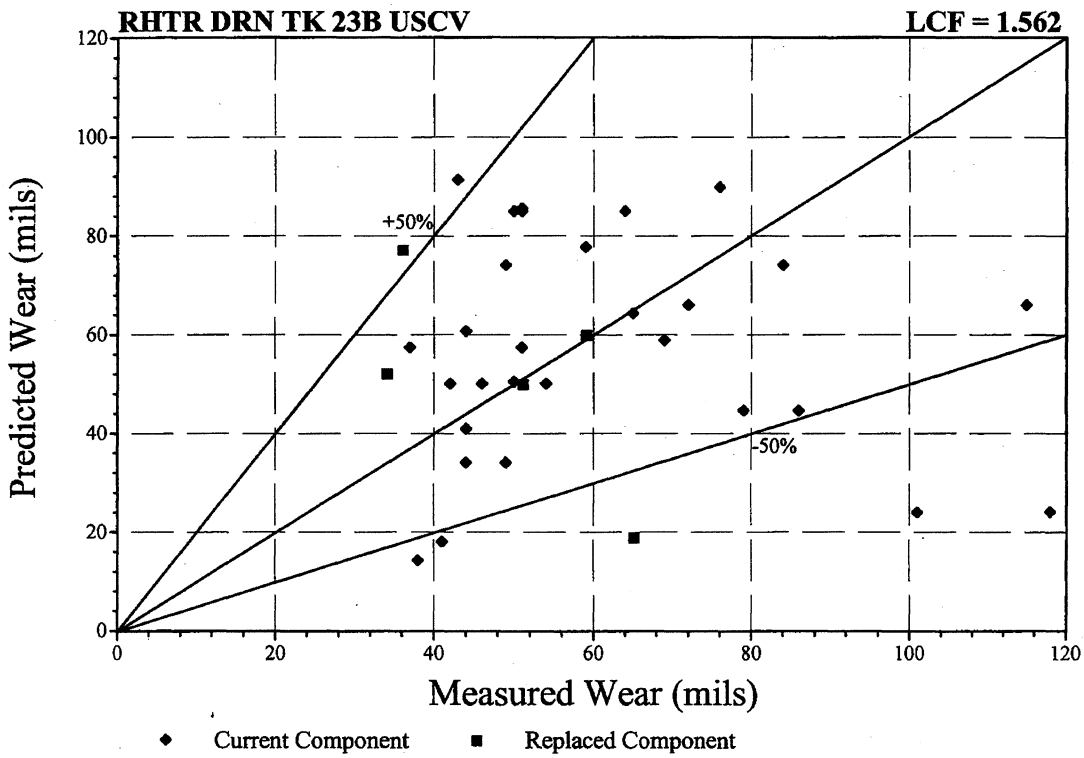
Comparison of Wear Predictions



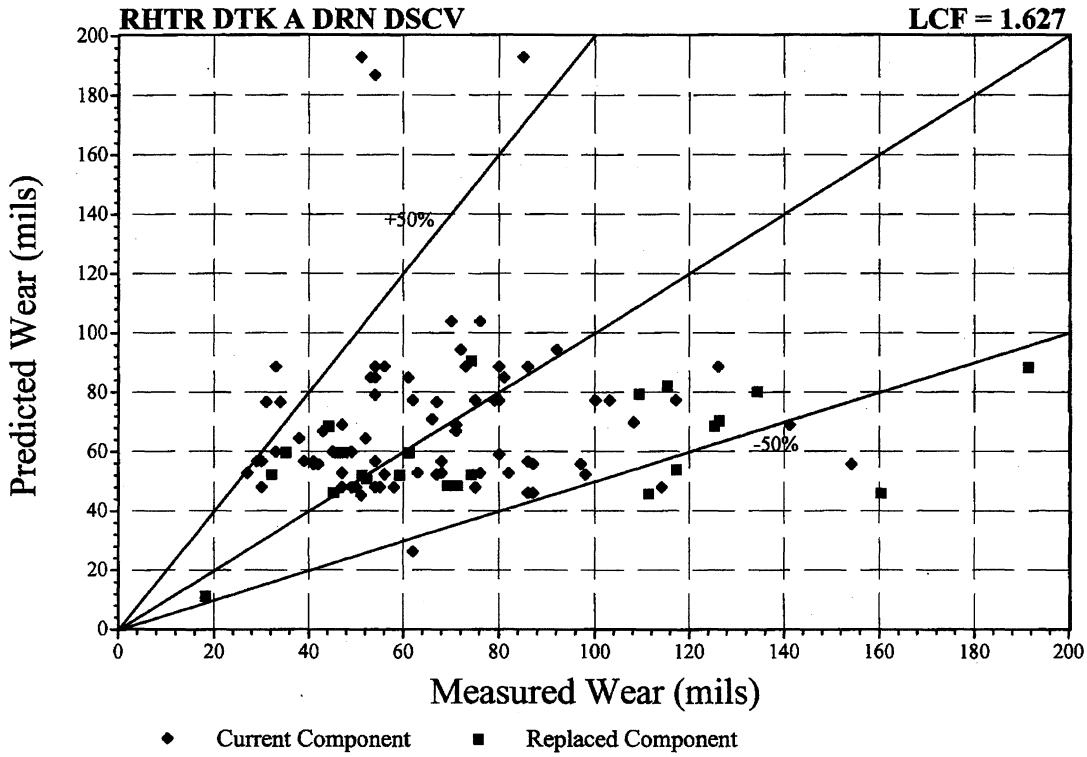
Comparison of Wear Predictions



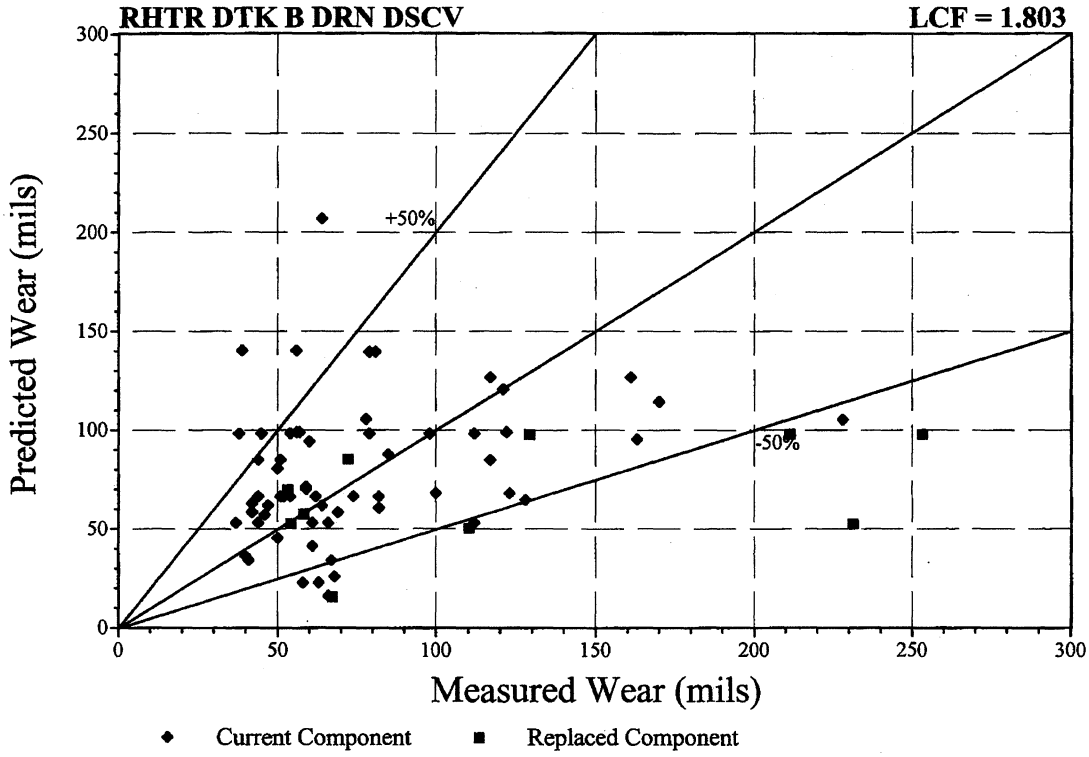
Comparison of Wear Predictions



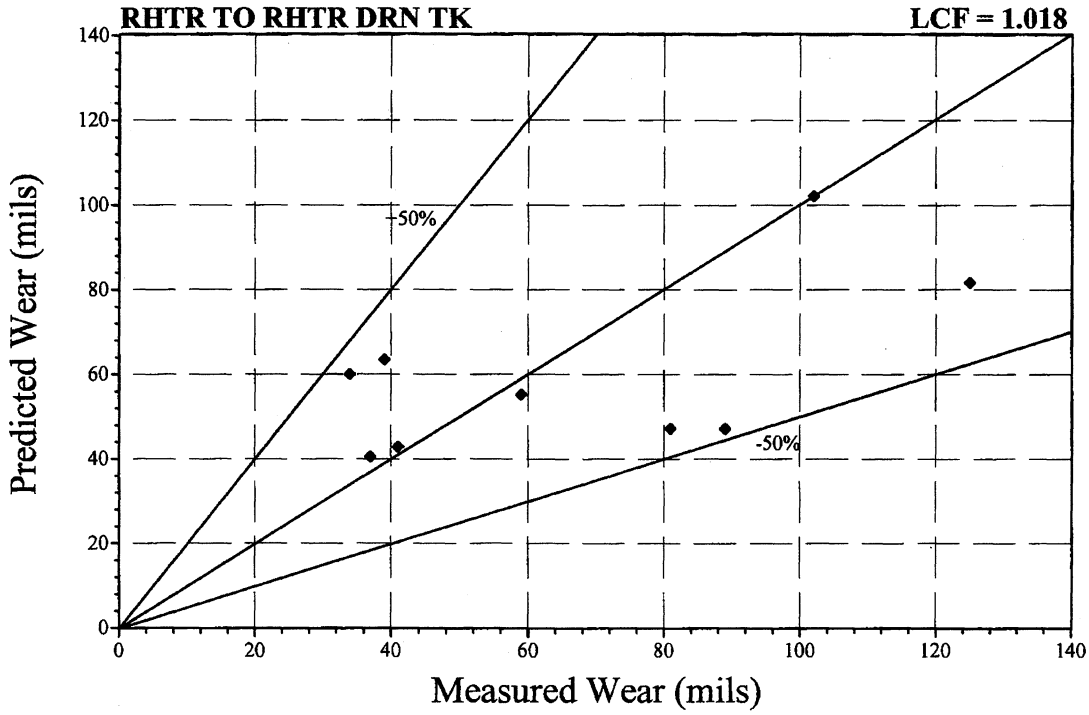
Comparison of Wear Predictions



Comparison of Wear Predictions



Comparison of Wear Predictions



Indian Point Unit 2
CHECWORKS SFA Model

CSI Calculation No. 0705.101-01
Revision A
Issued For-Use

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1. Introduction

Flow-Accelerated Corrosion (FAC) is a form of material degradation that results in thinning of the inside pipe wall in carbon steel piping and fittings under certain flow and chemistry conditions. Undetected FAC-induced wall thinning may cause a pipe to leak or rupture, potentially causing injury to plant personnel and/or plant shutdown. For these reasons, and in response to regulatory requirements, Indian Point 2 Nuclear Power Plant (IP2) has developed and implemented a program to monitor and mitigate FAC-induced wall thinning in high energy, large-bore piping systems [7.1].

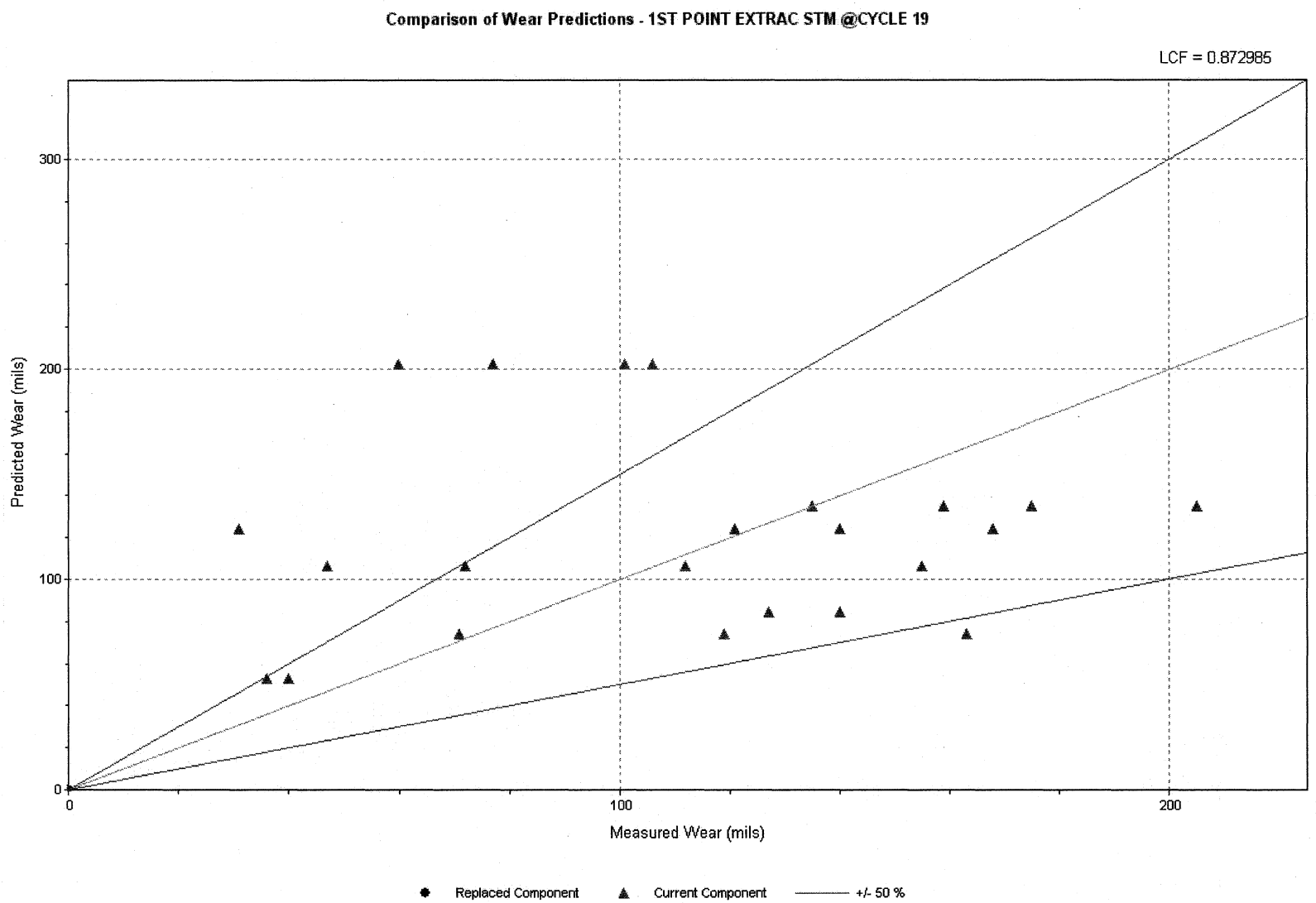
This calculation uses plant design and operation information to document the CHECWORKS model for IP2. It documents the CHECWORKS Pass 1 analysis to generate a wear rate prediction for every piping component modeled in CHECWORKS. Component inspection data through the Refuel Outage 18 was imported to the model where available. A Pass 2 analysis was performed on all lines to provide wear predictions calibrated to the inspection data, as well as remaining life based upon measured wear rates for inspected components. The results of these analyses can be used to select components for inspection in order to mitigate pipe deterioration due to FAC.

This calculation replaces all previous CHECWORKS model calculations used to document the IP2 model. Previous CHECWORKS model calculations are listed in the References [7.16].

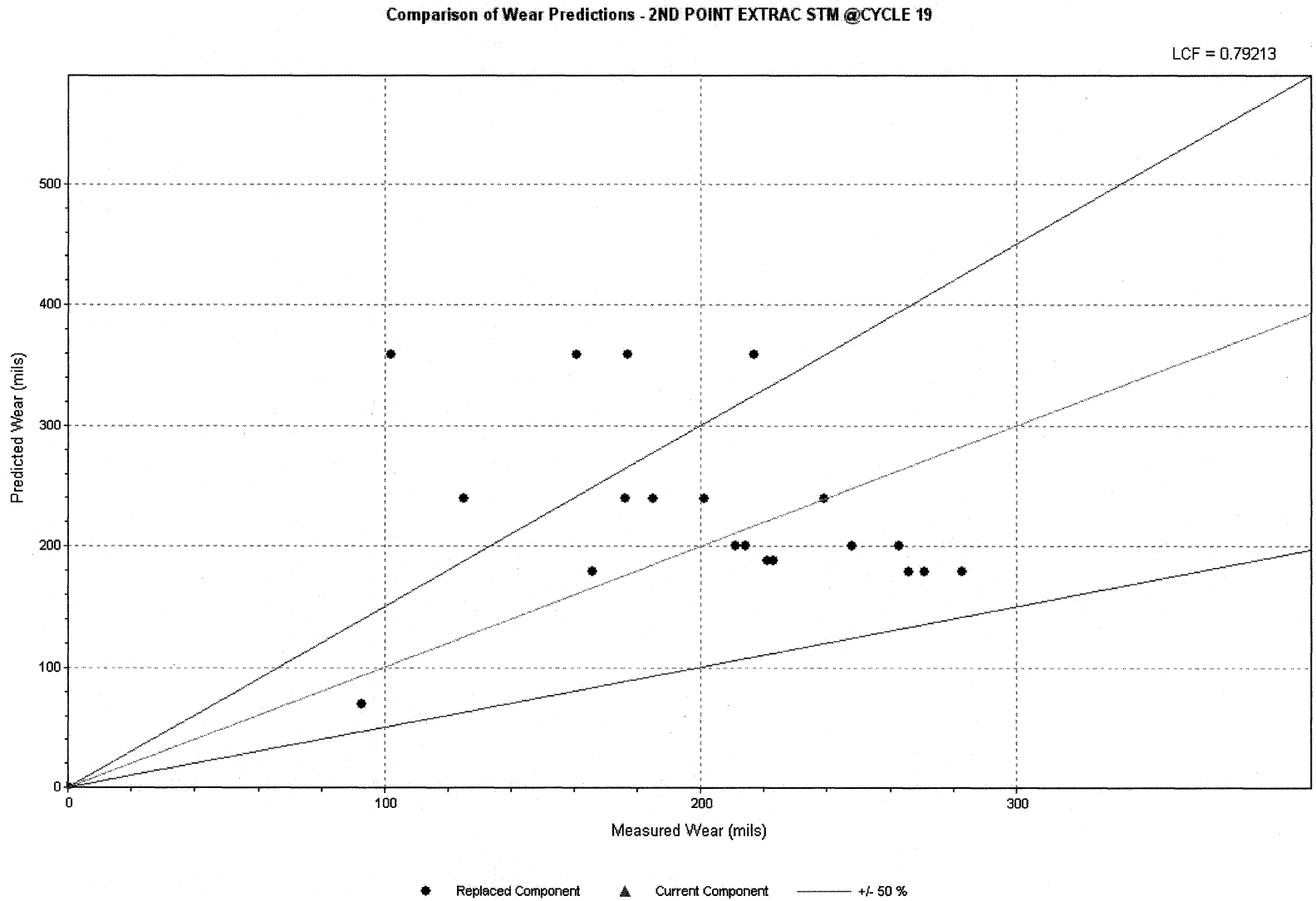
Appendix J

Wear Plots (with LCF values)

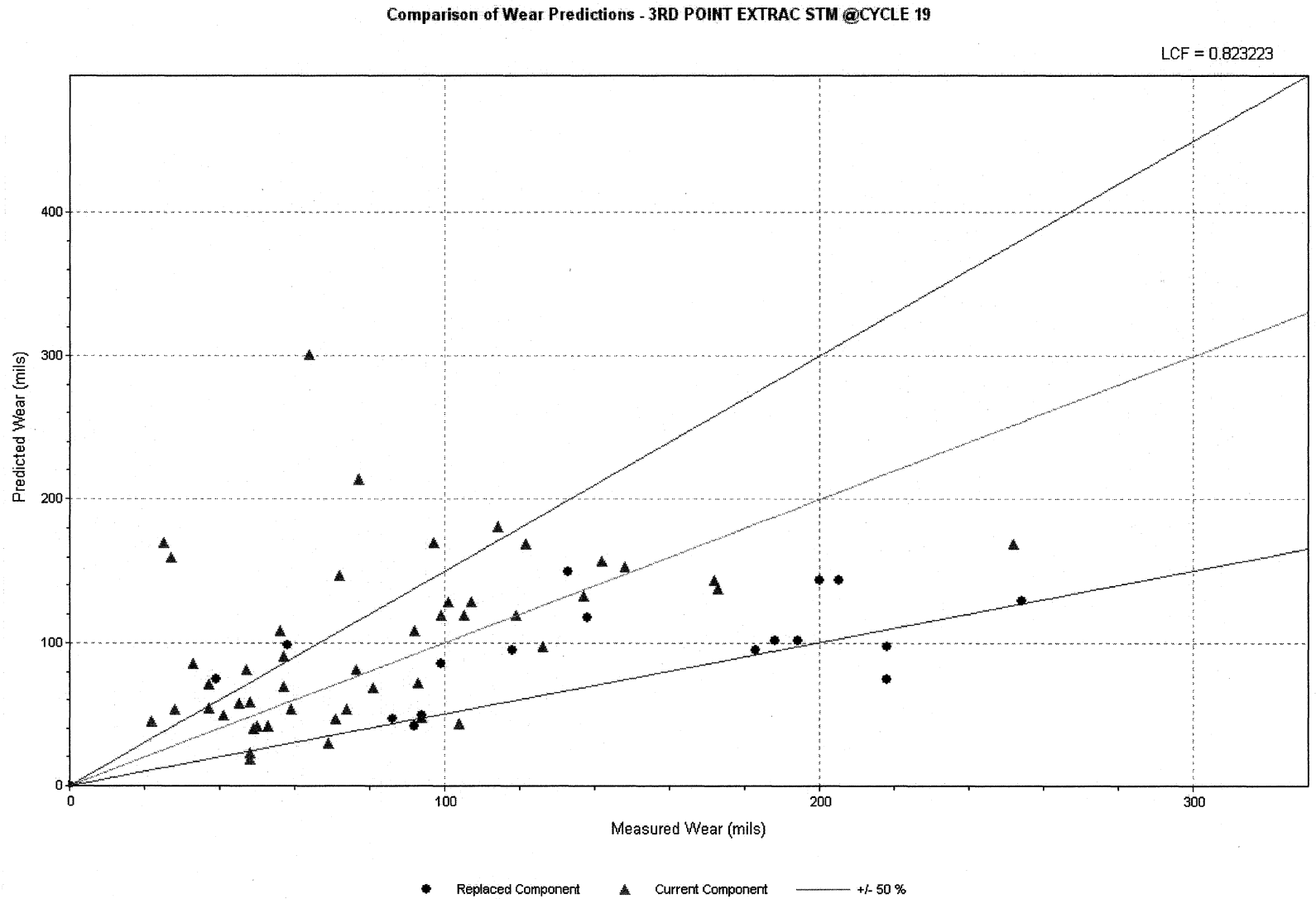
Plot J.1: 1ST POINT EXTRAC STM



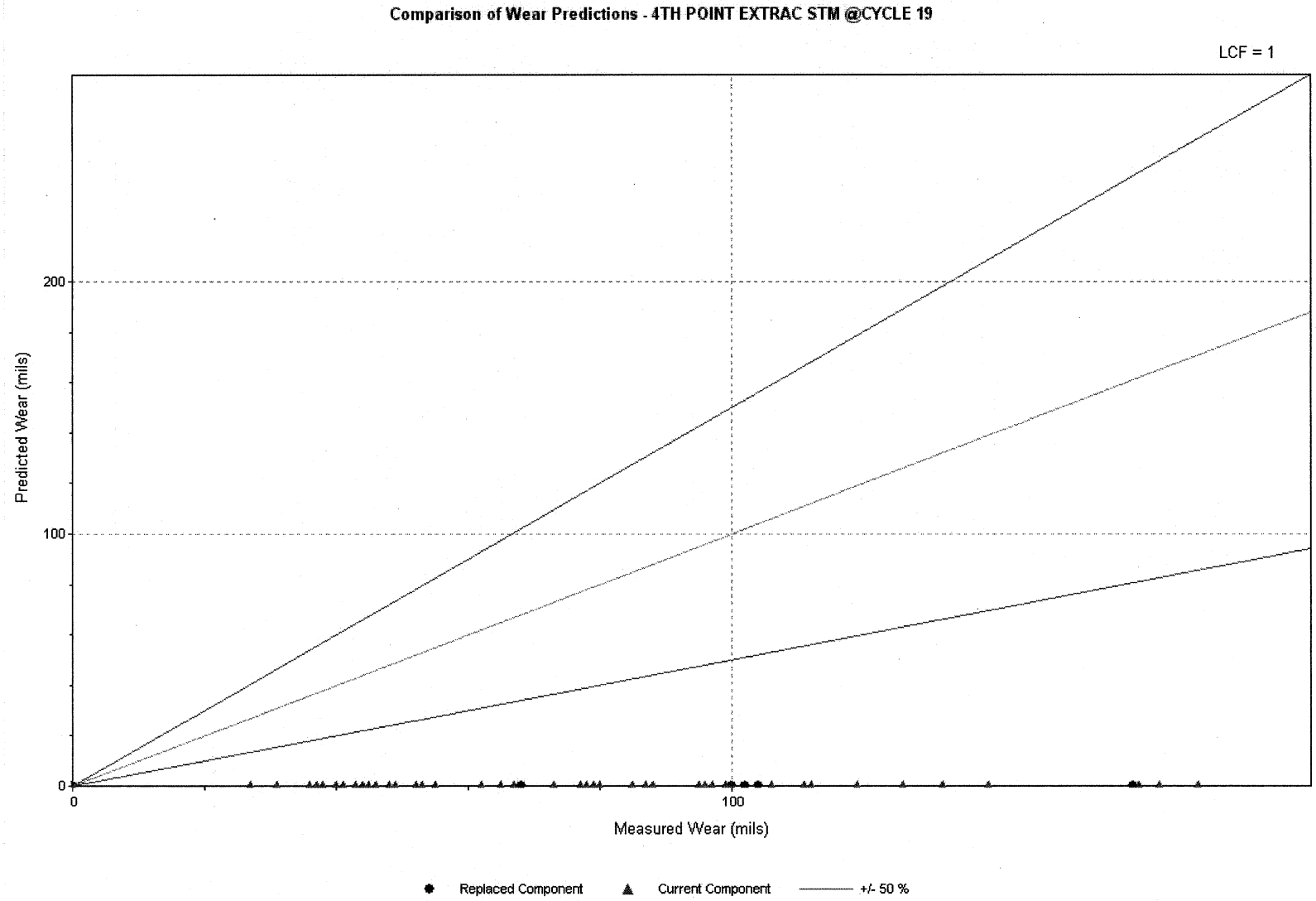
Plot J.2: 2ND POINT EXTRAC STM



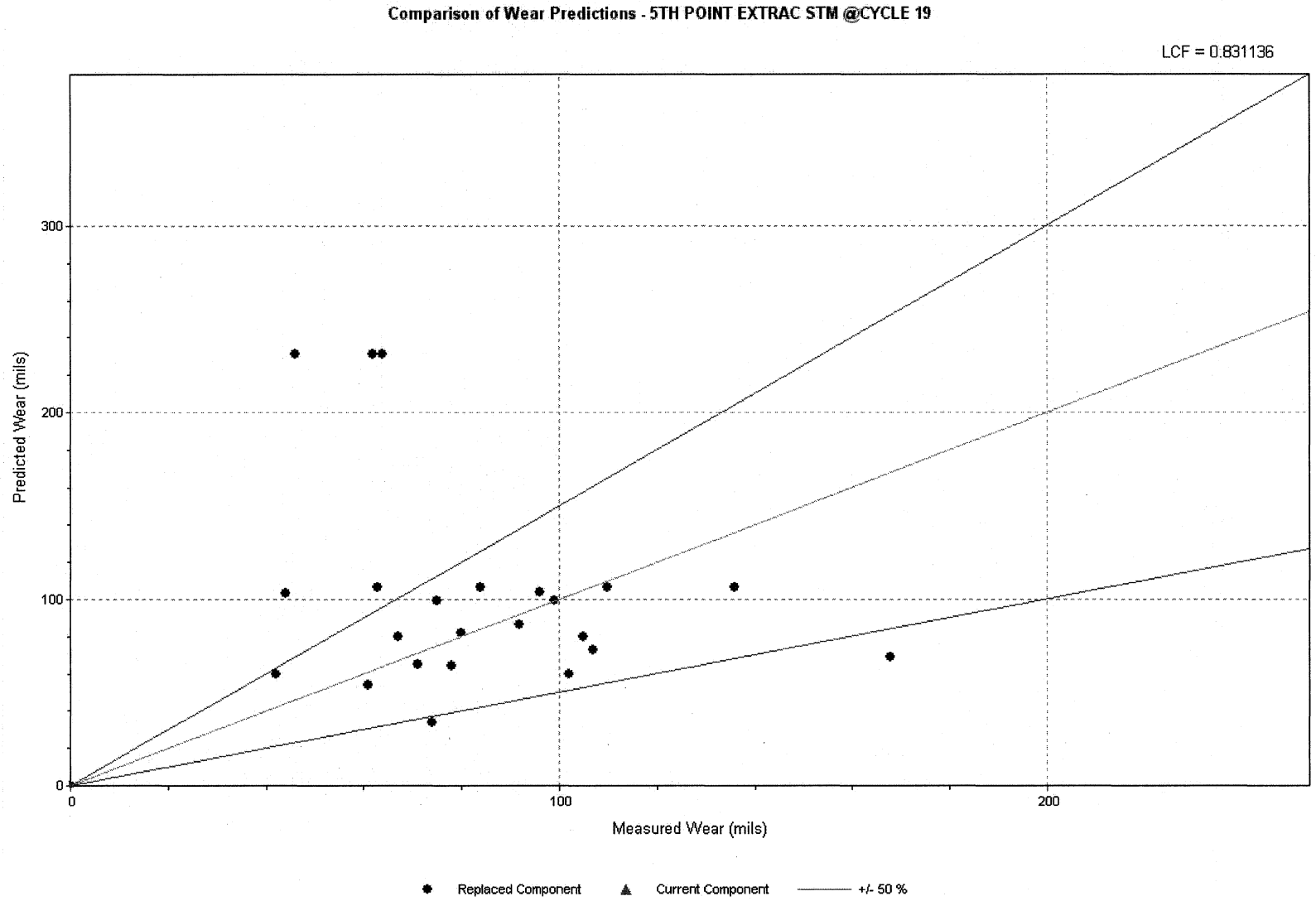
Plot J.3: 3RD POINT EXTRAC STM



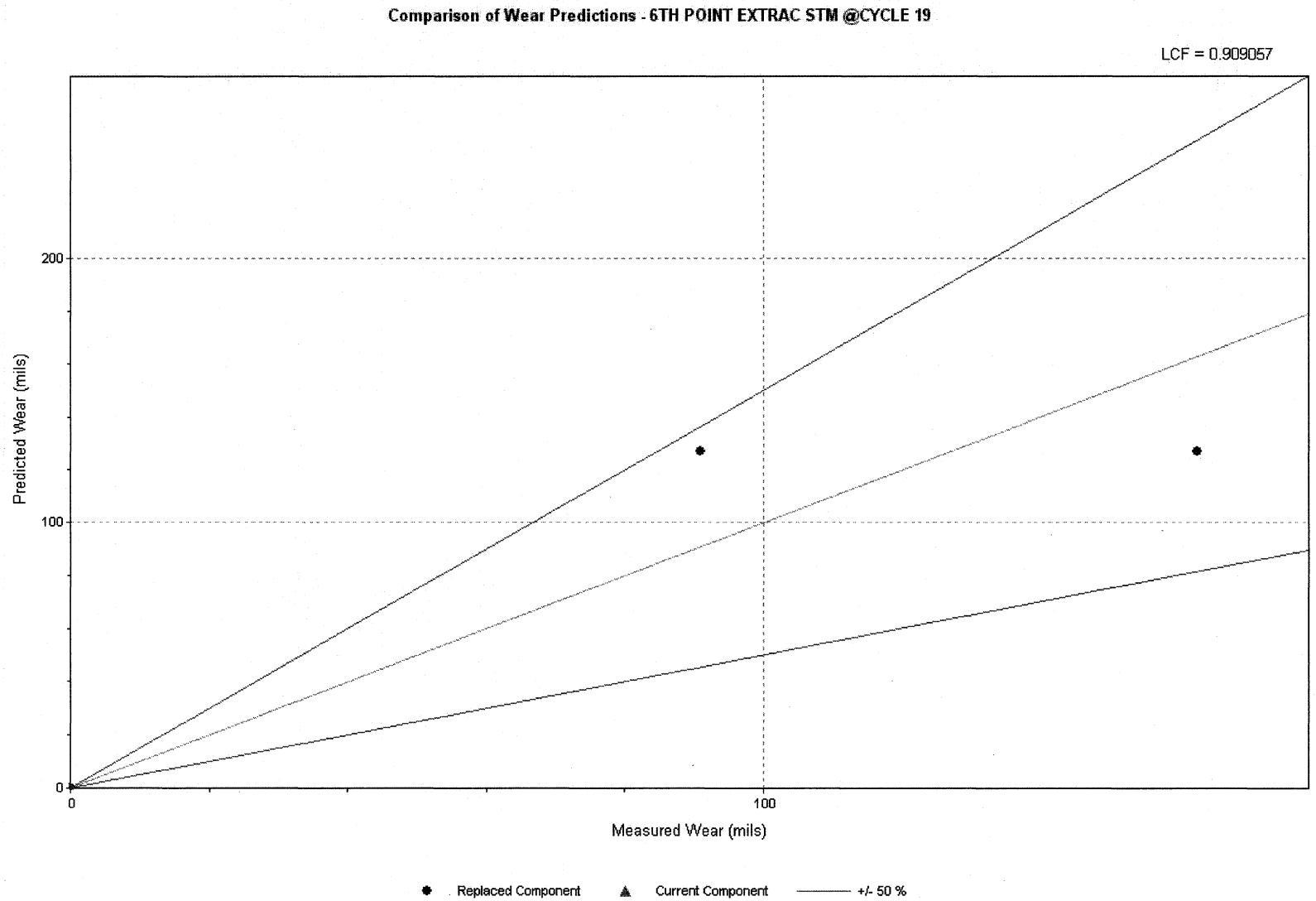
Plot J.4: 4TH POINT EXTRAC STM



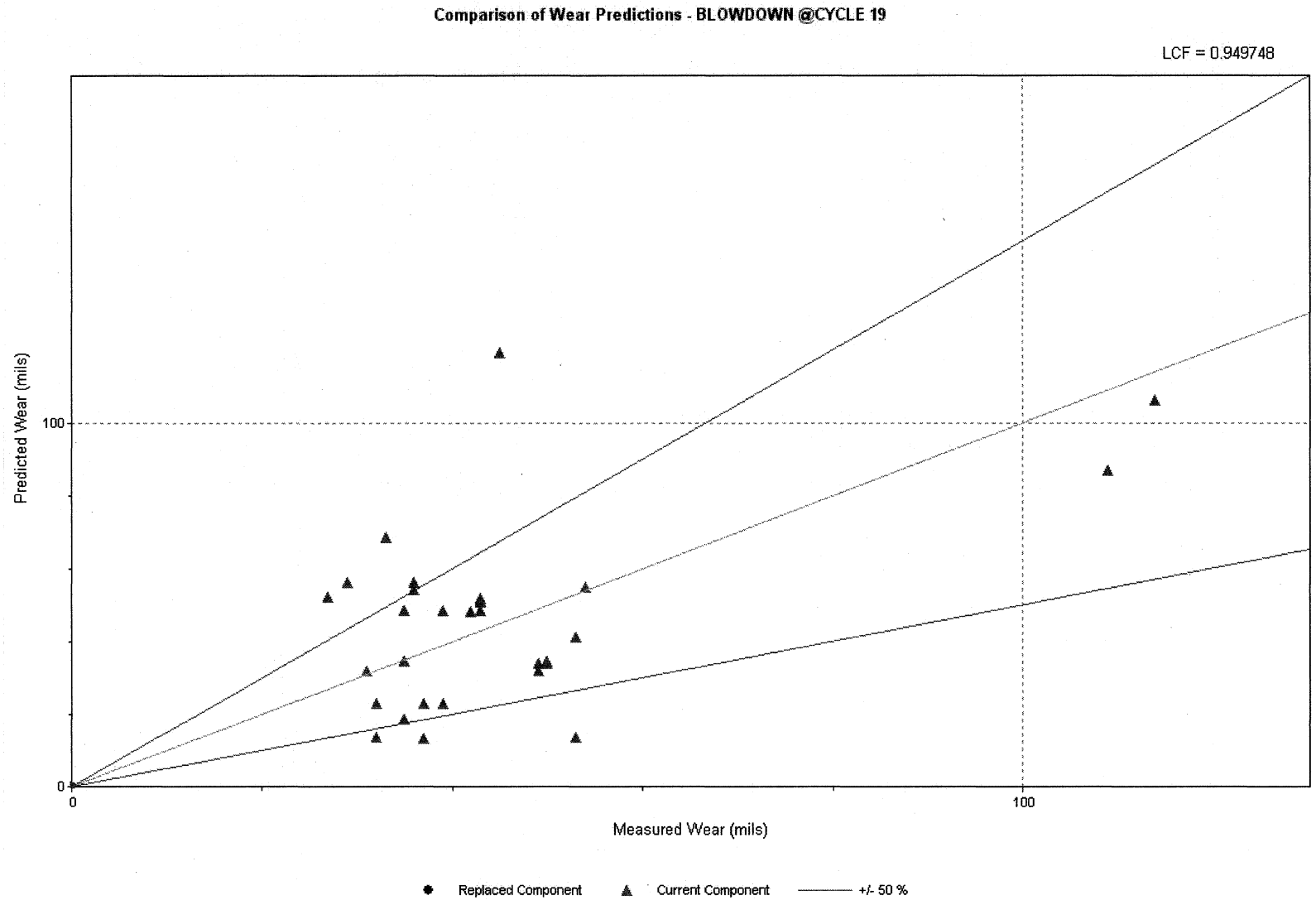
Plot J.5: 5TH POINT EXTRAC STM



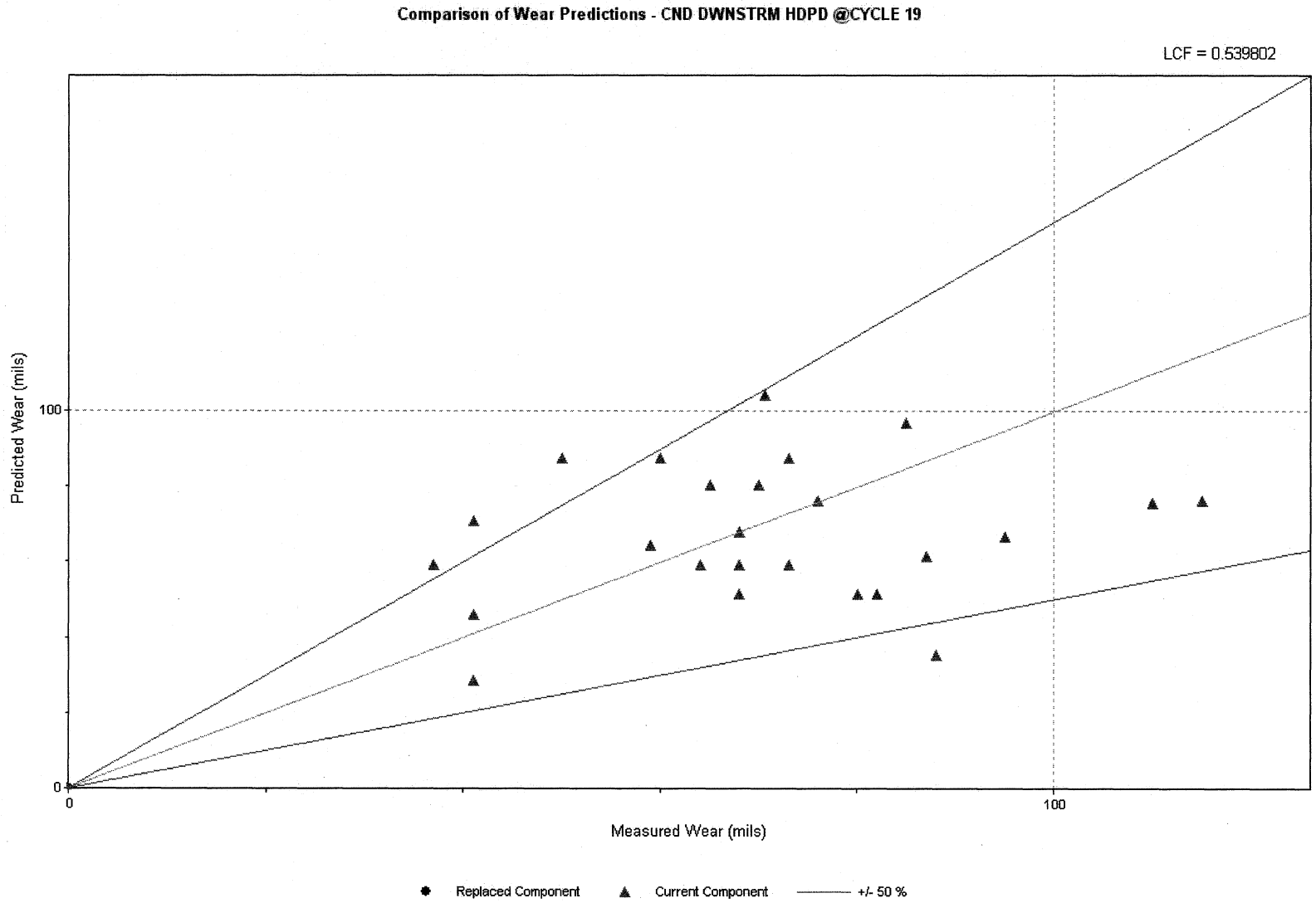
Plot J.6: 6TH POINT EXTRAC STM



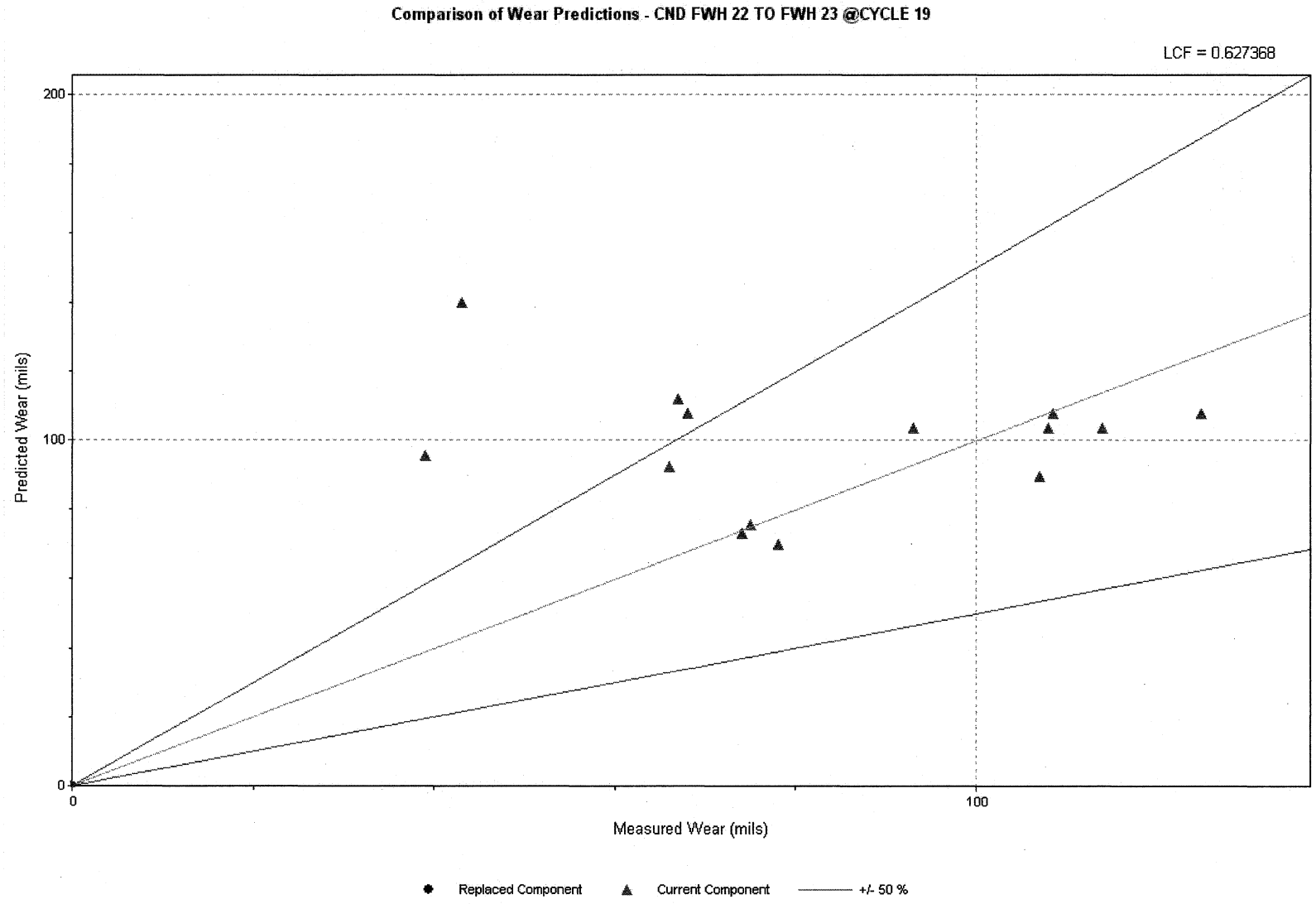
Plot J.7: BLOWDOWN



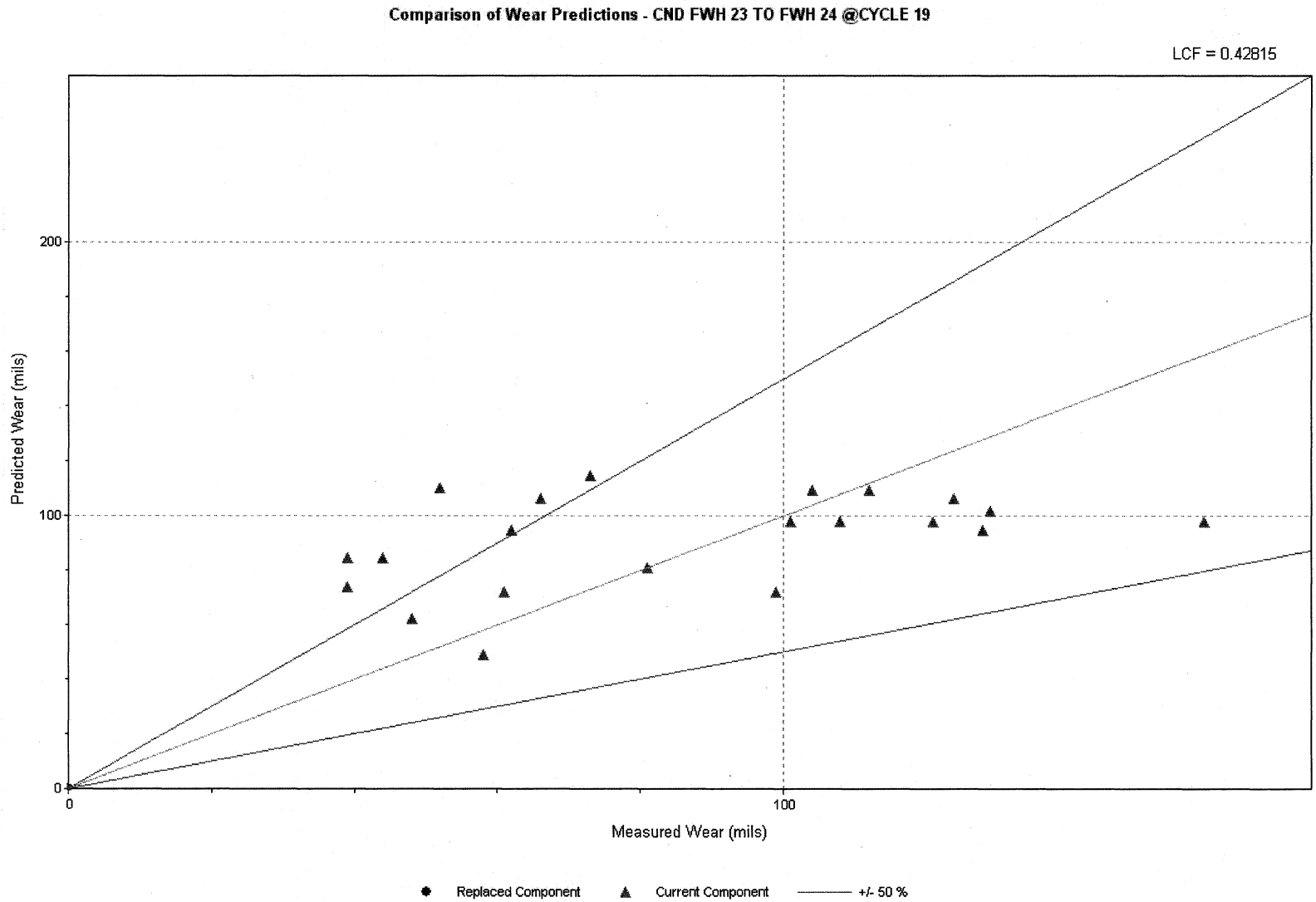
Plot J.8: CND DWNSTRM HDPD



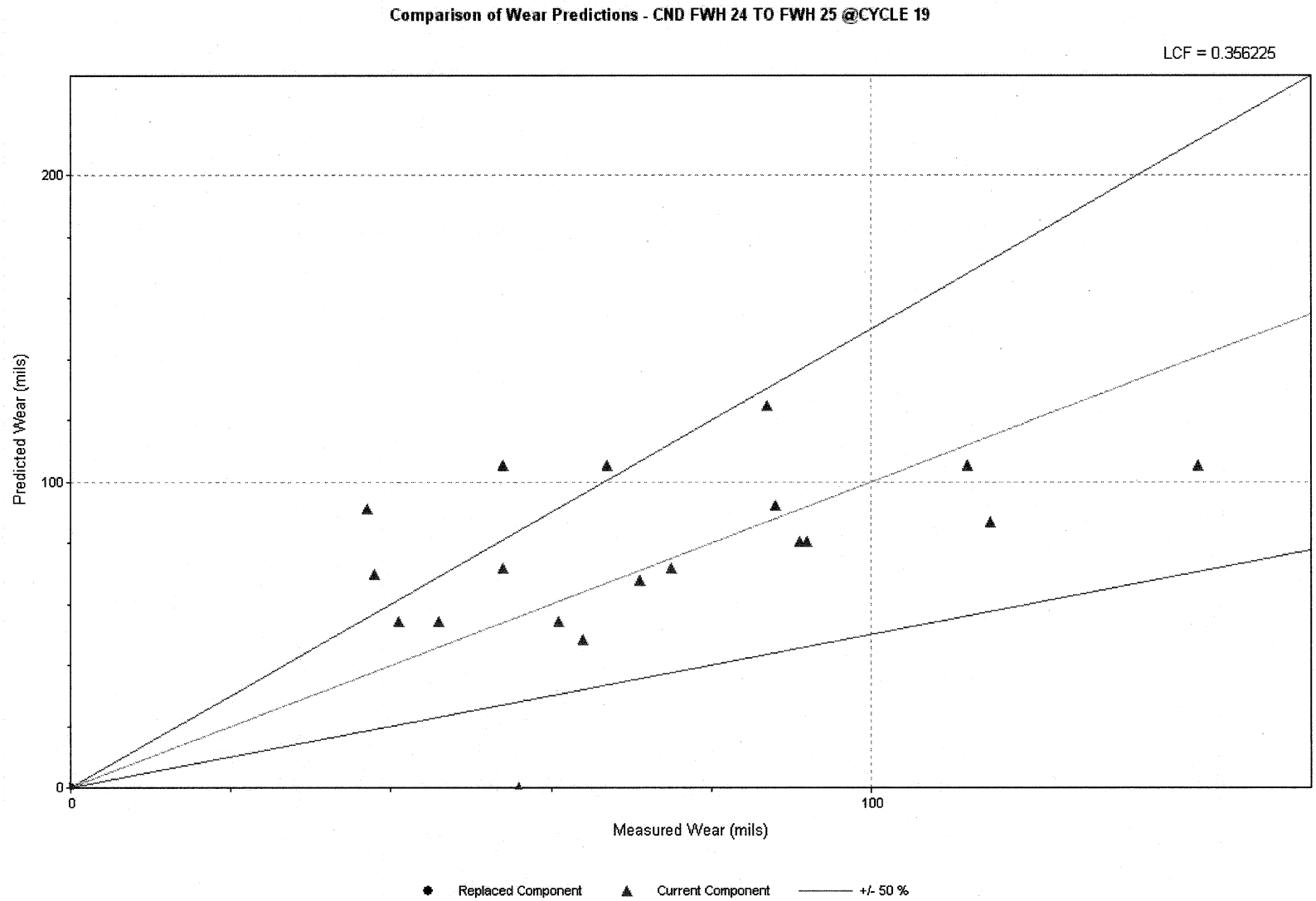
Plot J.9: CND FWH 22 TO FWH 23



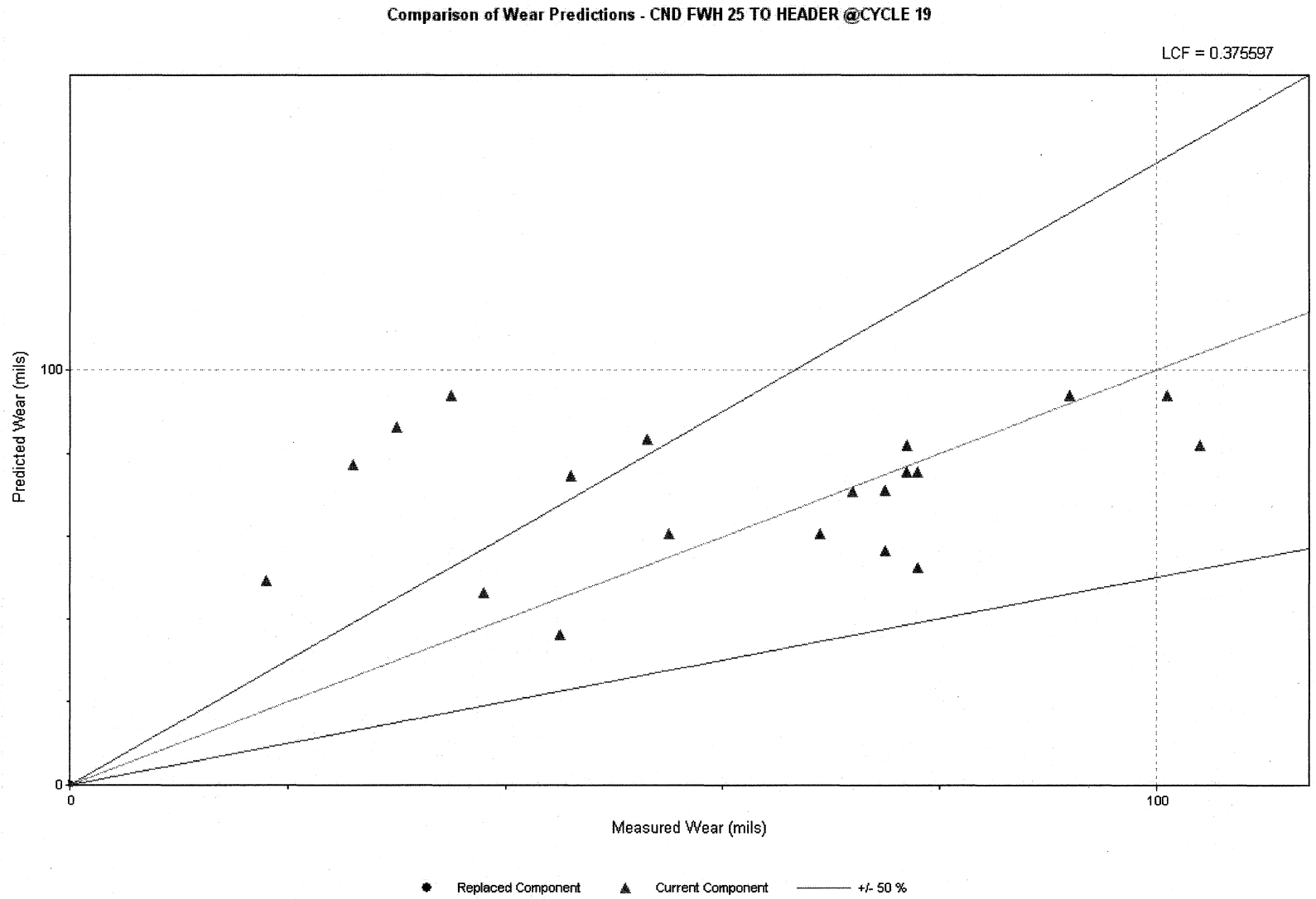
Plot J.10: CND FWH 23 TO FWH 24



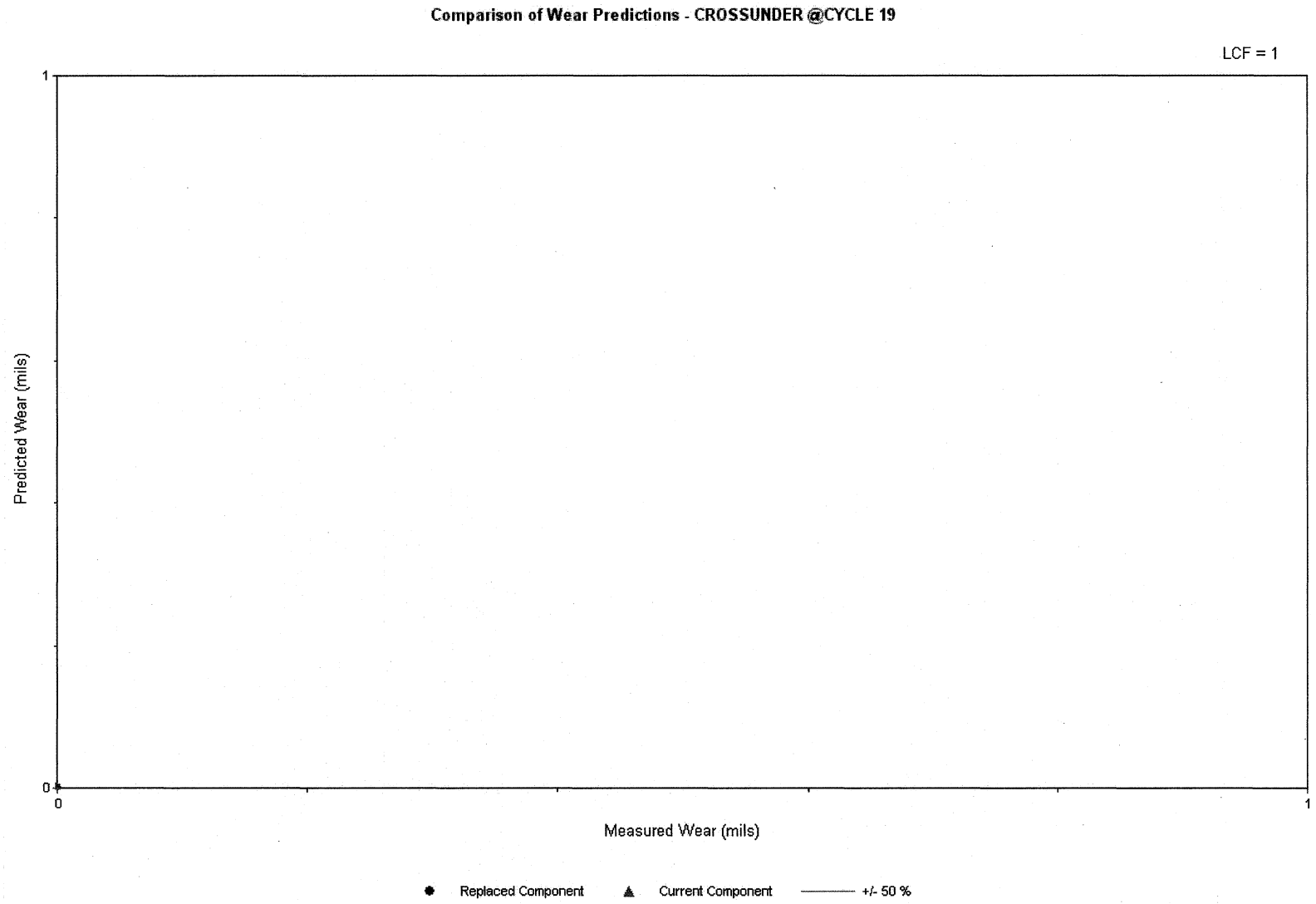
Plot J.11: CND FWH 24 TO FWH 25



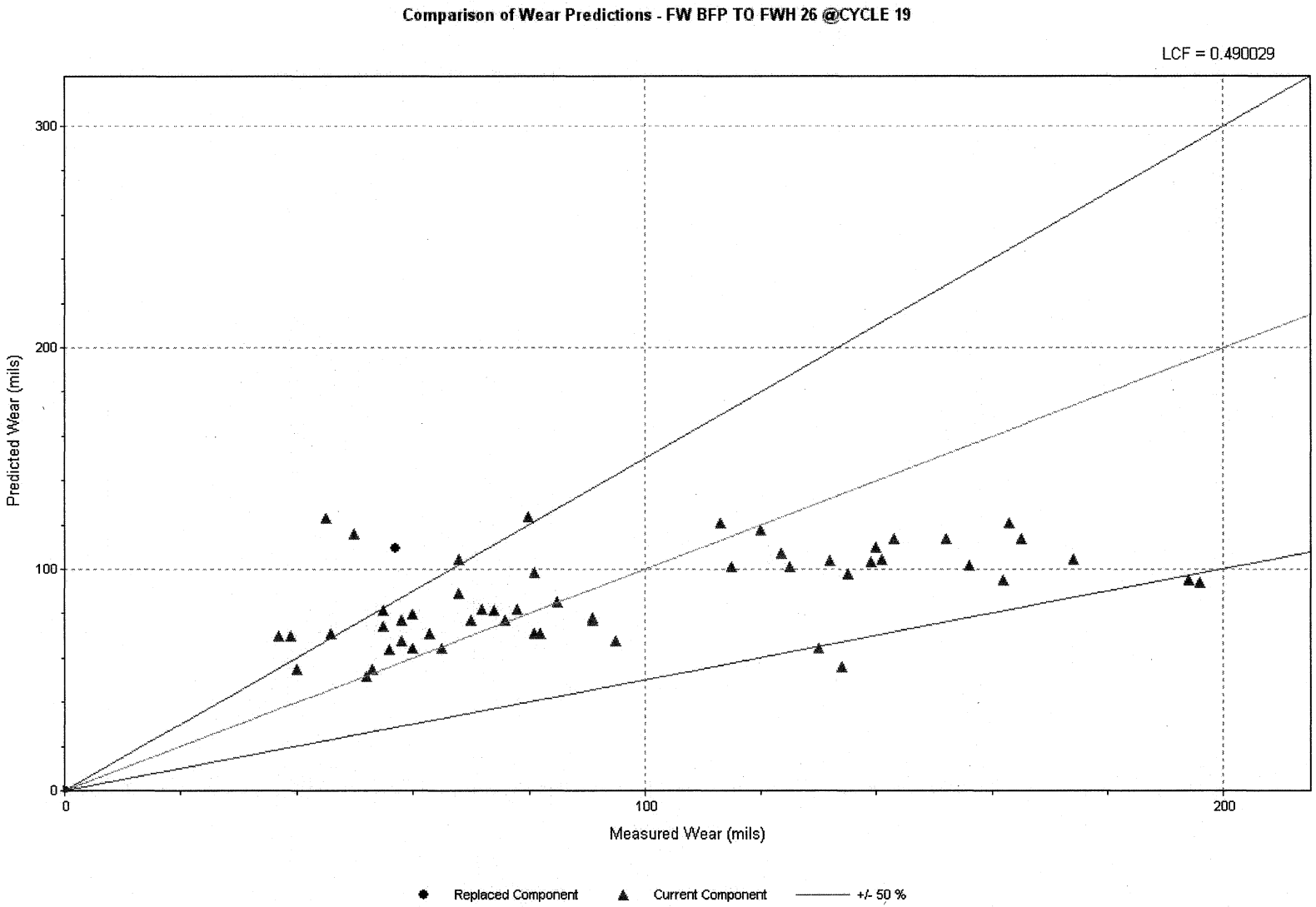
Plot J.12: CND FWH 25 TO HEADER



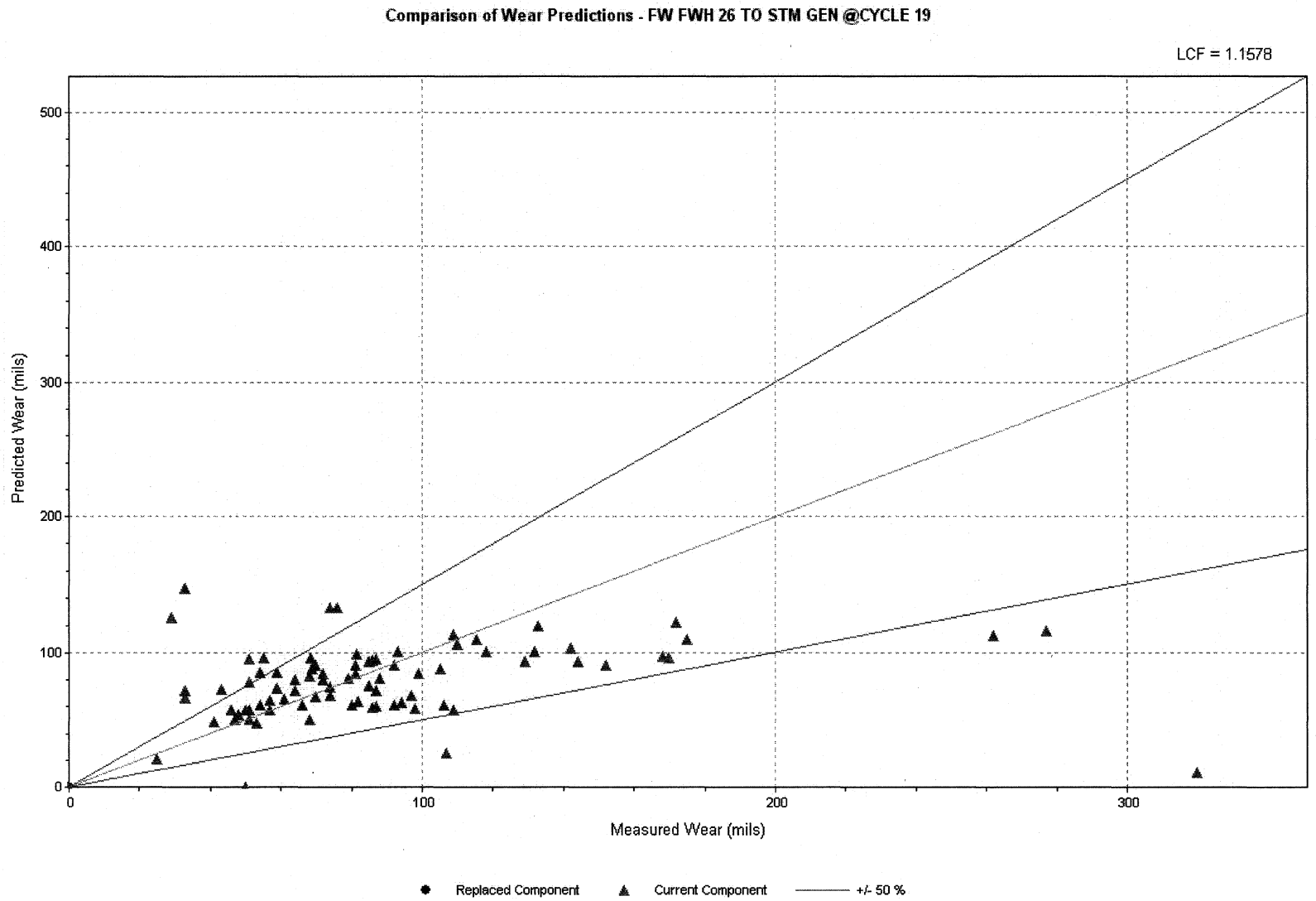
Plot J.13: CROSSUNDER



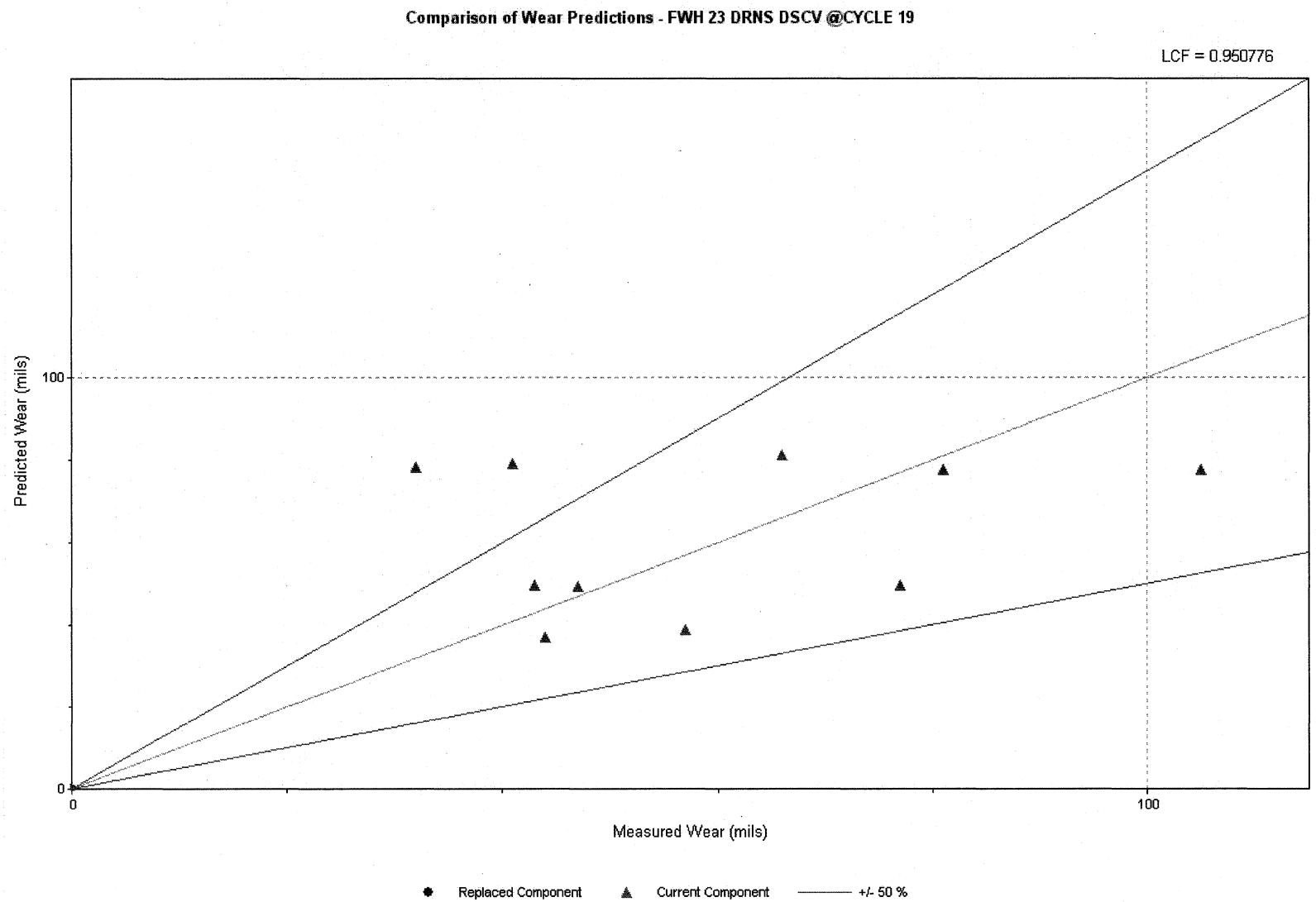
Plot J.14: FW BFP TO FWH 26



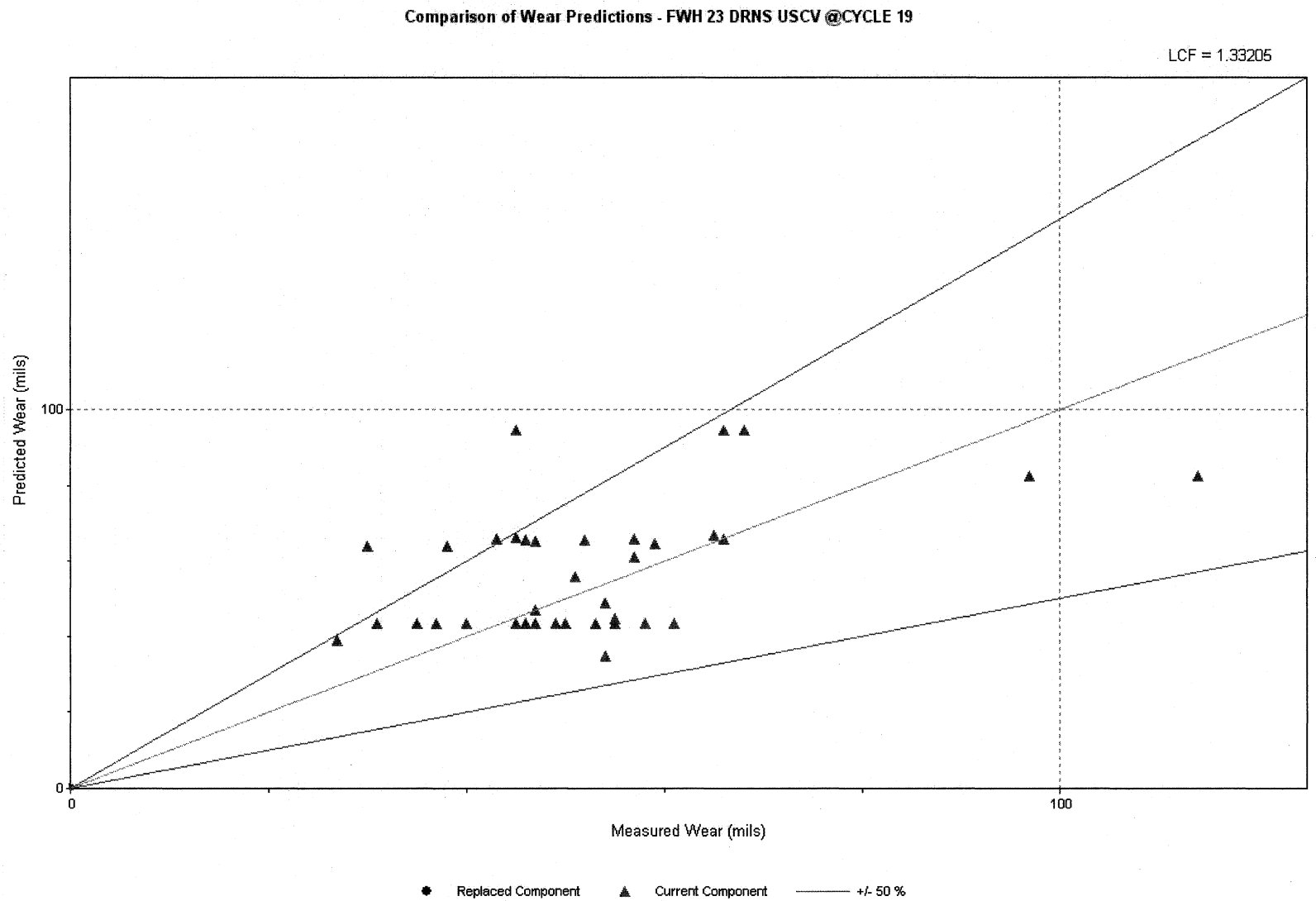
Plot J.15: FW FWH 26 TO STM GEN



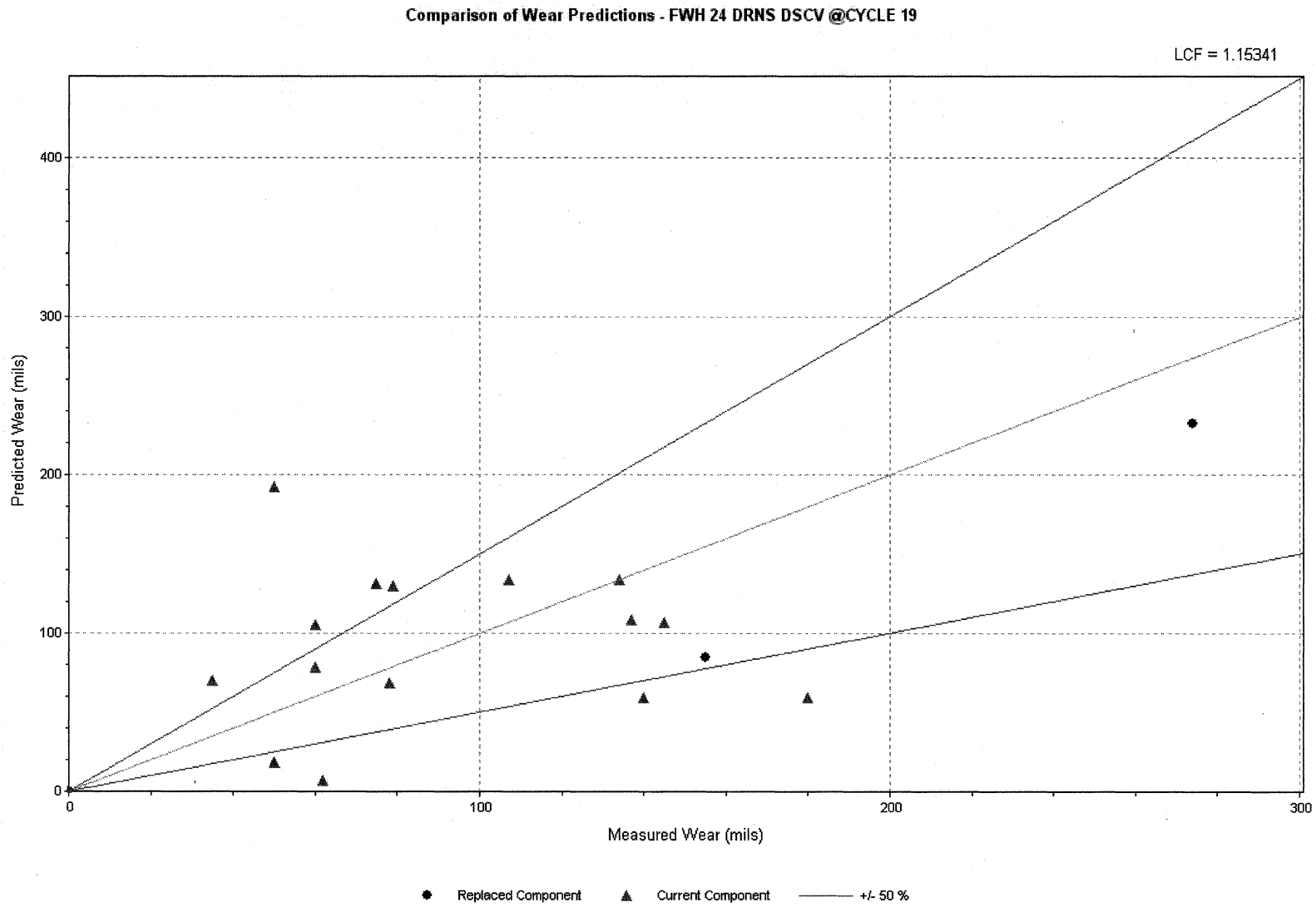
Plot J.16: FWH 23 DRNS DSCV



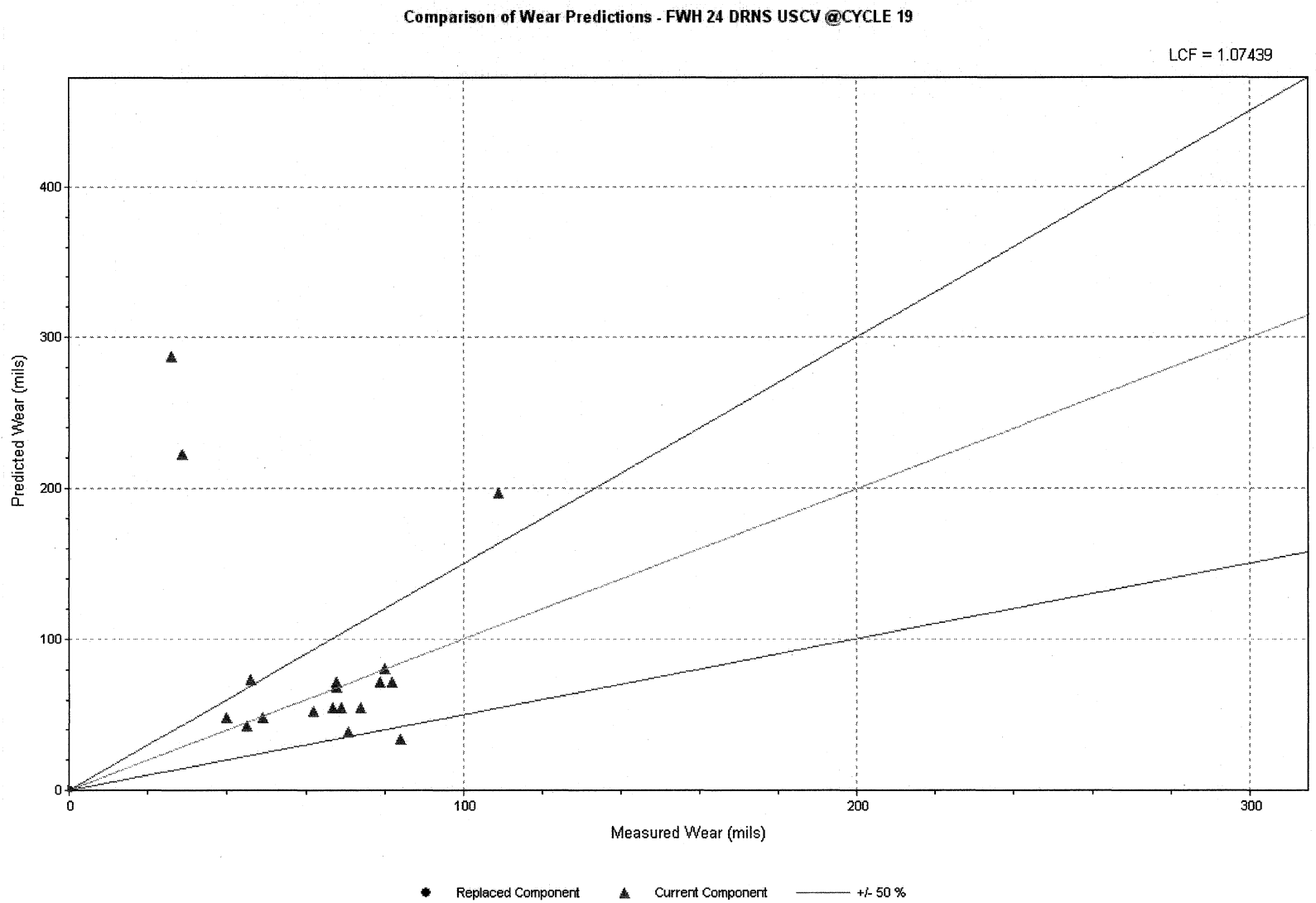
Plot J.17: FWH 23 DRNS USCV



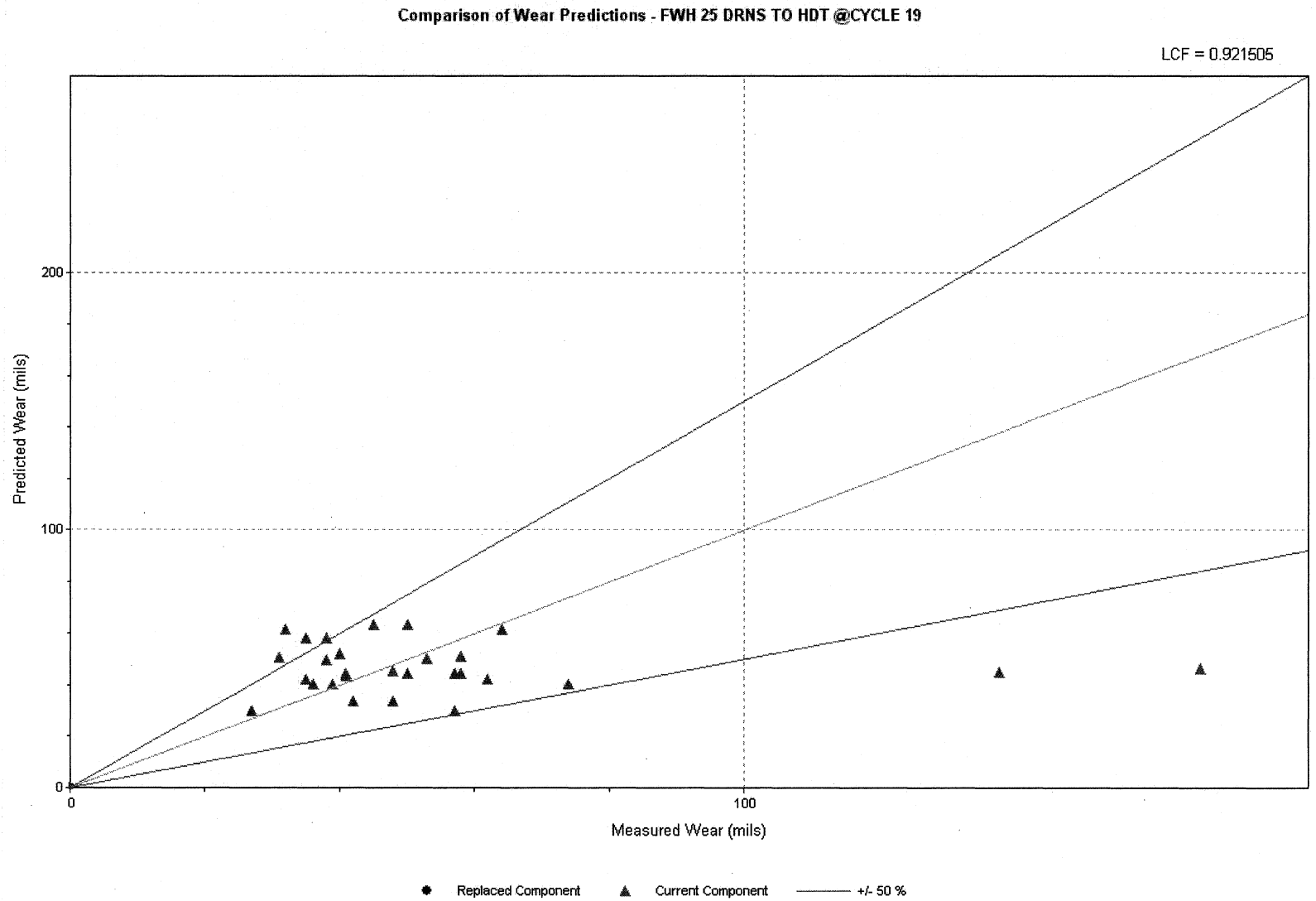
Plot J.18: FWH 24 DRNS DSCV



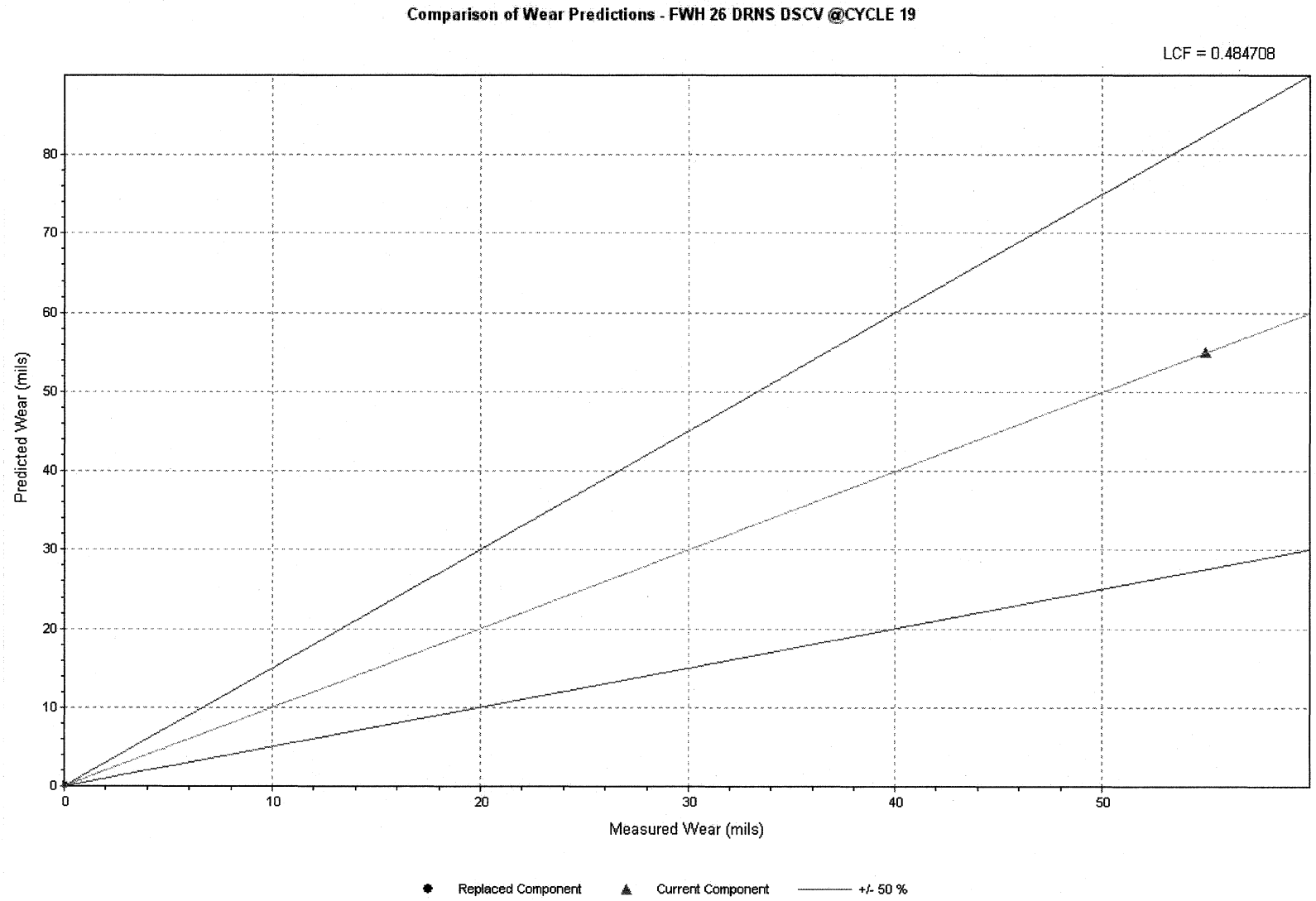
Plot J.19: FWH 24 DRNS USCV



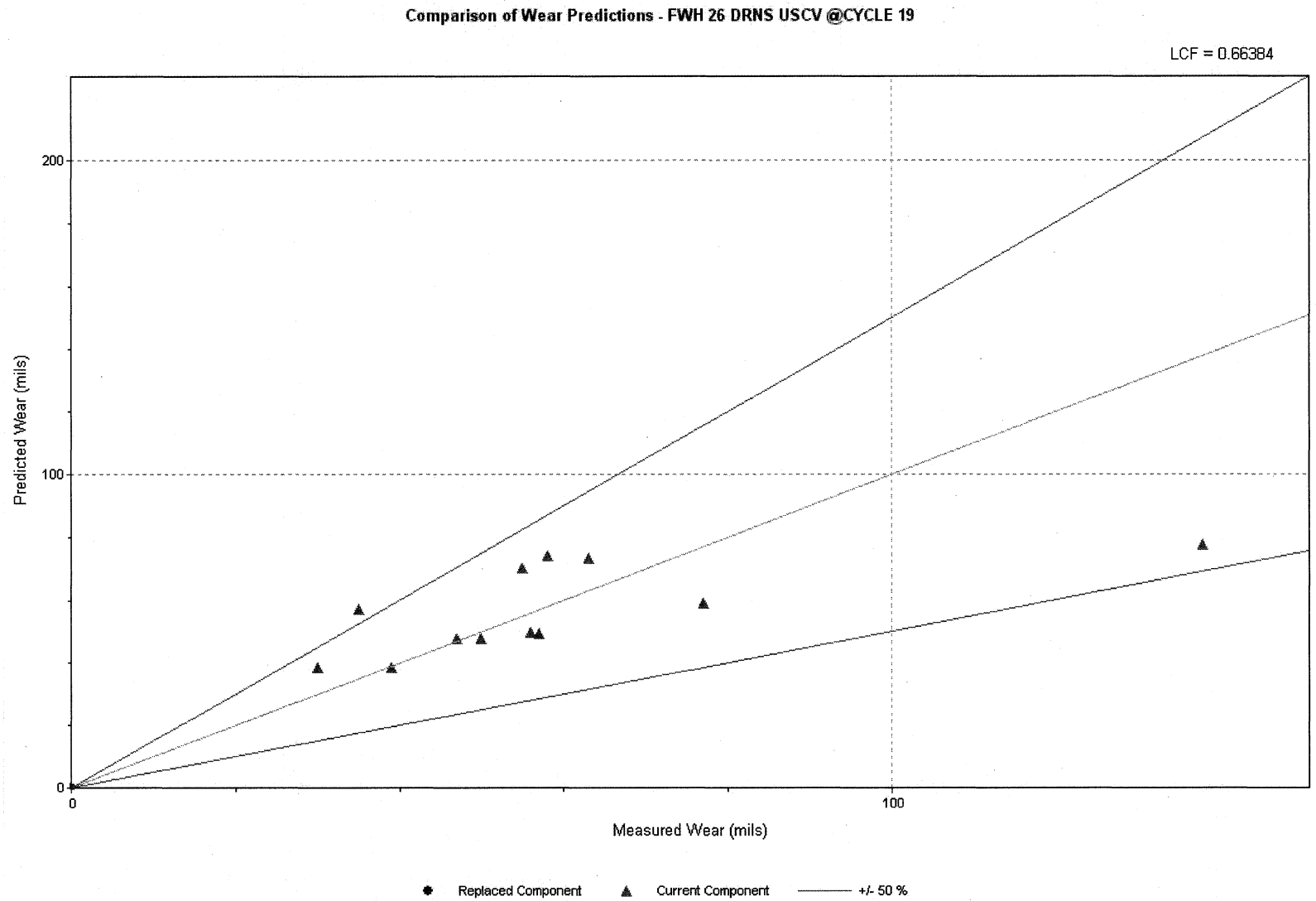
Plot J.20: FWH 25 DRNS TO HDT



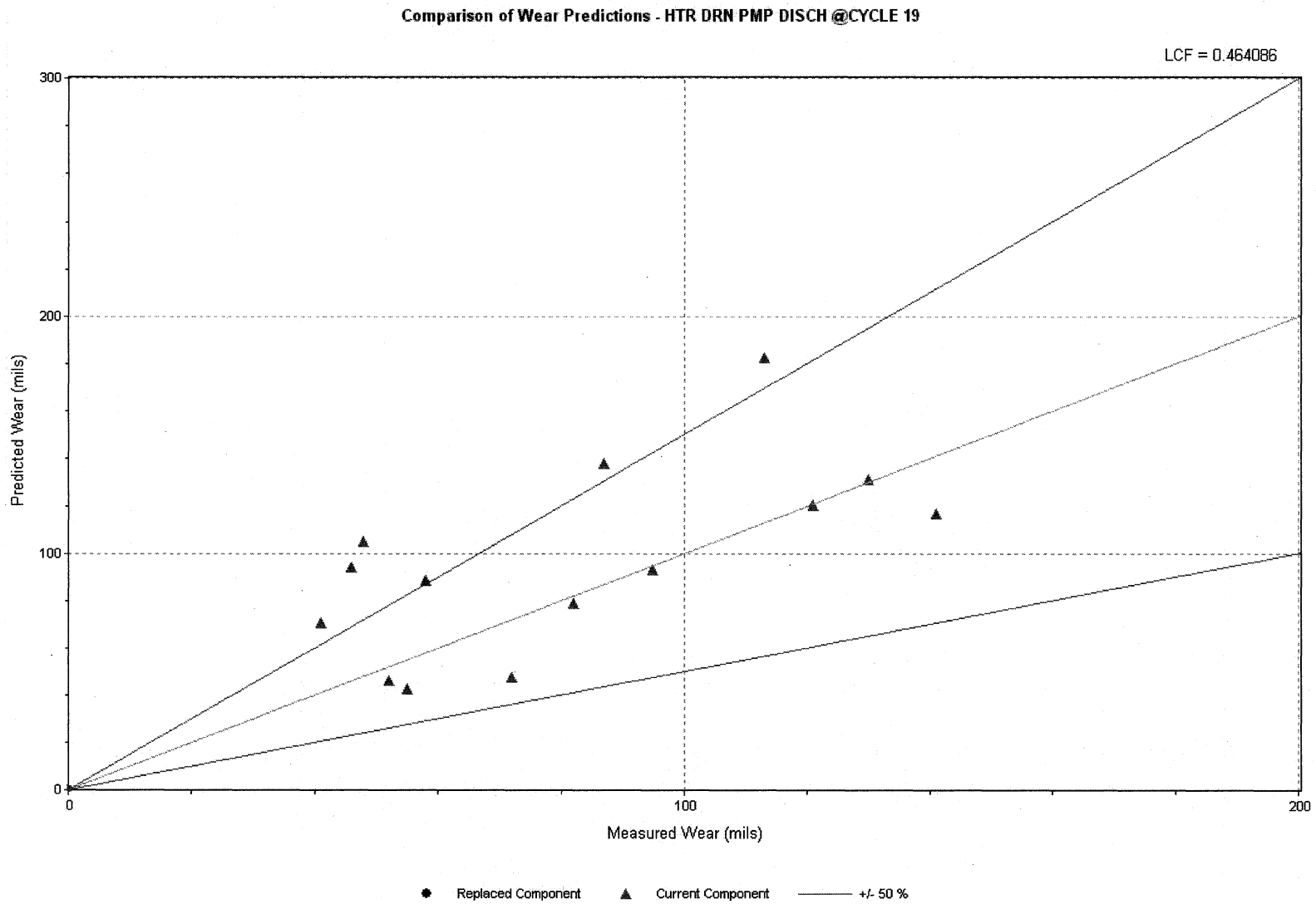
Plot J.21: FWH 26 DRNS DSCV



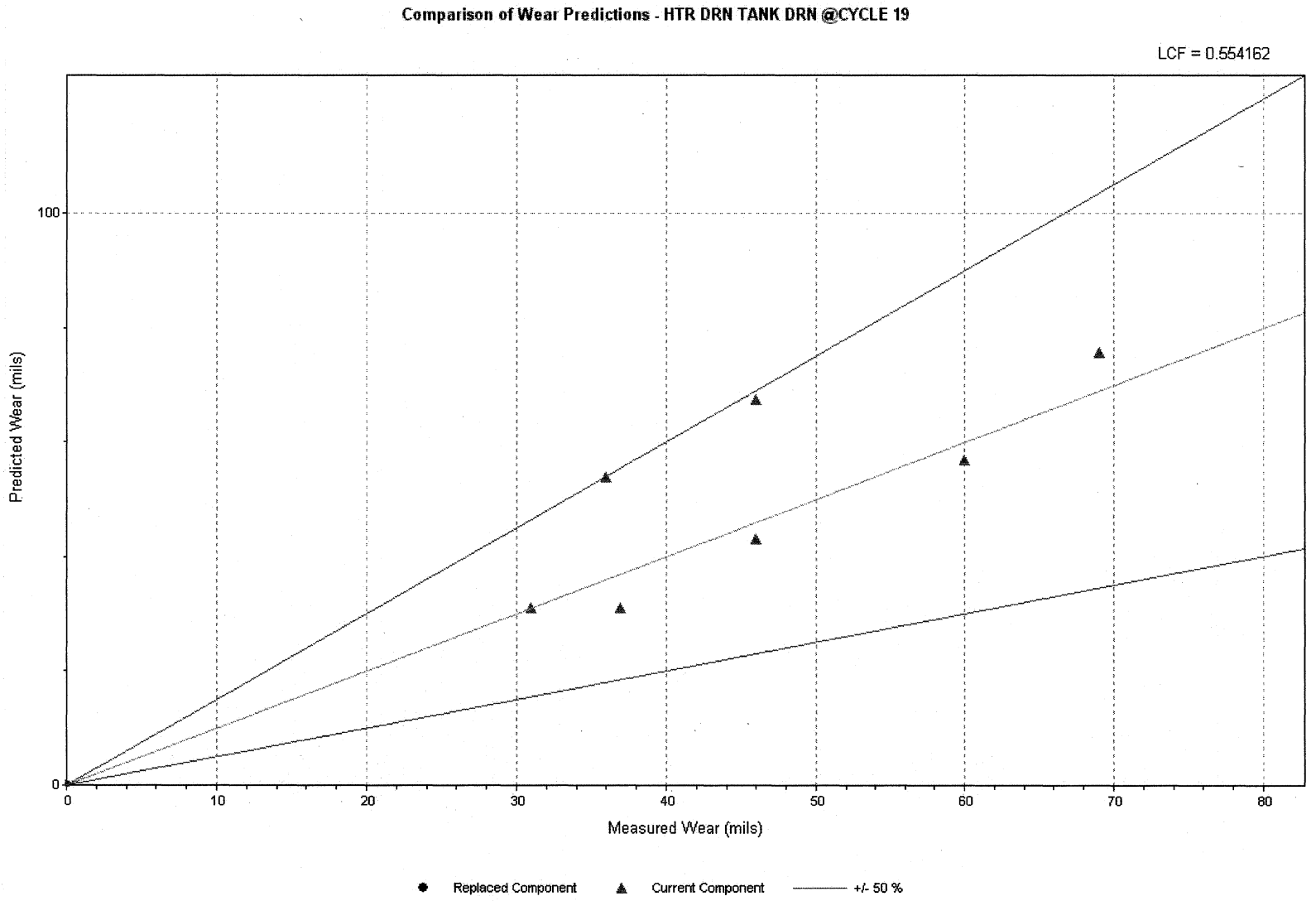
Plot J.22: FWH 26 DRNS USCV



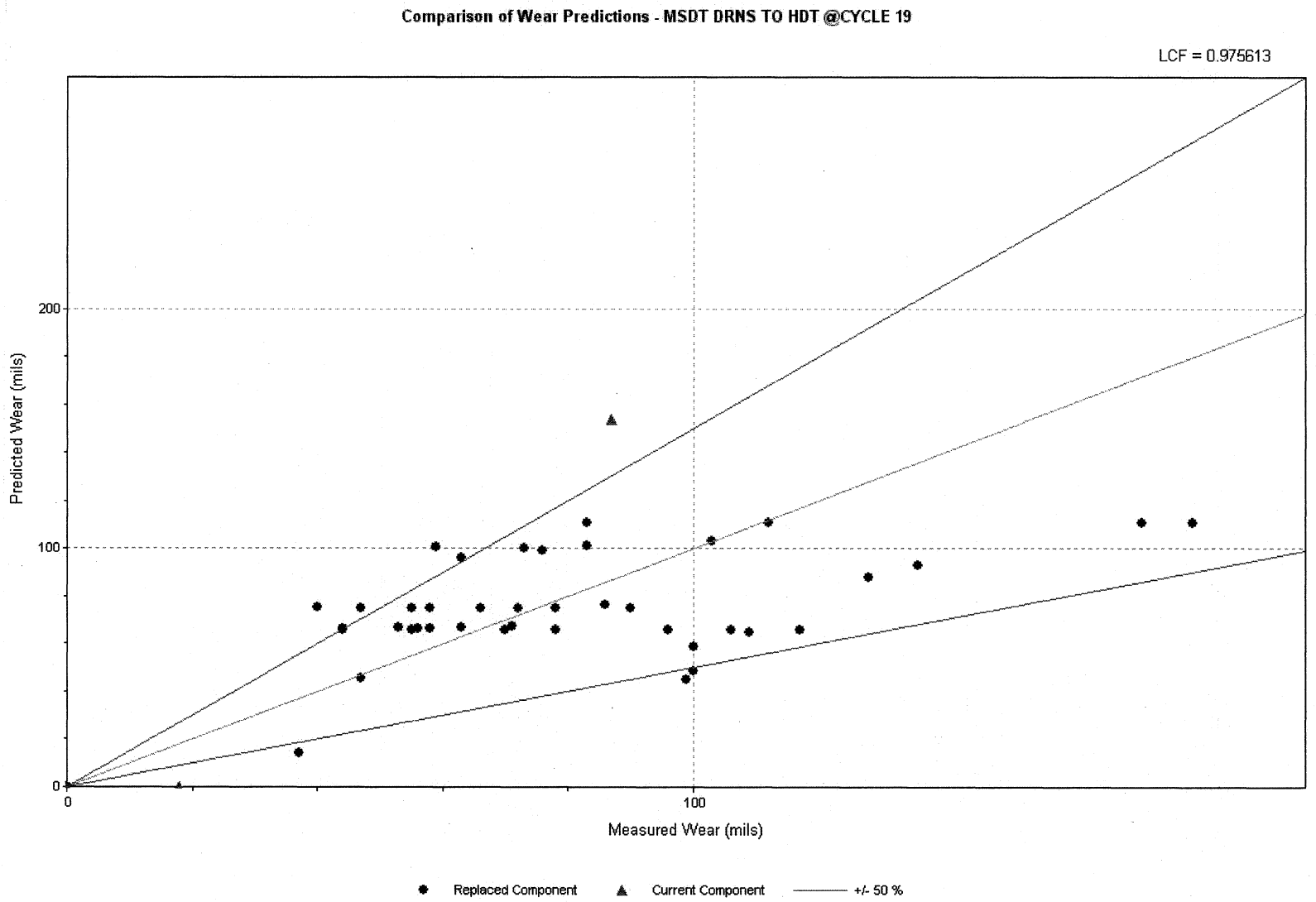
Plot J.23: HTR DRN PMP DISCH



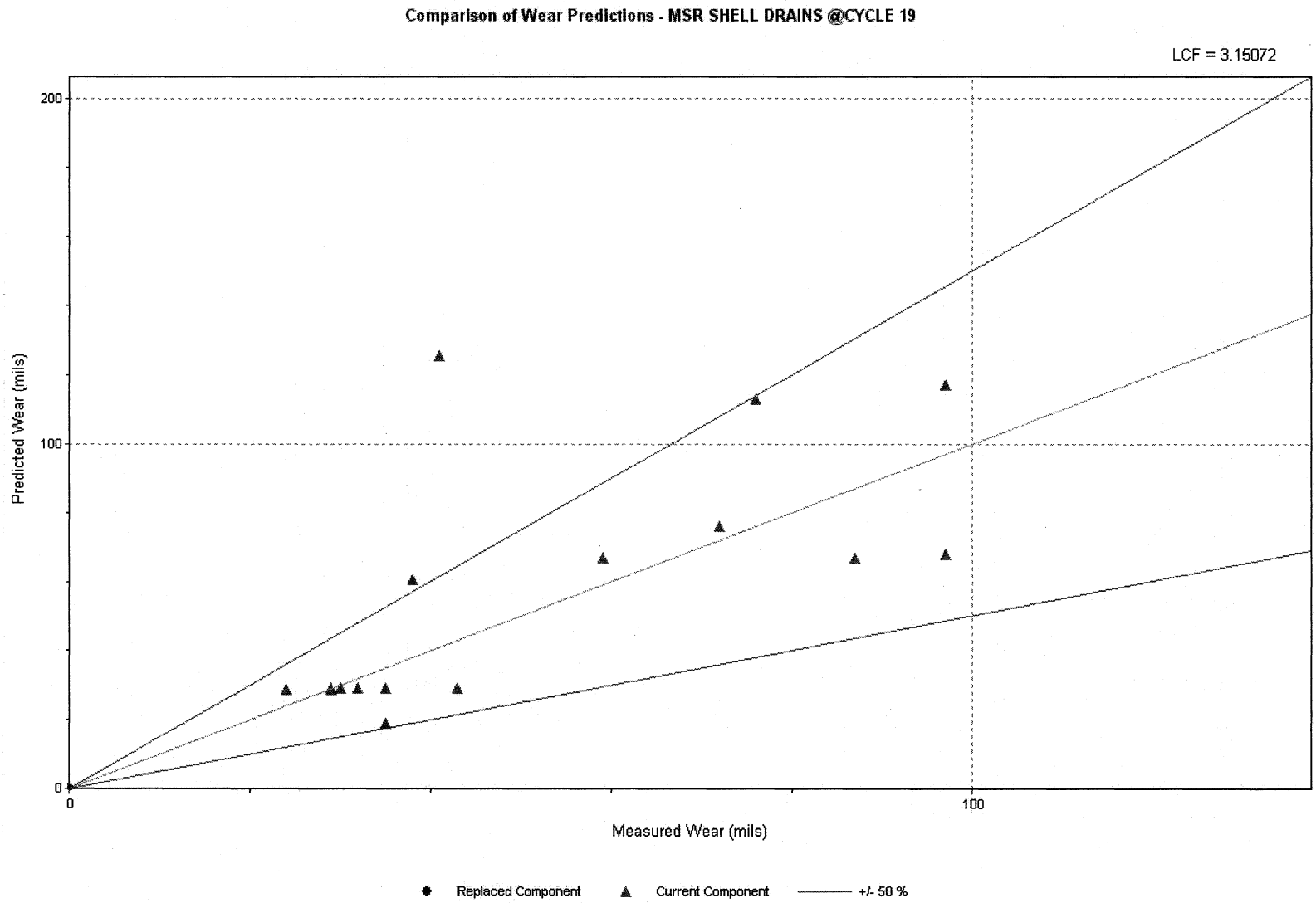
Plot J.24: HTR DRN TANK DRN



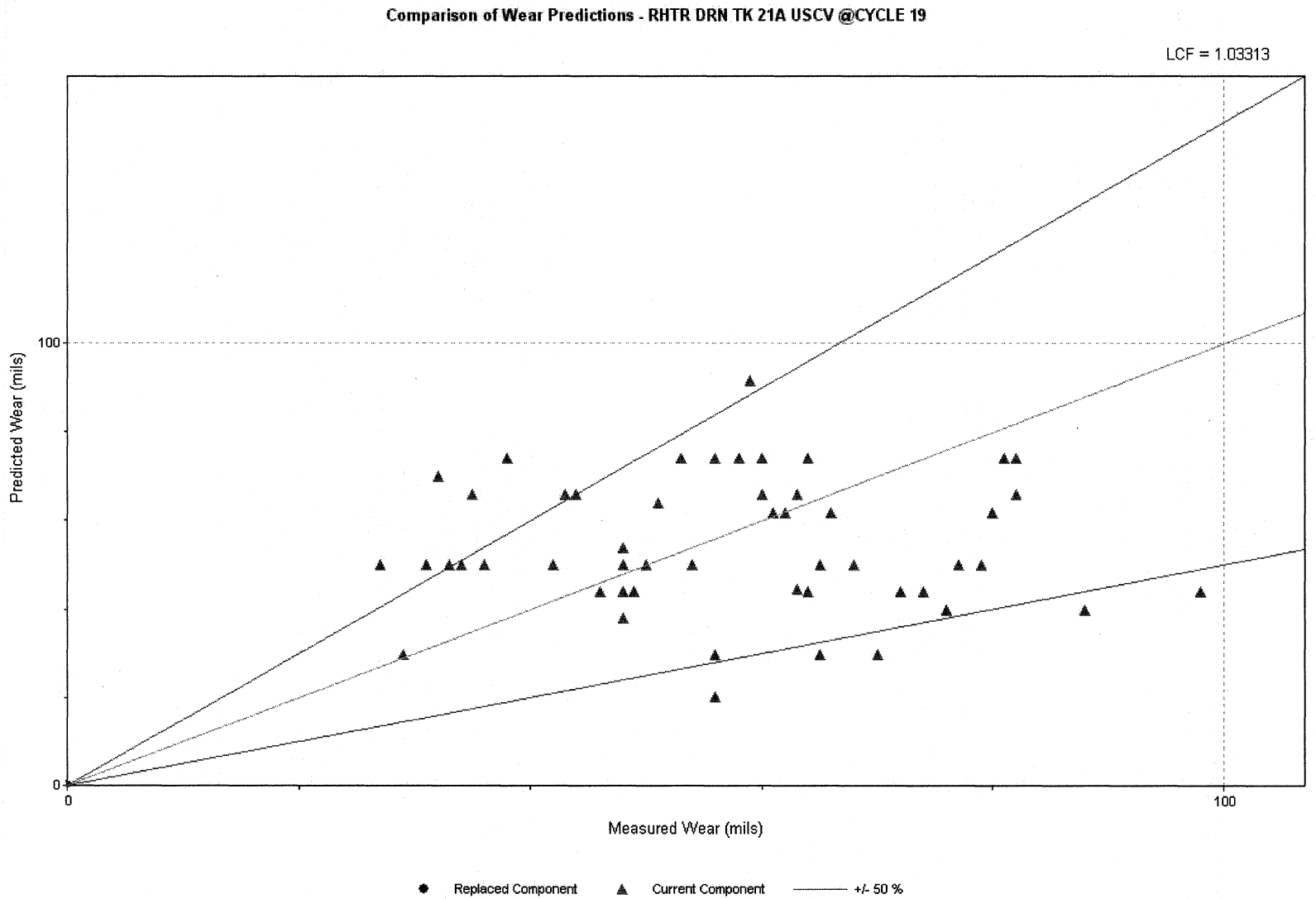
Plot J.25: MSDT DRNS TO HDT



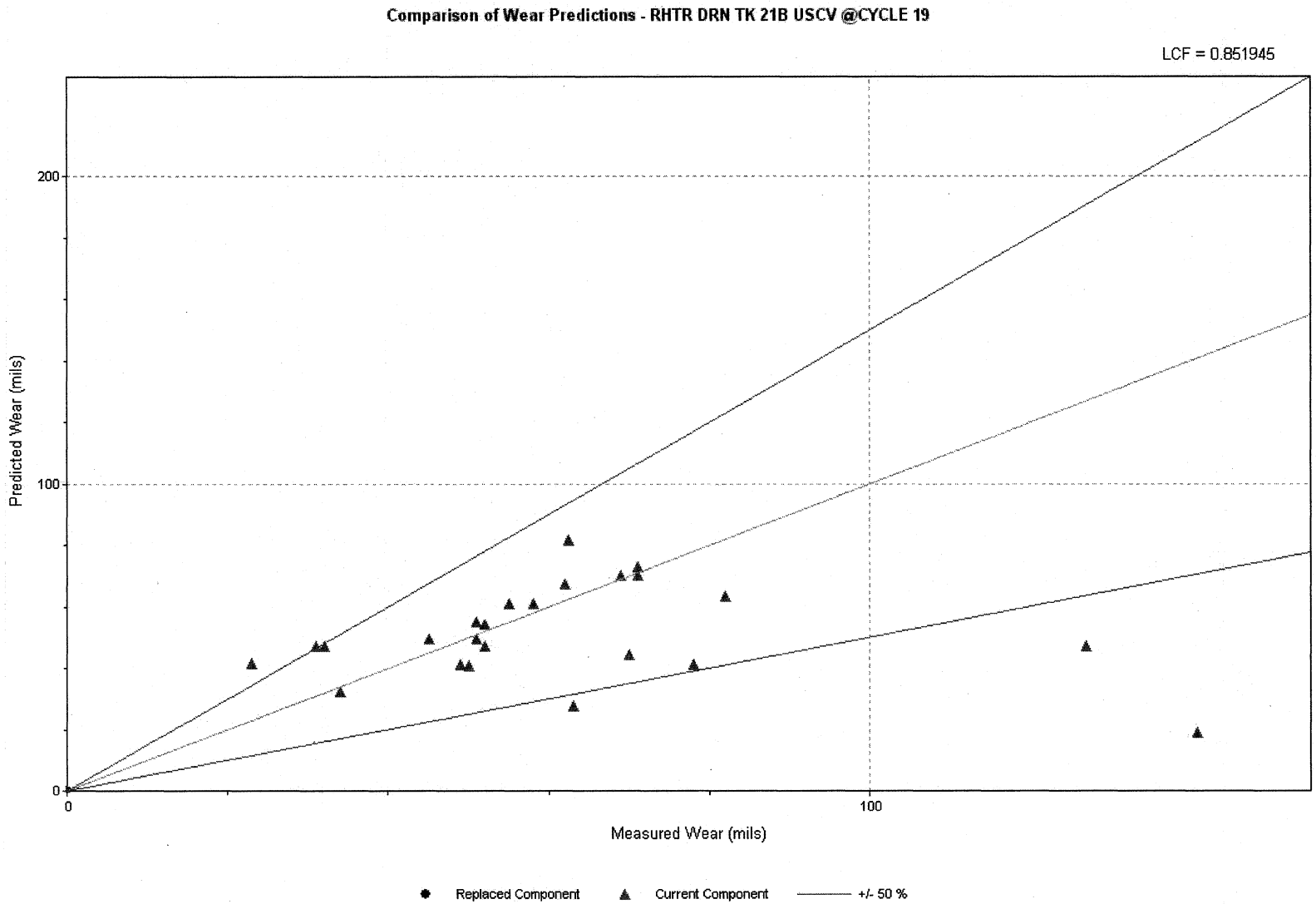
Plot J.26: MSR SHELL DRAINS



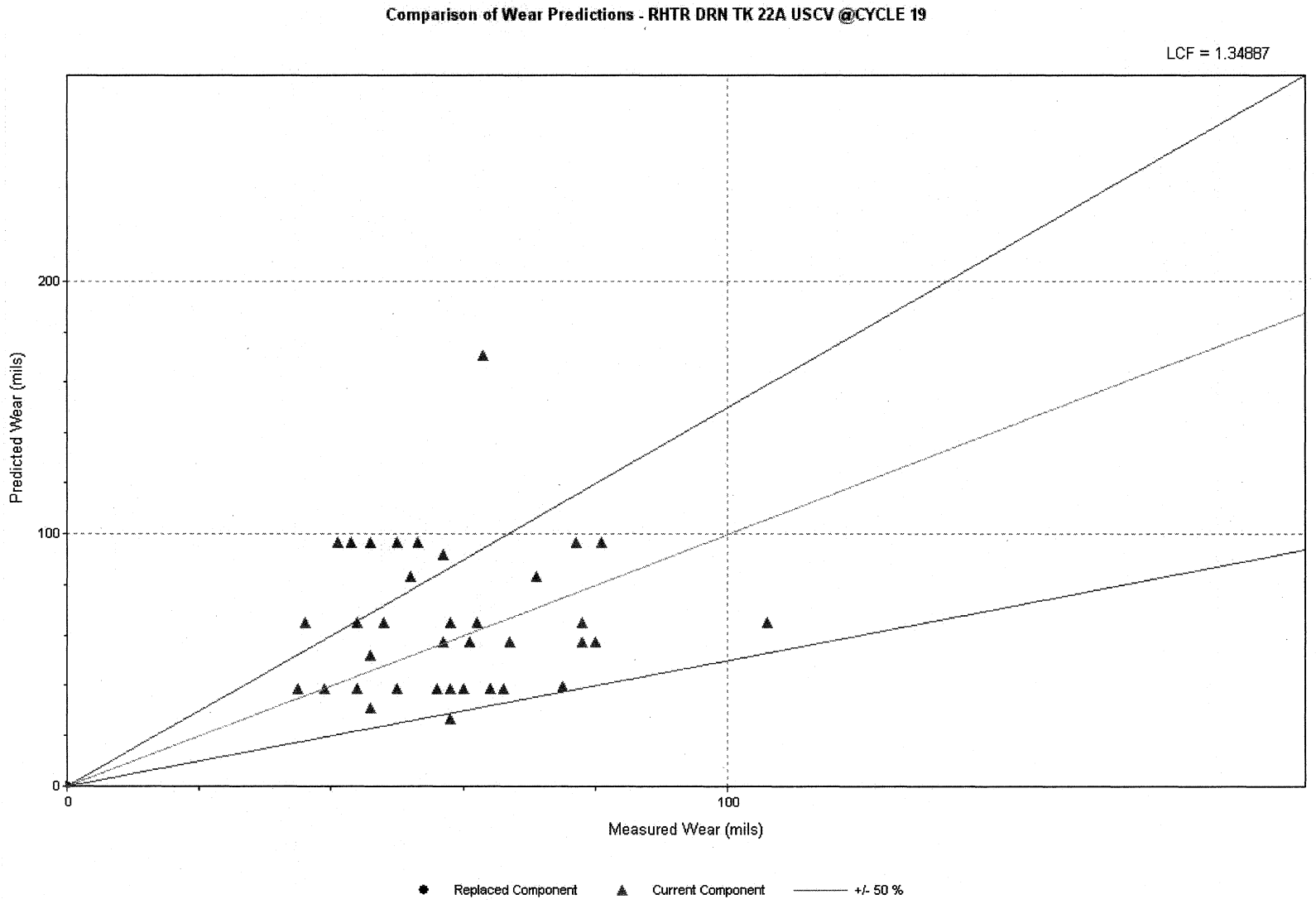
Plot J.27: RHTR DRN TK 21A USCV



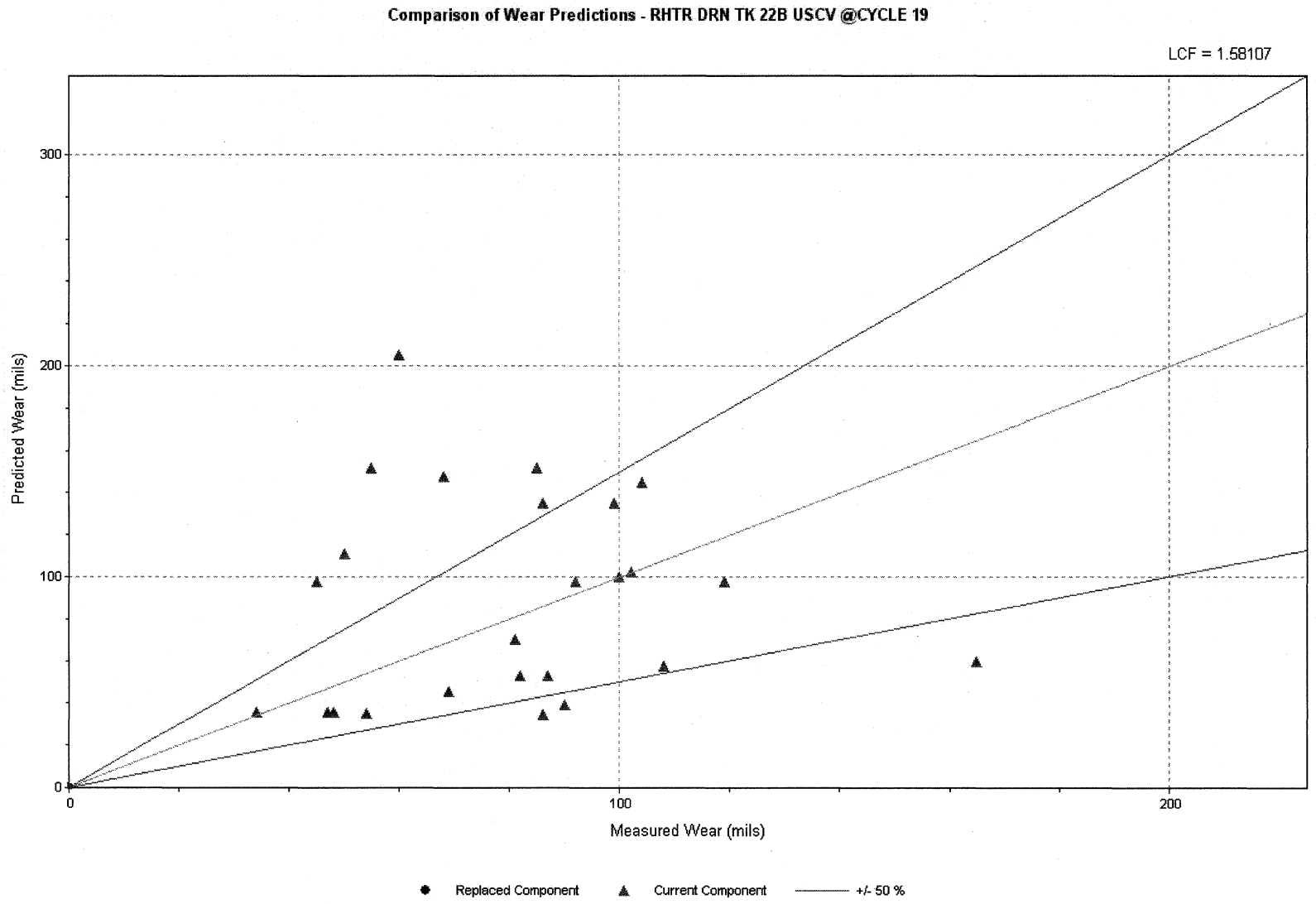
Plot J.28: RHTR DRN TK 21B USCV



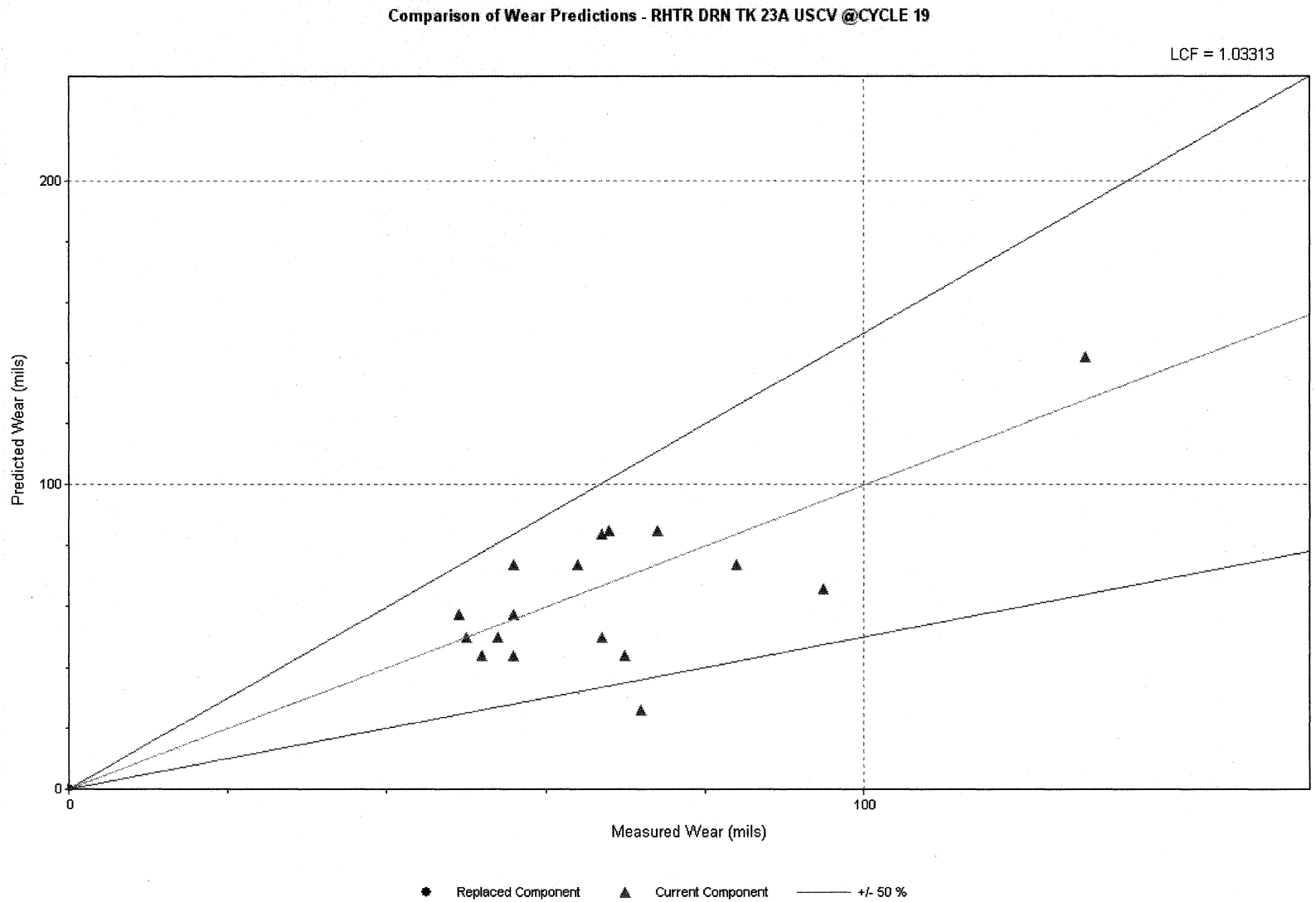
Plot J.29: RHTR DRN TK 22A USCV



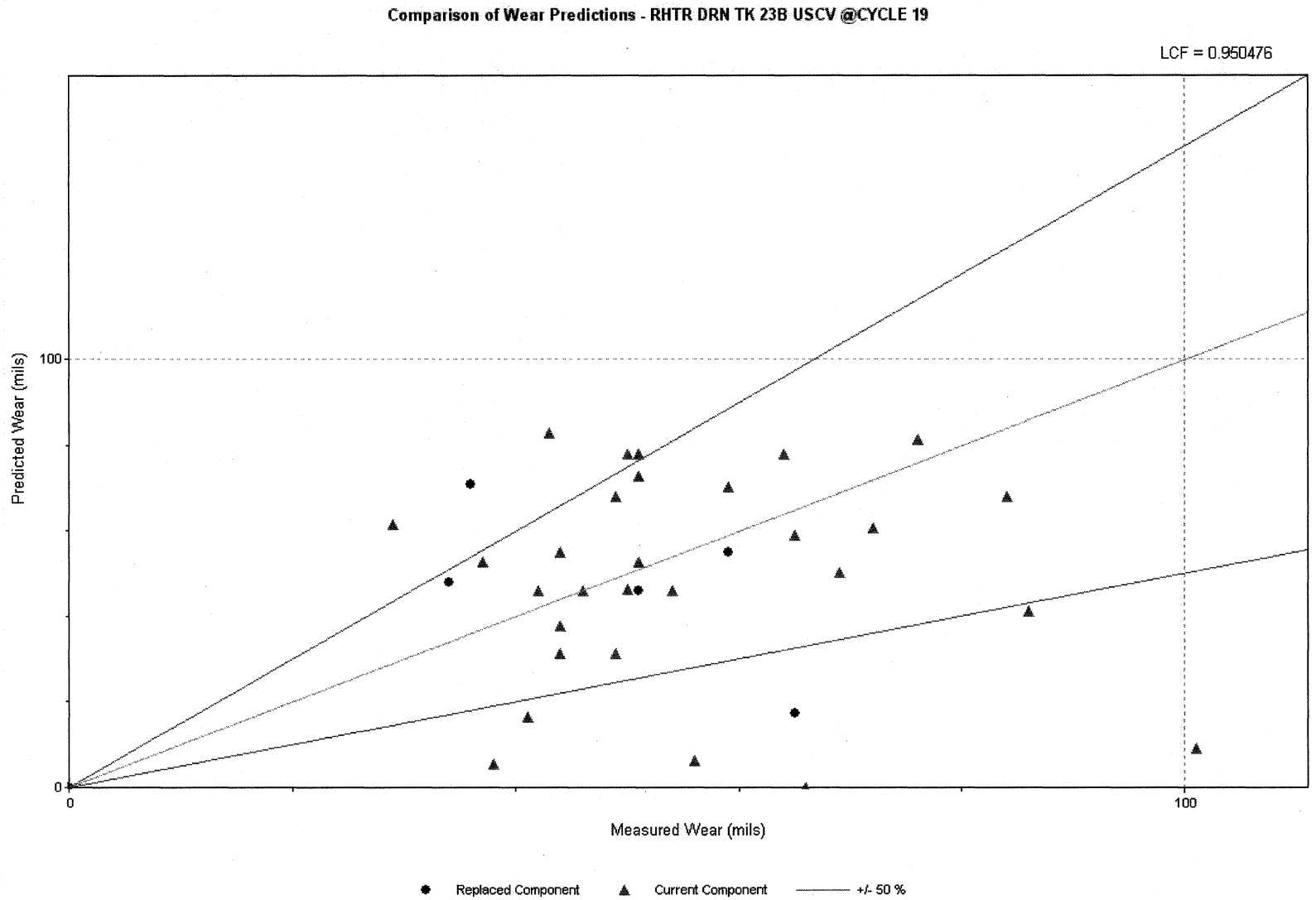
Plot J.30: RHTR DRN TK 22B USCV



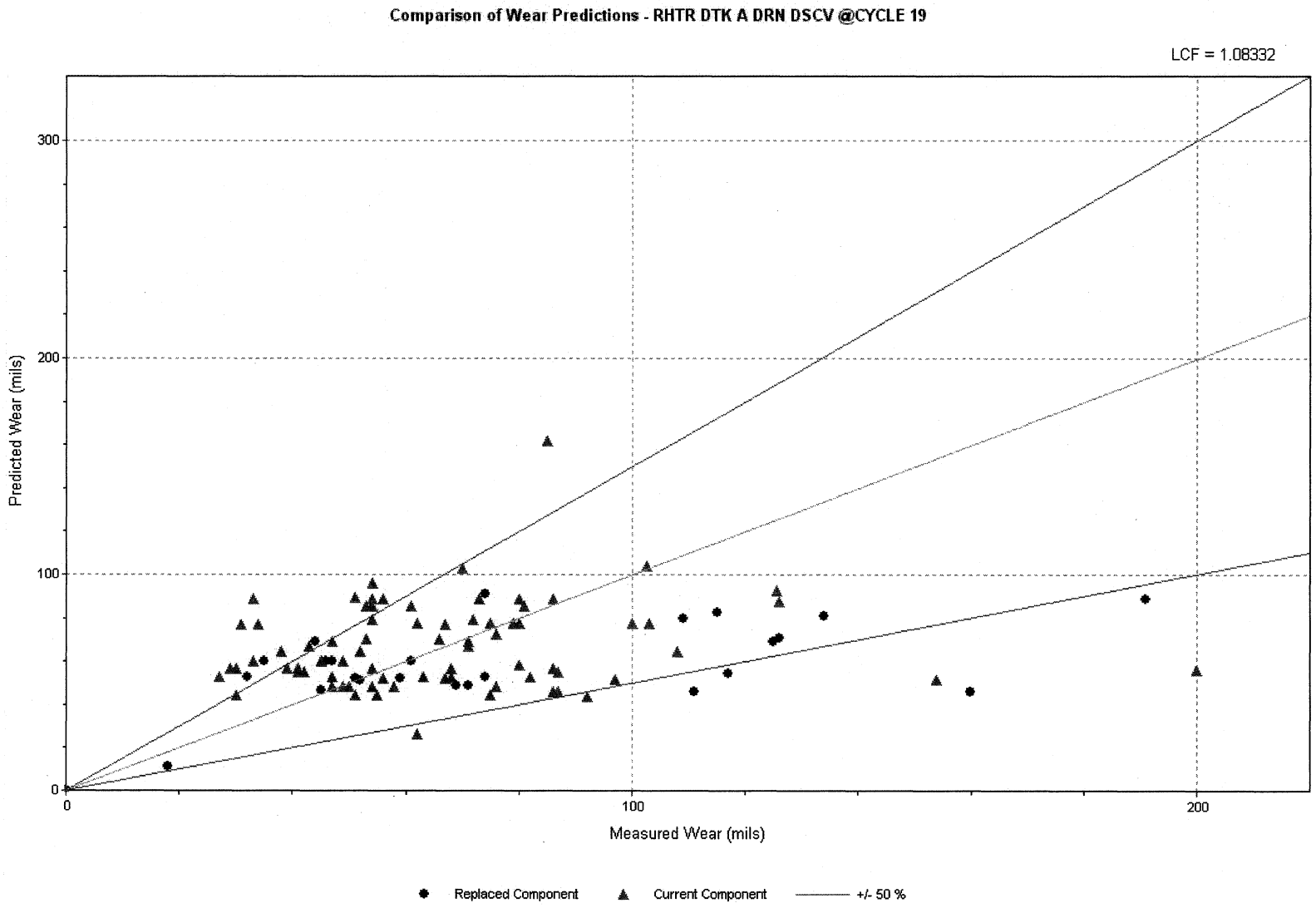
Plot J.31: RHTR DRN TK 23A USCV



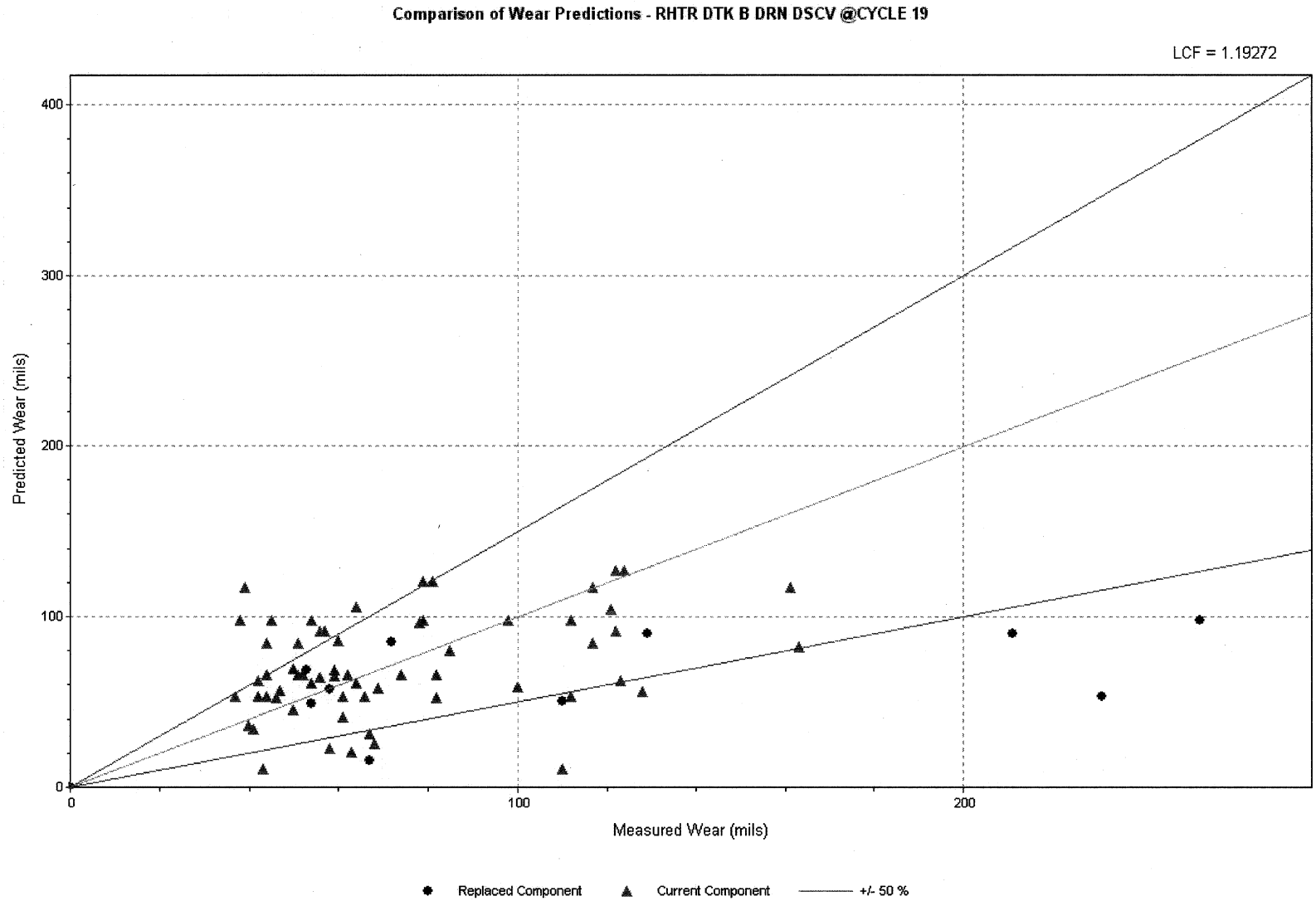
Plot J.32: RHTR DRN TK 23B USCV



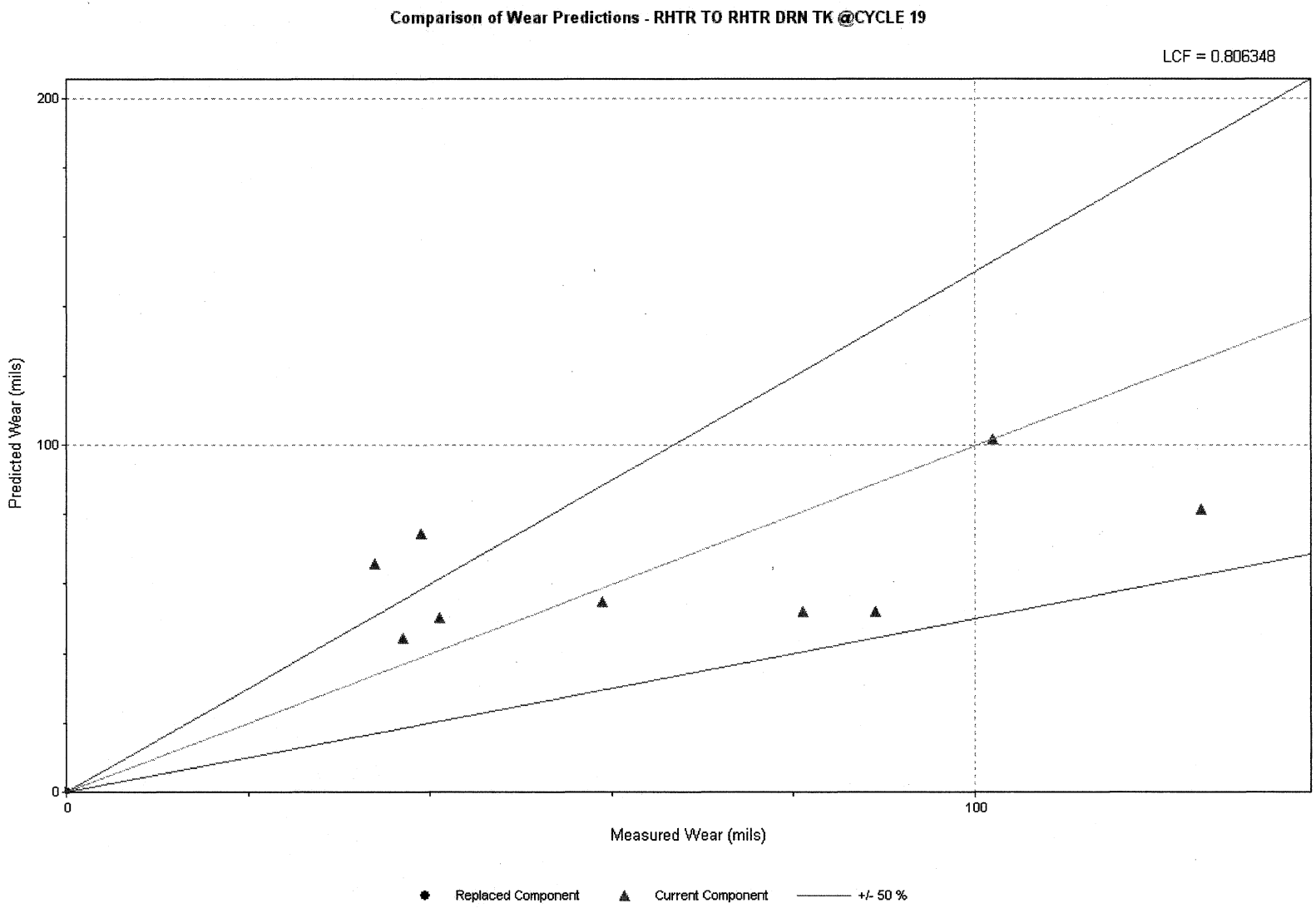
Plot J.33: RHTR DTK A DRN DSCV



Plot J.34: RHTR DTK B DRN DSCV



Plot J.35: RHTR TO RHTR DRN TK



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CHECWORKS SFA Model

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Elgin, IL 60120

1. Introduction

Flow-Accelerated Corrosion (FAC) is a form of material degradation that results in thinning of the inside pipe wall in carbon steel piping and fittings under certain flow and chemistry conditions. Undetected FAC-induced wall thinning may cause a pipe to leak or rupture, potentially causing injury to plant personnel and/or plant shutdown. For these reasons, and in response to regulatory requirements, Indian Point 2 Nuclear Power Plant (IP2) has developed and implemented a program to monitor and mitigate FAC-induced wall thinning in high energy, large-bore piping systems [7.1].

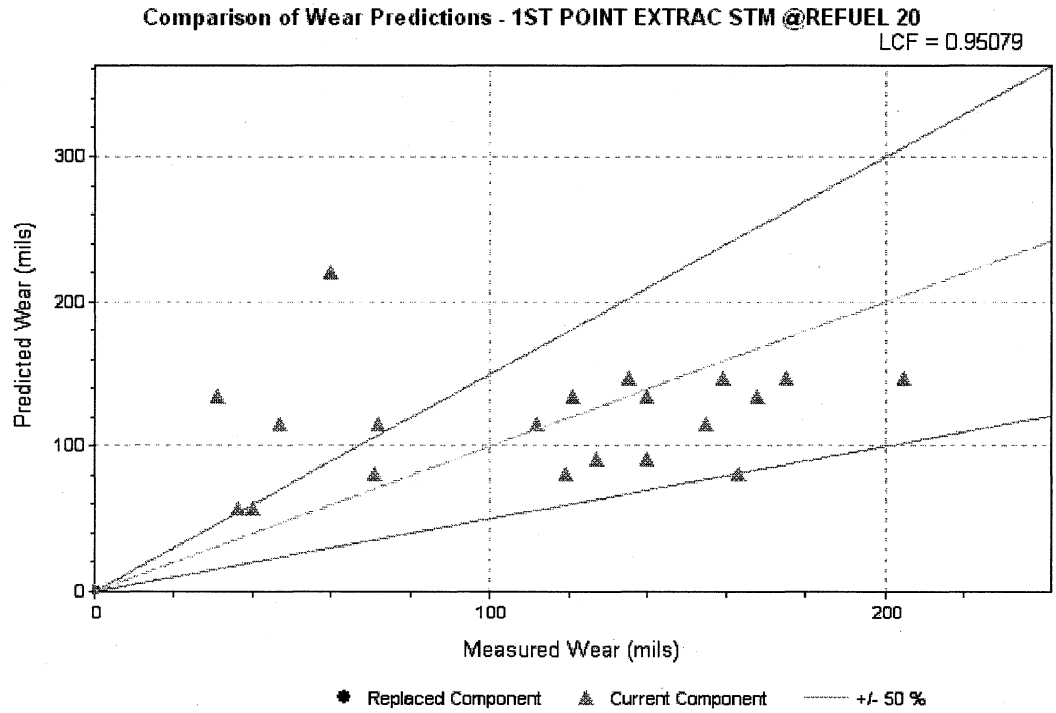
This calculation uses plant design and operation information to document the CHECWORKS model for IP2. It documents the CHECWORKS Pass 1 analysis to generate a wear rate prediction for every piping component modeled in CHECWORKS. Component inspection data through the Refuel Outage 18 was imported to the model where available. A Pass 2 analysis was performed on all lines to provide wear predictions calibrated to the inspection data, as well as remaining life based upon measured wear rates for inspected components. The results of these analyses can be used to select components for inspection in order to mitigate pipe deterioration due to FAC.

This calculation replaces all previous CHECWORKS model calculations used to document the IP2 model. Previous CHECWORKS model calculations are listed in the References [7.2].

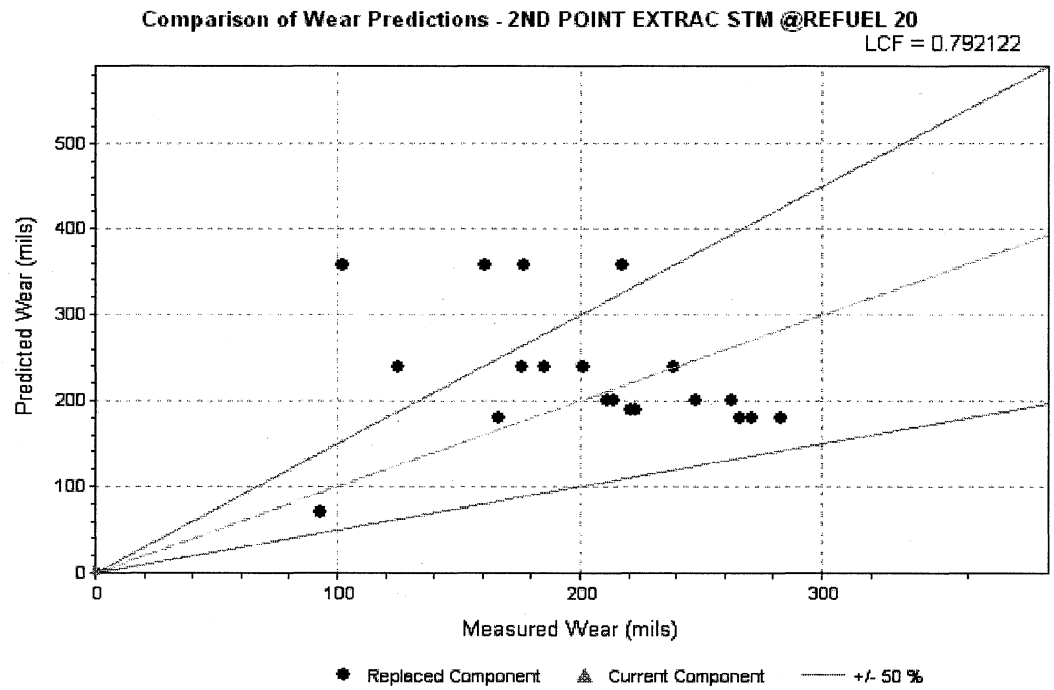
Appendix J

Wear Plots (with LCF values)

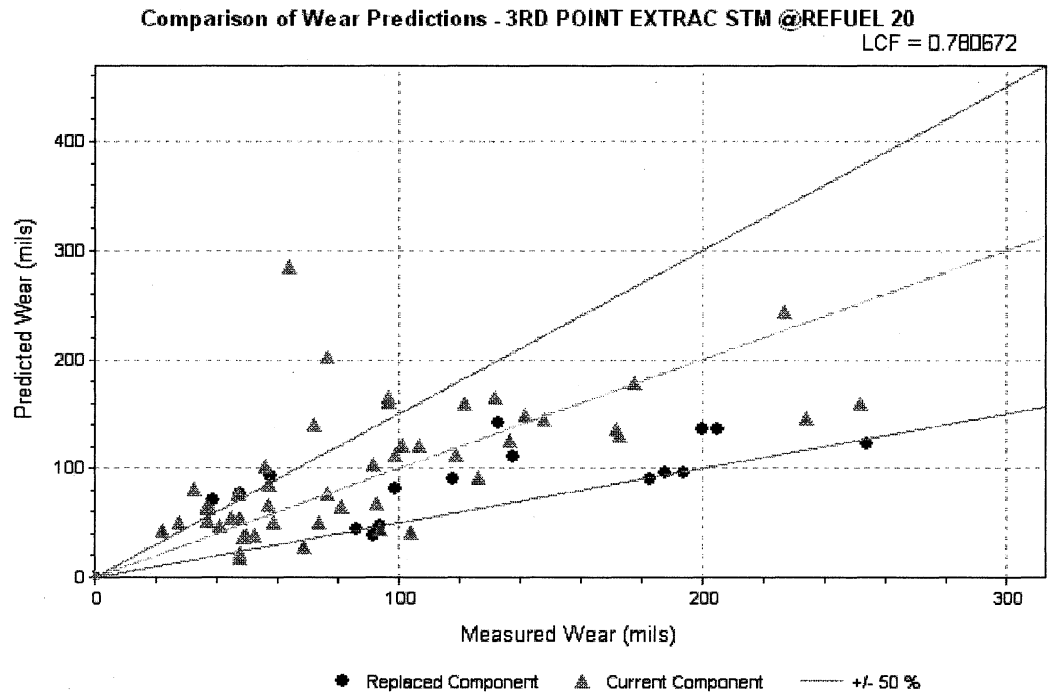
Plot J.1: 1ST POINT EXTRAC STM



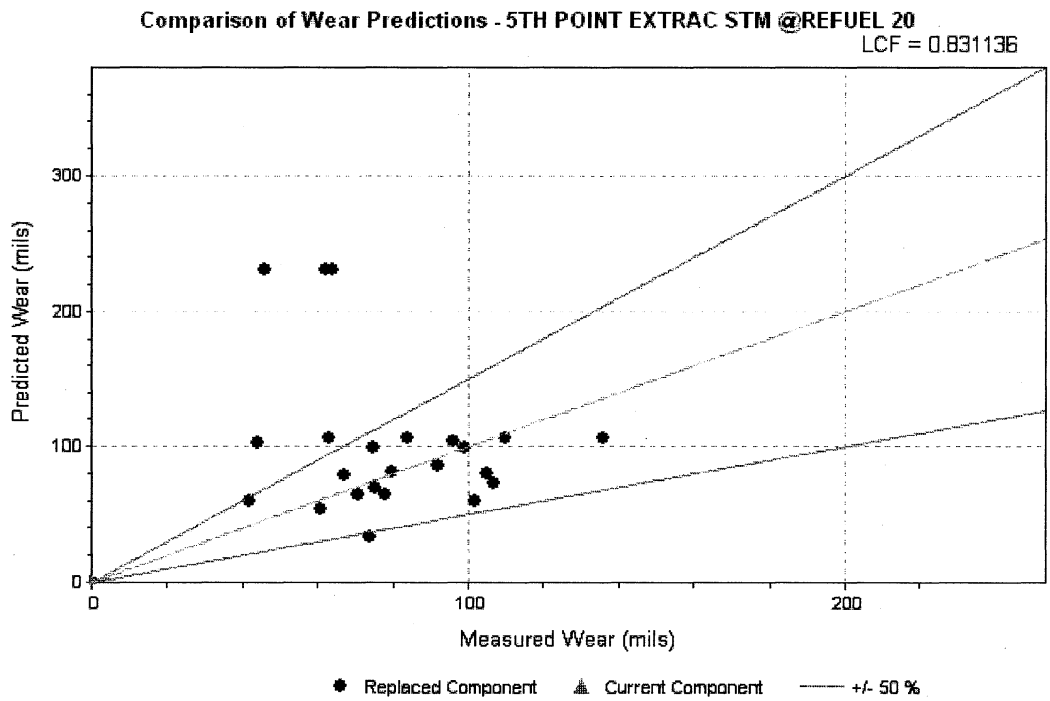
Plot J.2: 2ND POINT EXTRAC STM



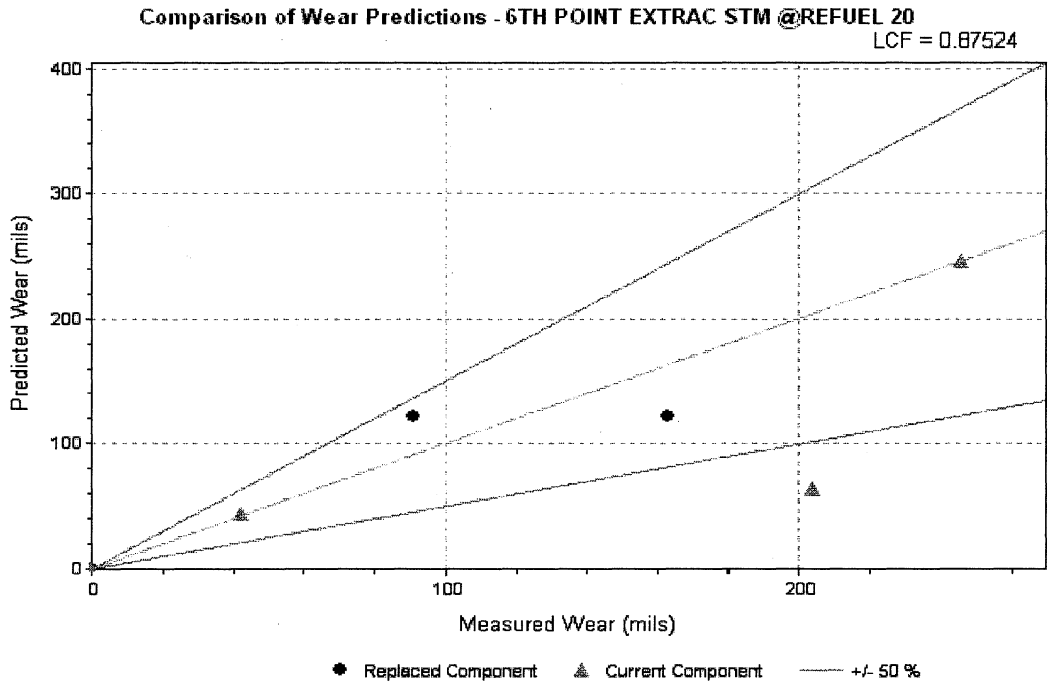
Plot J.3: 3RD POINT EXTRAC STM



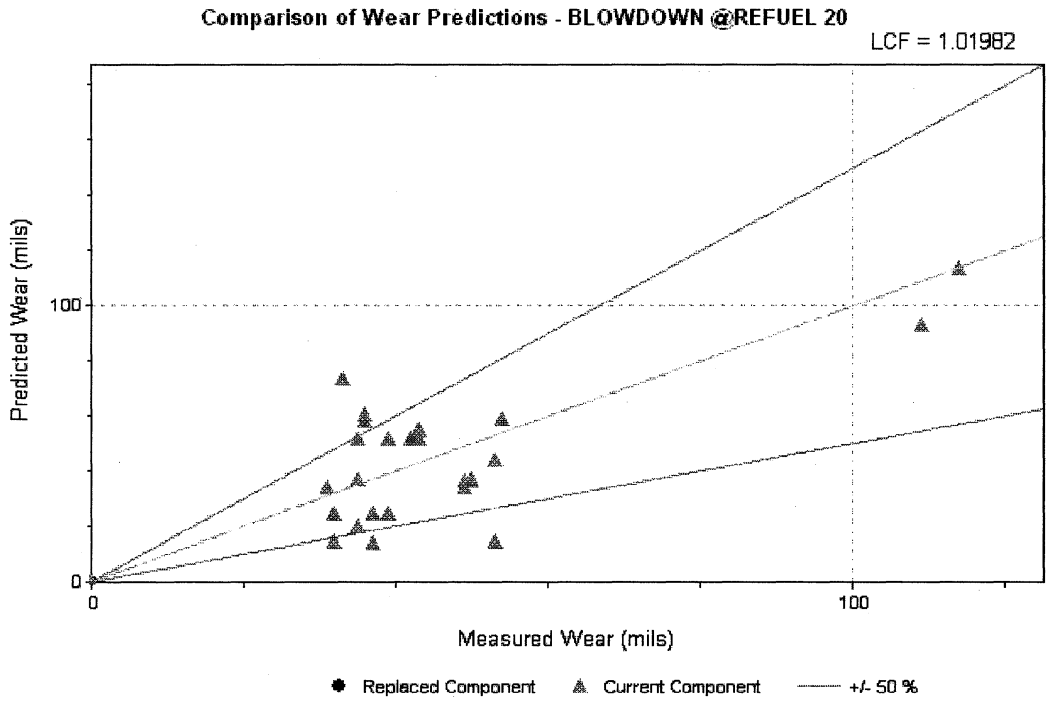
Plot J.4: 5TH POINT EXTRAC STM



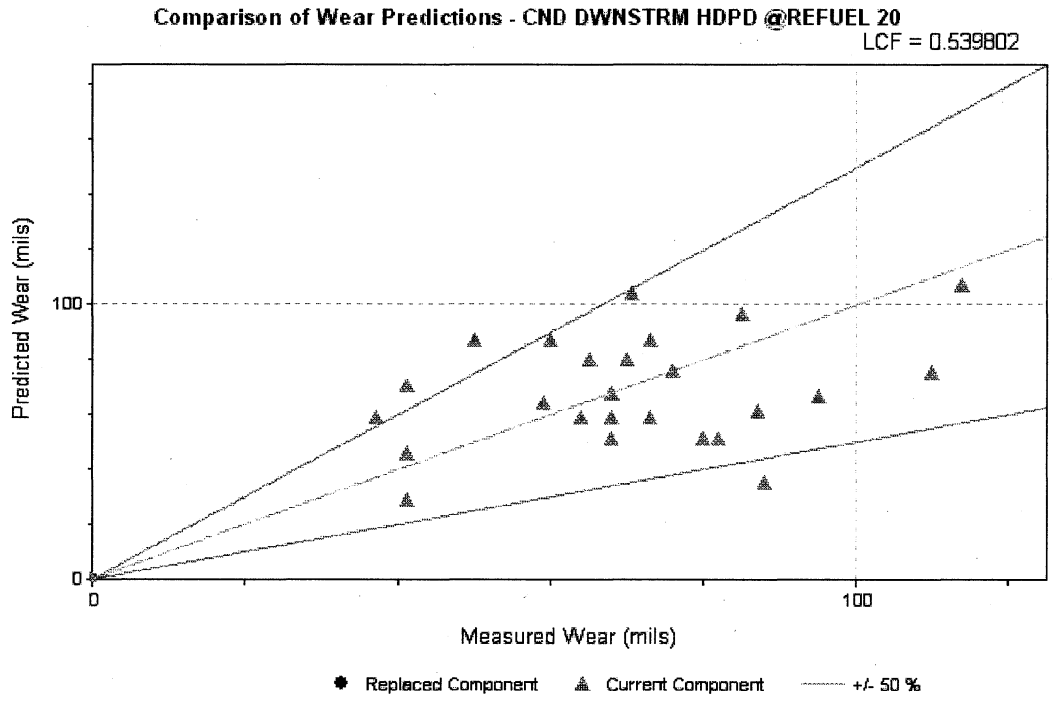
Plot J.5: 6TH POINT EXTRAC STM



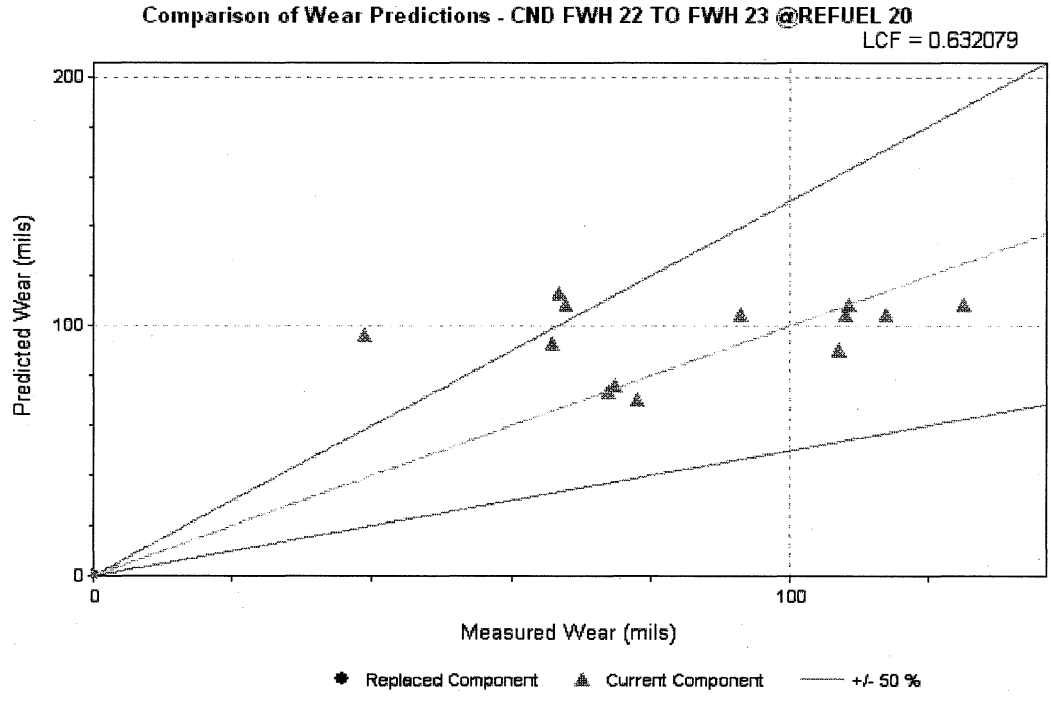
Plot J.6: BLOWDOWN



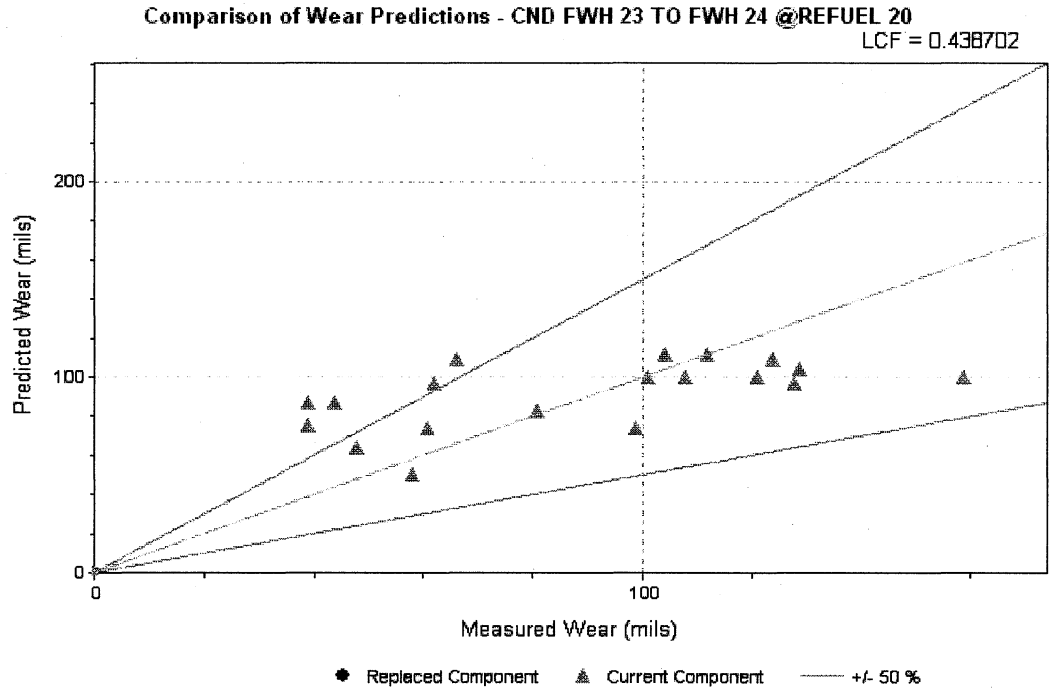
Plot J.7: CND DWNSTRM HDPD



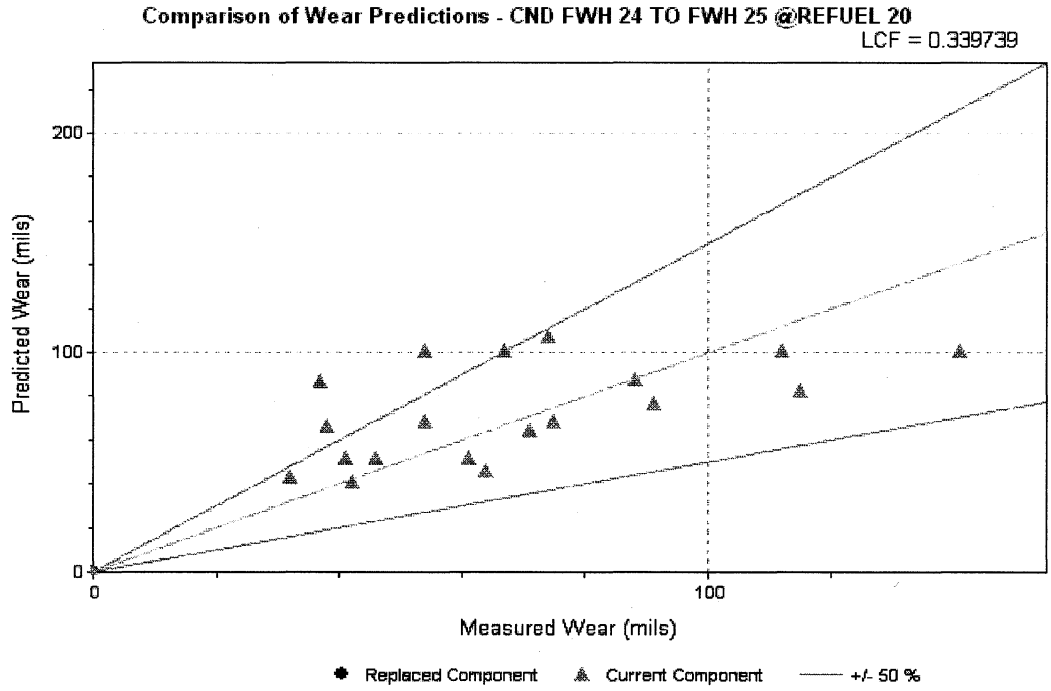
Plot J.8: CND FWH 22 TO FWH 23



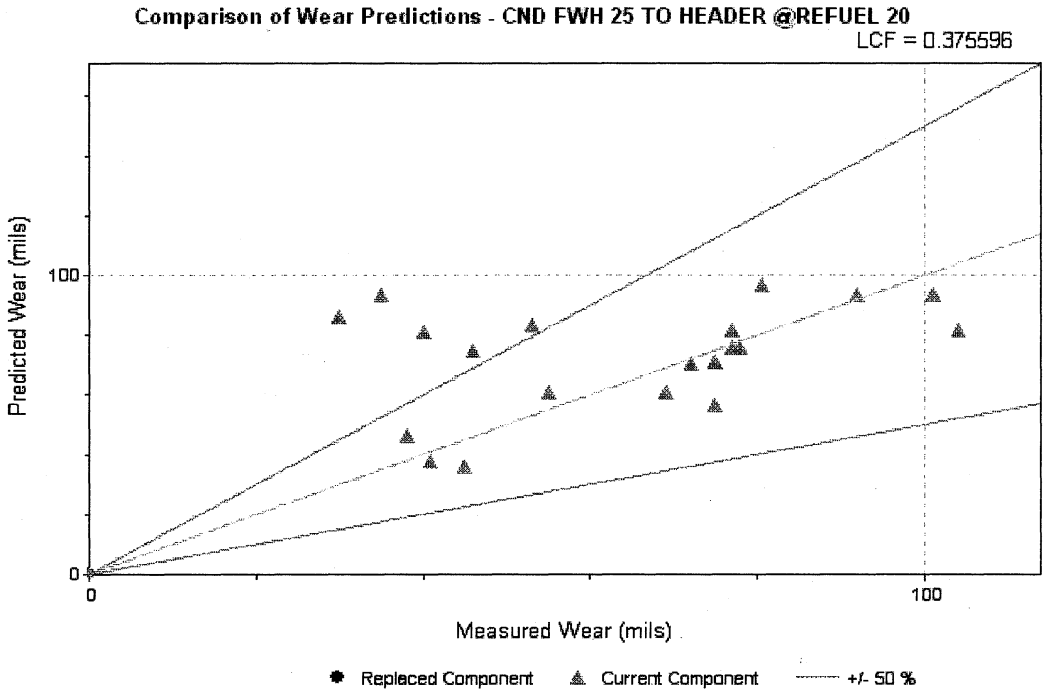
Plot J.9: CND FWH 23 TO FWH 24



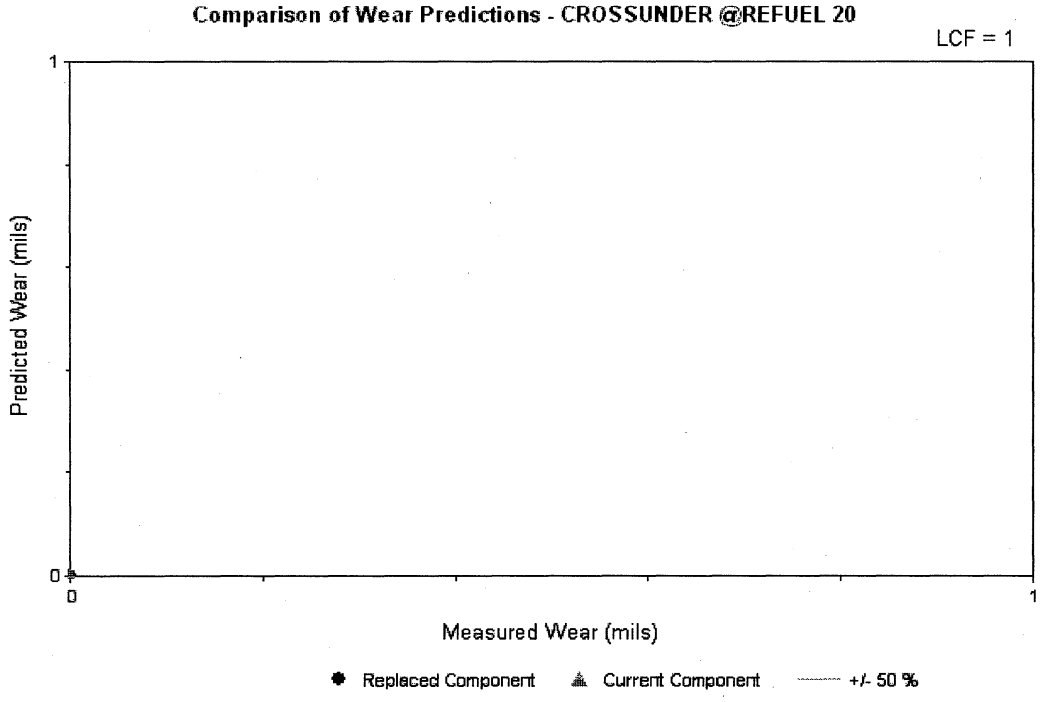
Plot J.10: CND FWH 24 TO FWH 25



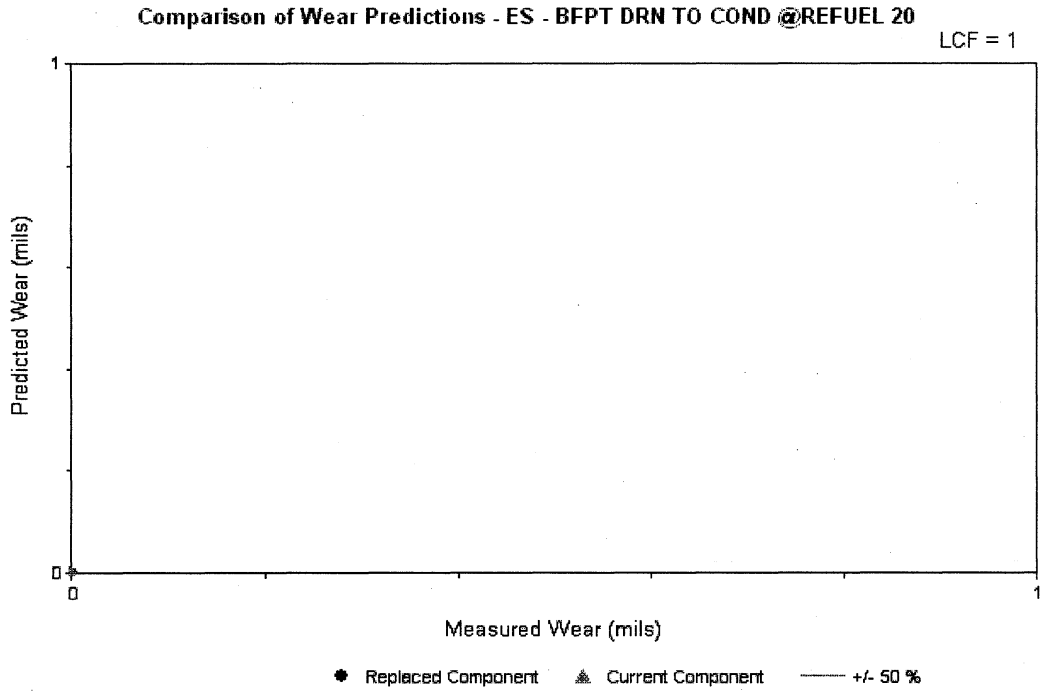
Plot J.11: CND FWH 25 TO HEADER



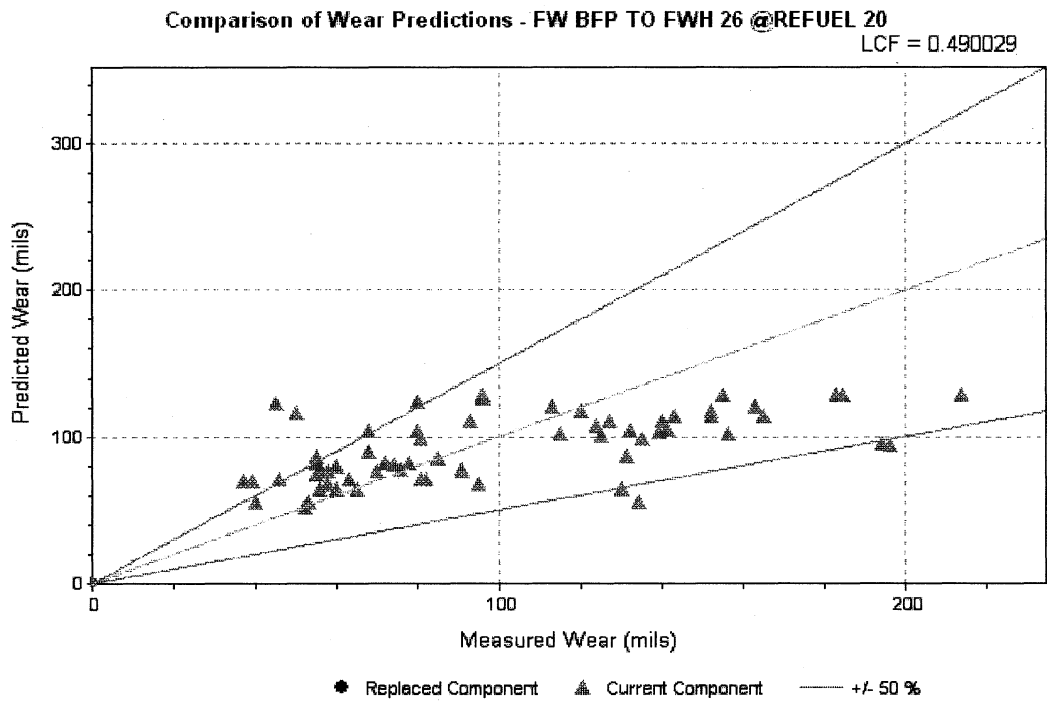
Plot J.12: CROSSUNDER



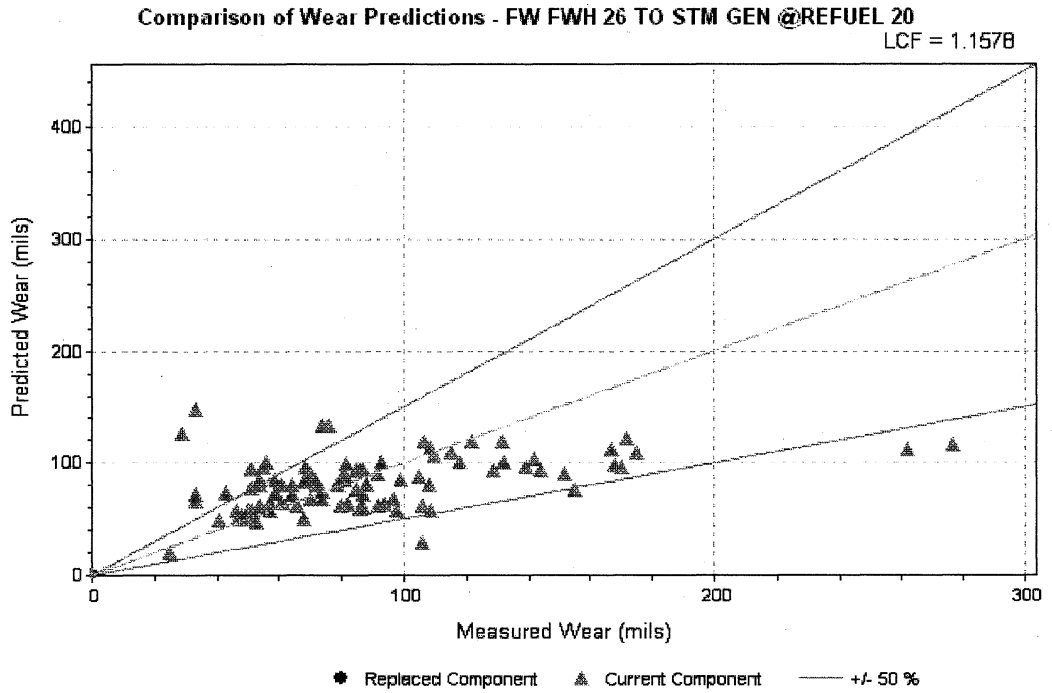
Plot J.13: ES – BFPT DRN TO COND



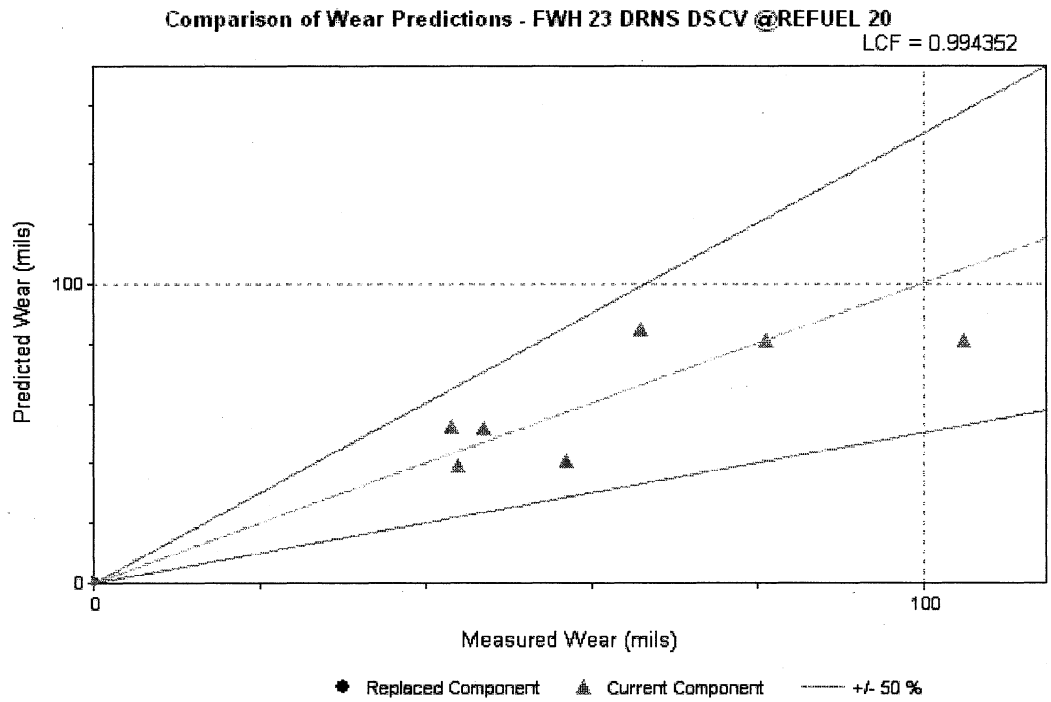
Plot J.14: FW BFP TO FWH 26



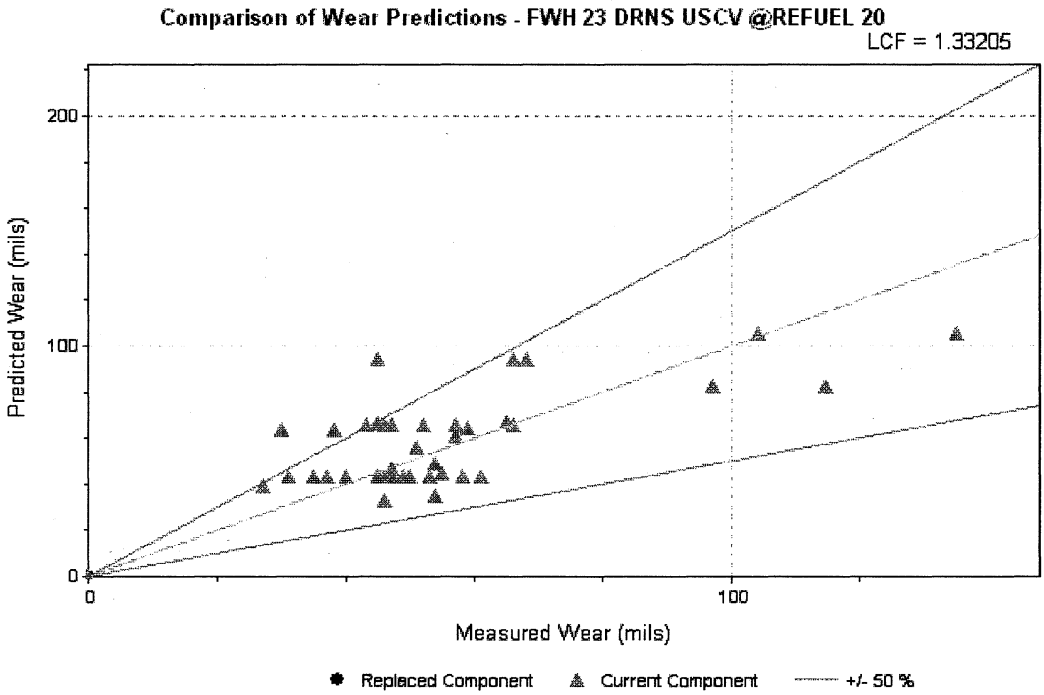
Plot J.15: FW FWH 26 TO STM GEN



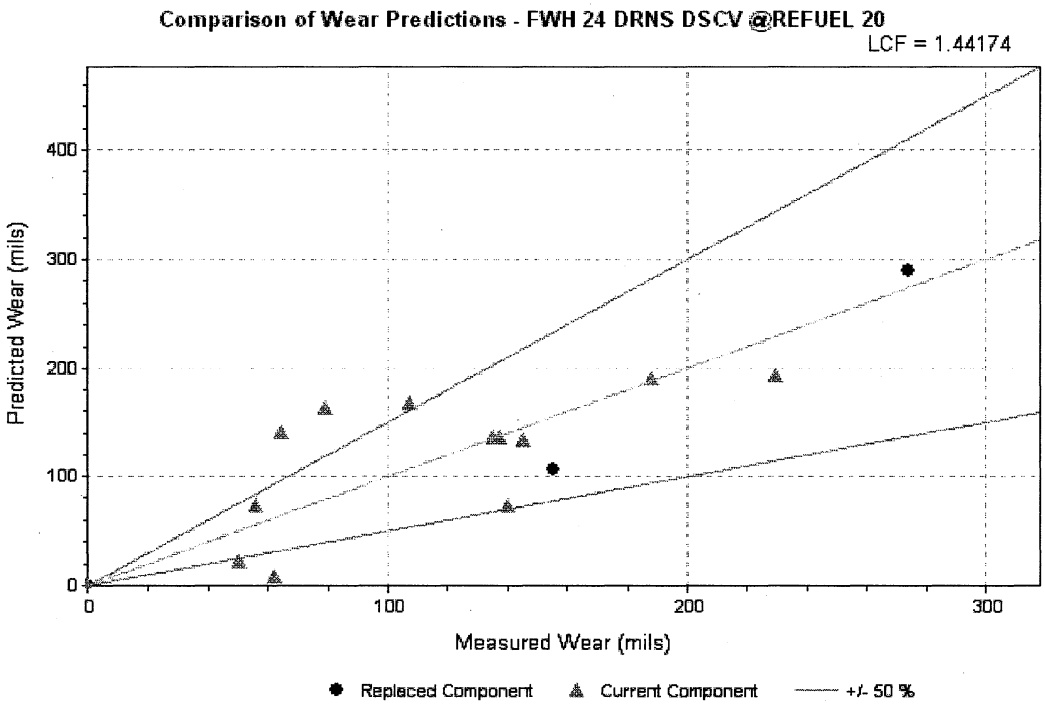
Plot J.16: FWH 23 DRNS DSCV



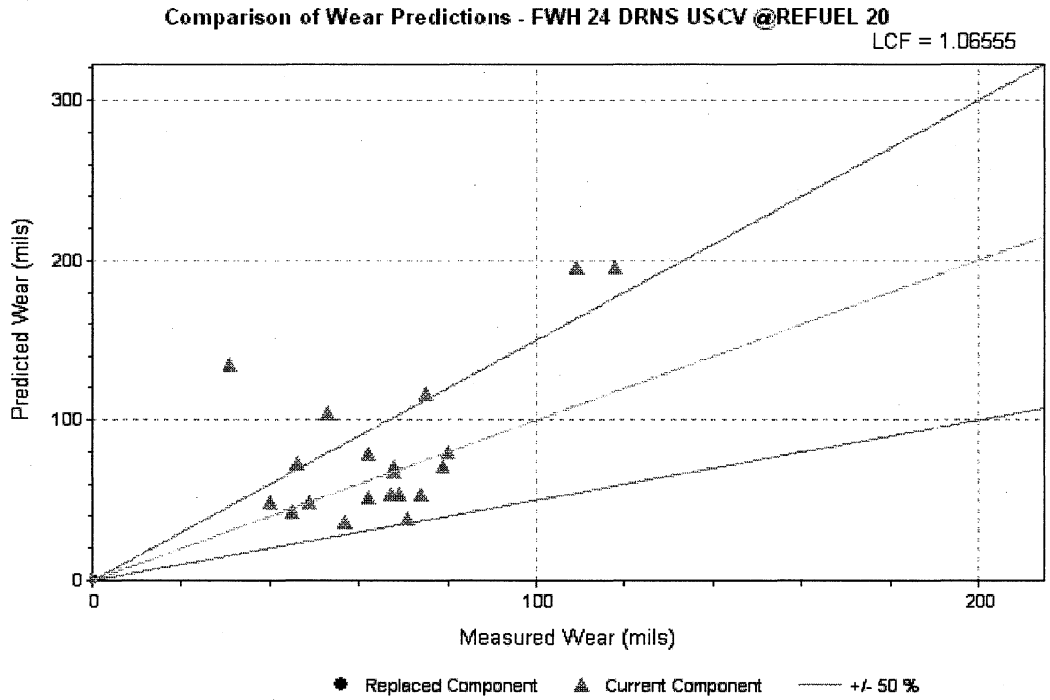
Plot J.17: FWH 23 DRNS USCV



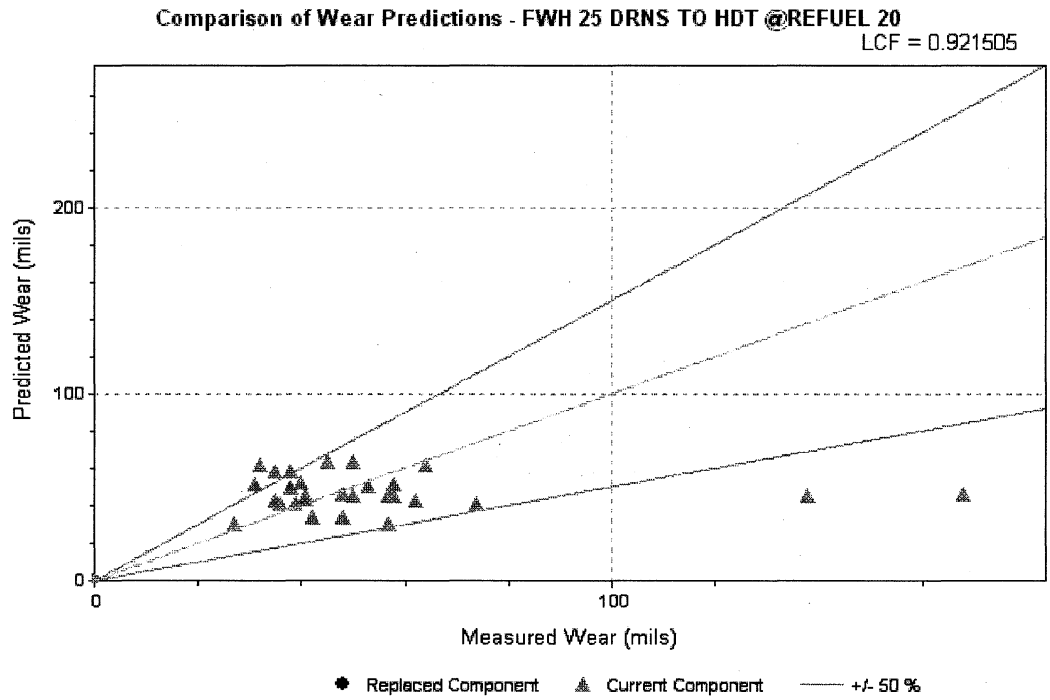
Plot J.18: FWH 24 DRNS DSCV



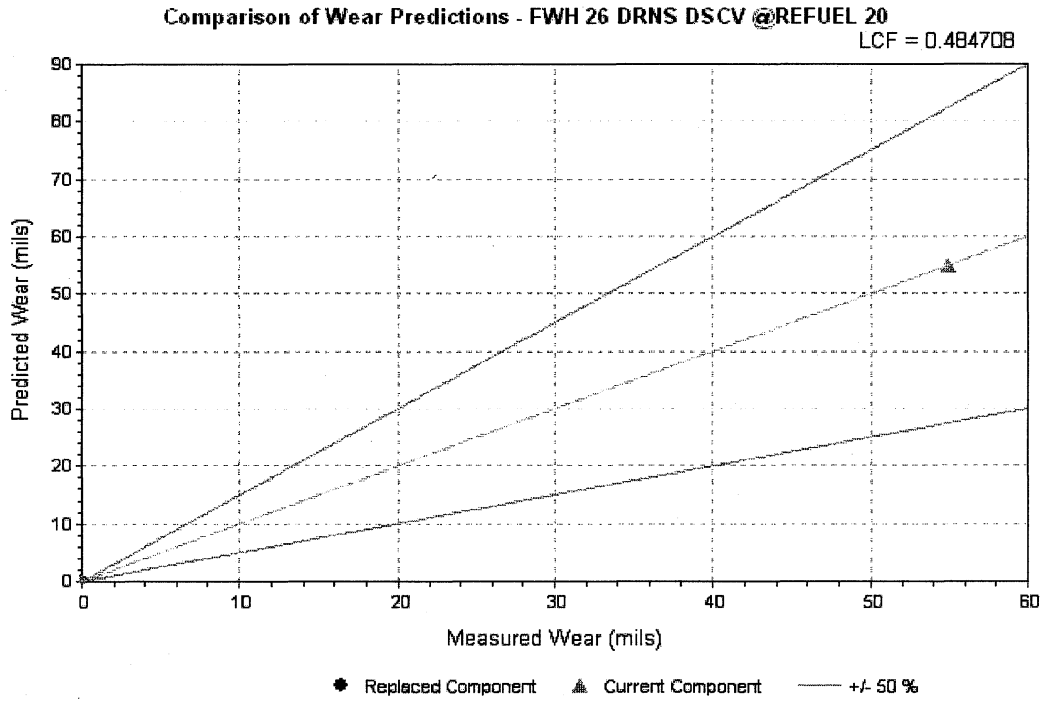
Plot J.19: FWH 24 DRNS USCV



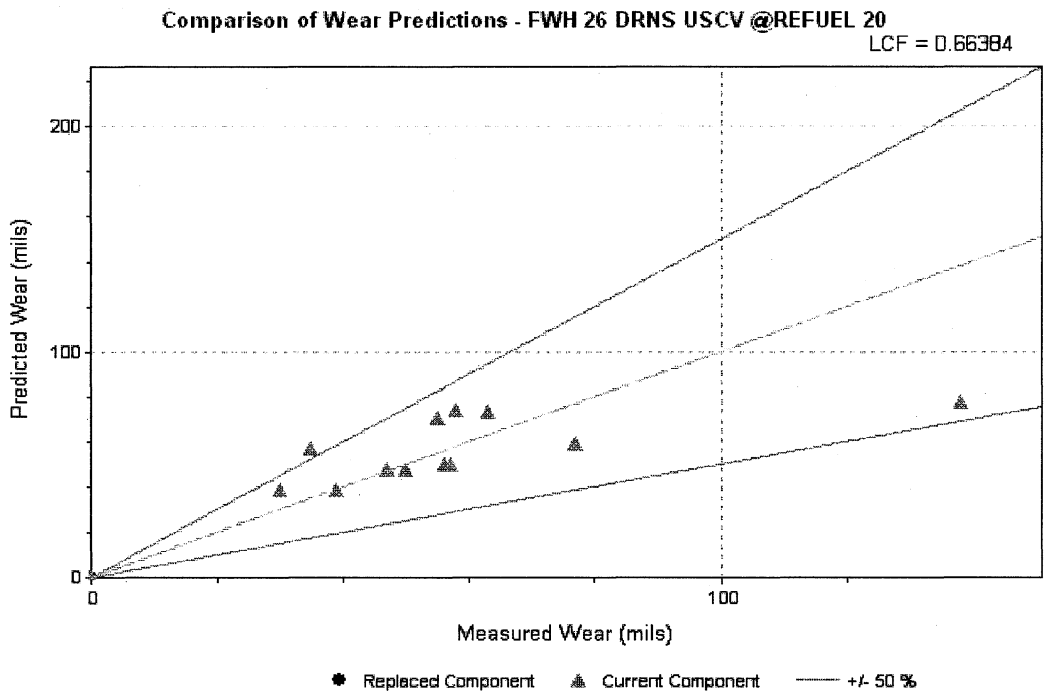
Plot J.20: FWH 25 DRNS TO HDT



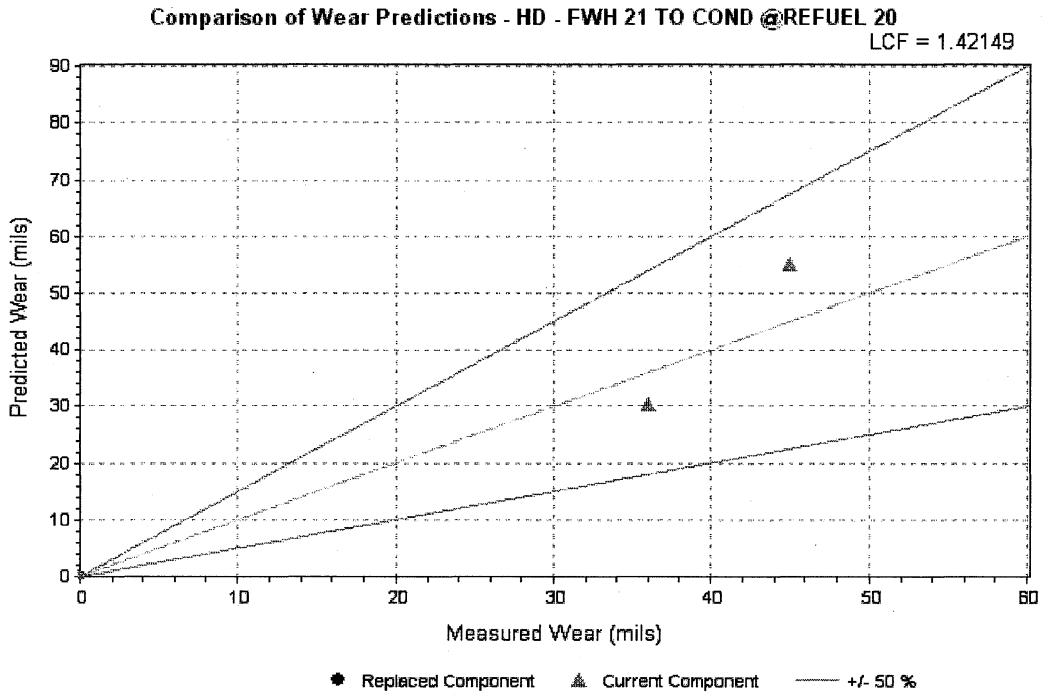
Plot J.21: FWH 26 DRNS DSCV



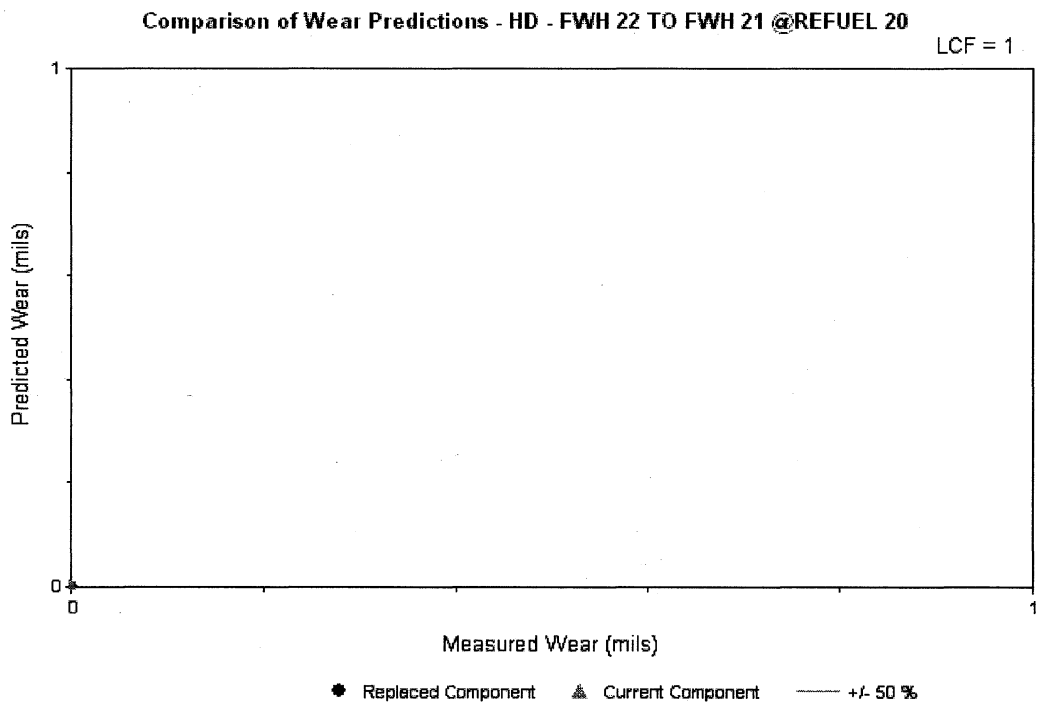
Plot J.22: FWH 26 DRNS USCV



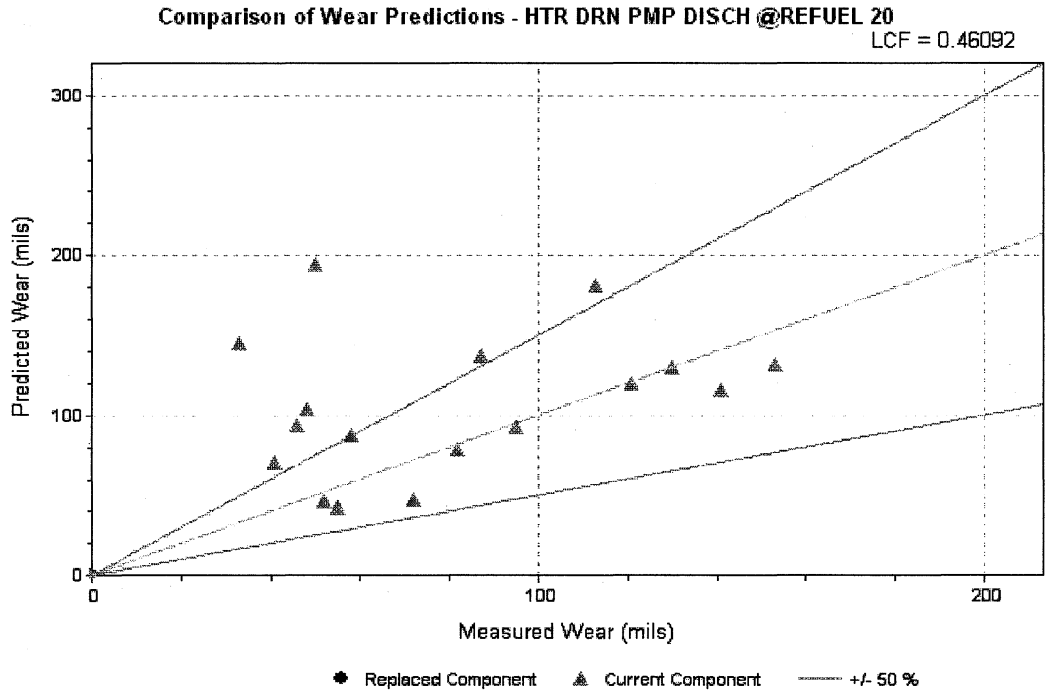
Plot J.23: HD – FWH 21 TO COND



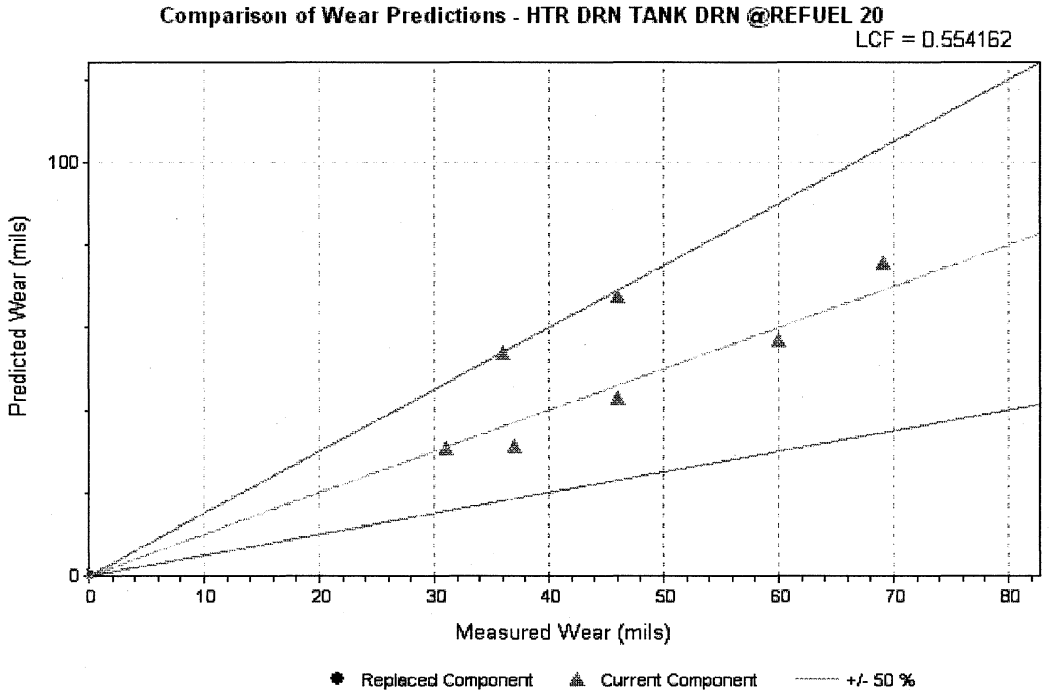
Plot J.24: HD – FWH 22 TO FWH 21



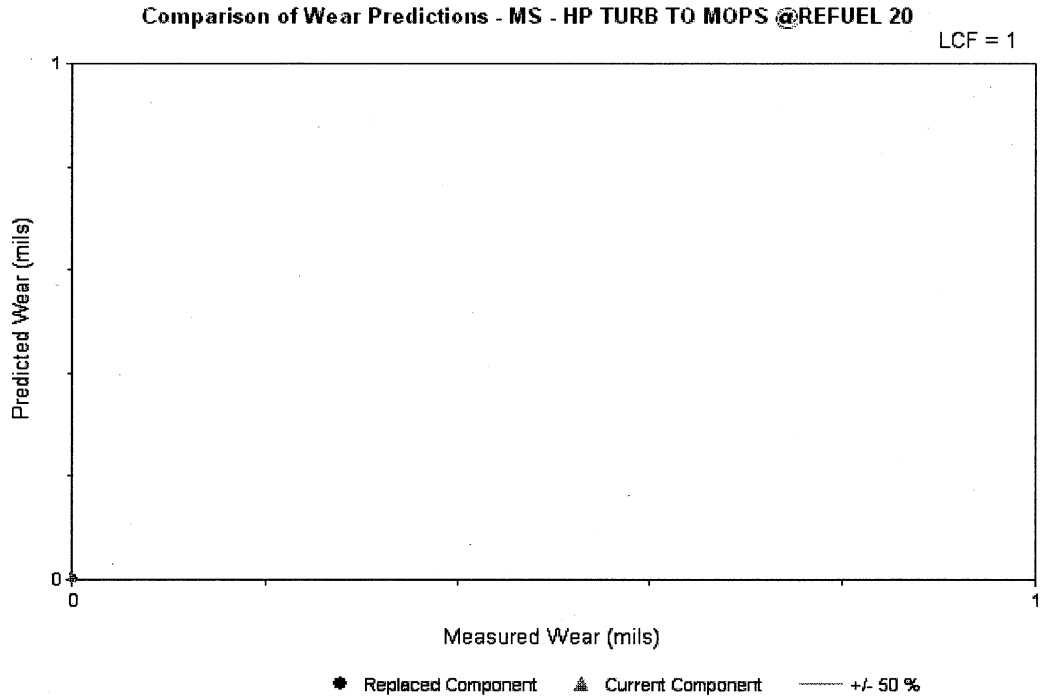
Plot J.25: HTR DRN PMP DISCH



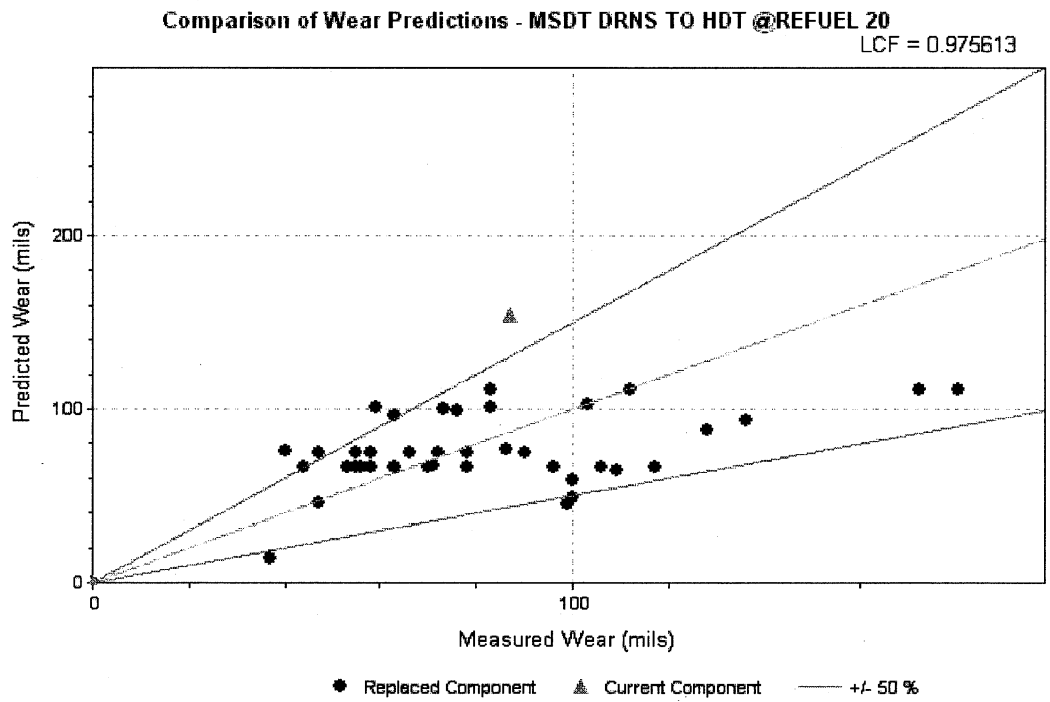
Plot J.26: HTR DRN TANK DRN



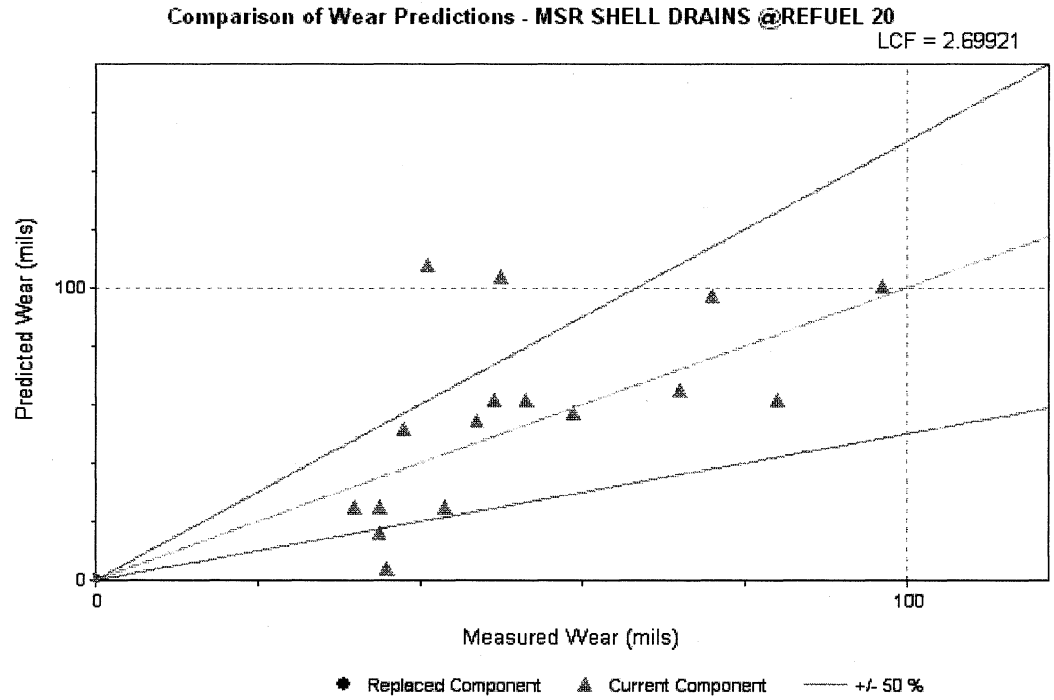
Plot J.27: MS – HP TURB TO MOPS



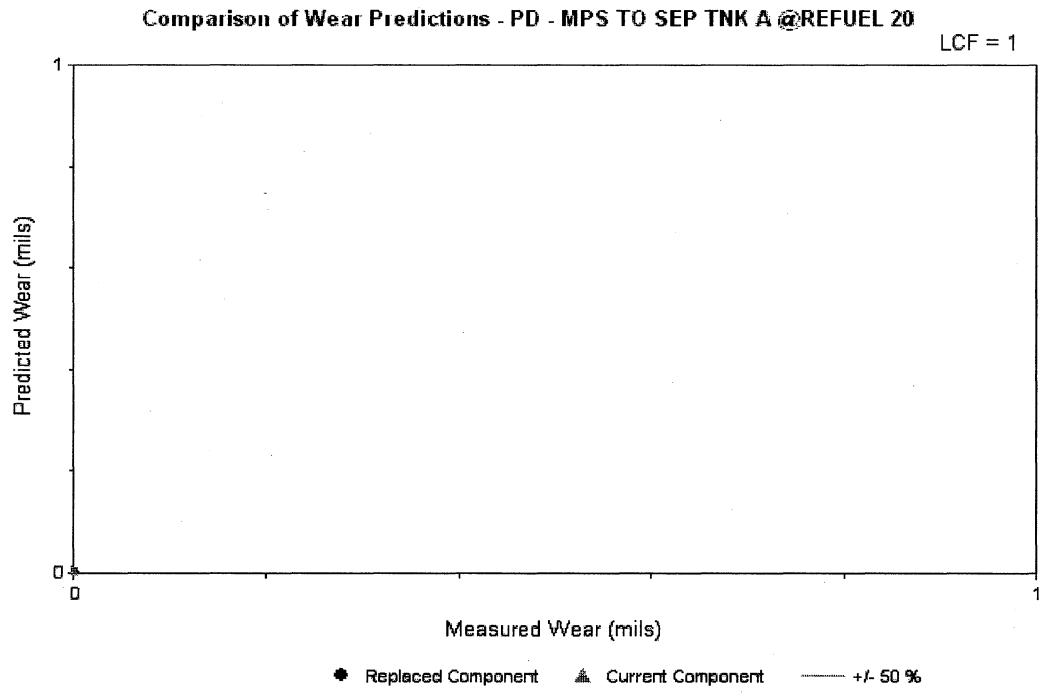
Plot J.28: MSDT DRNS TO HDT



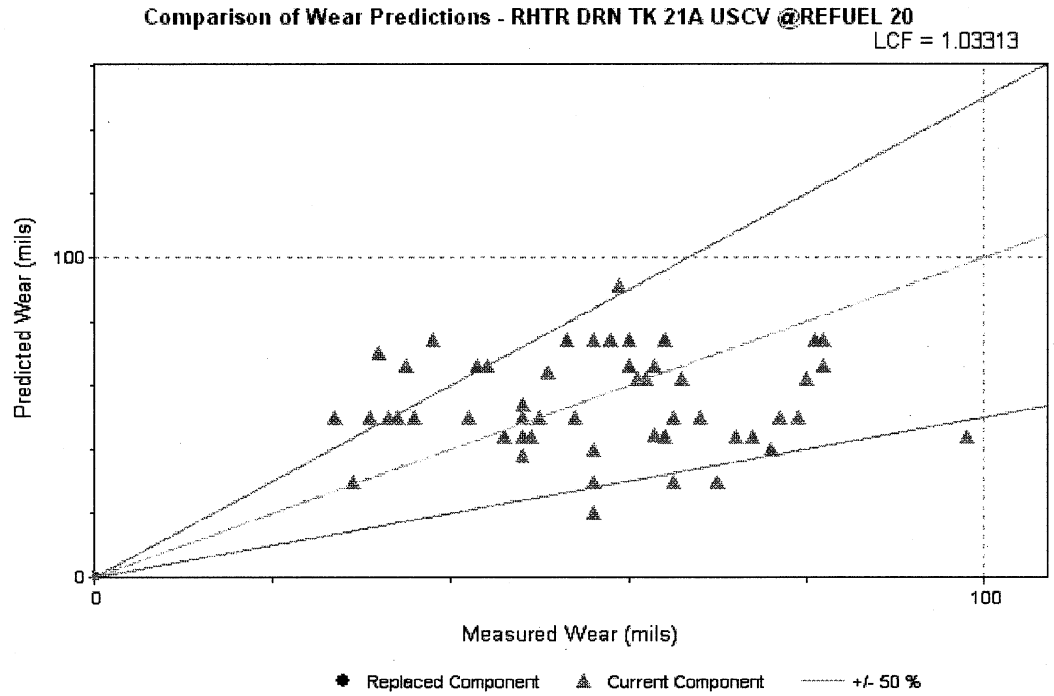
Plot J.29: MSR SHELL DRAINS



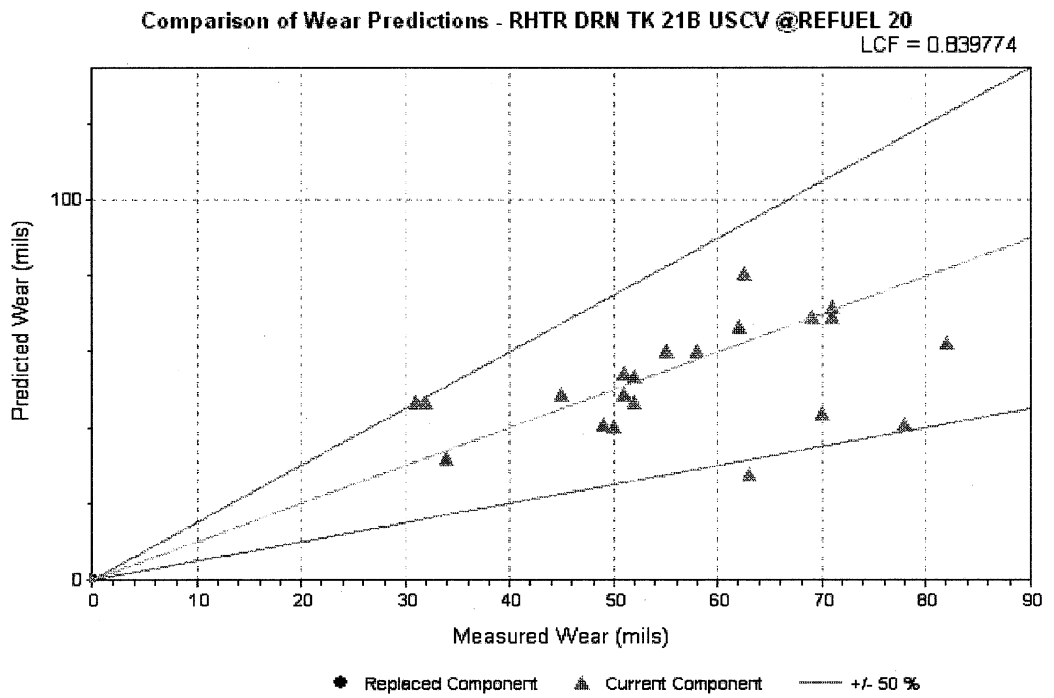
Plot J.30: PD – MPS TO SEP TNK A



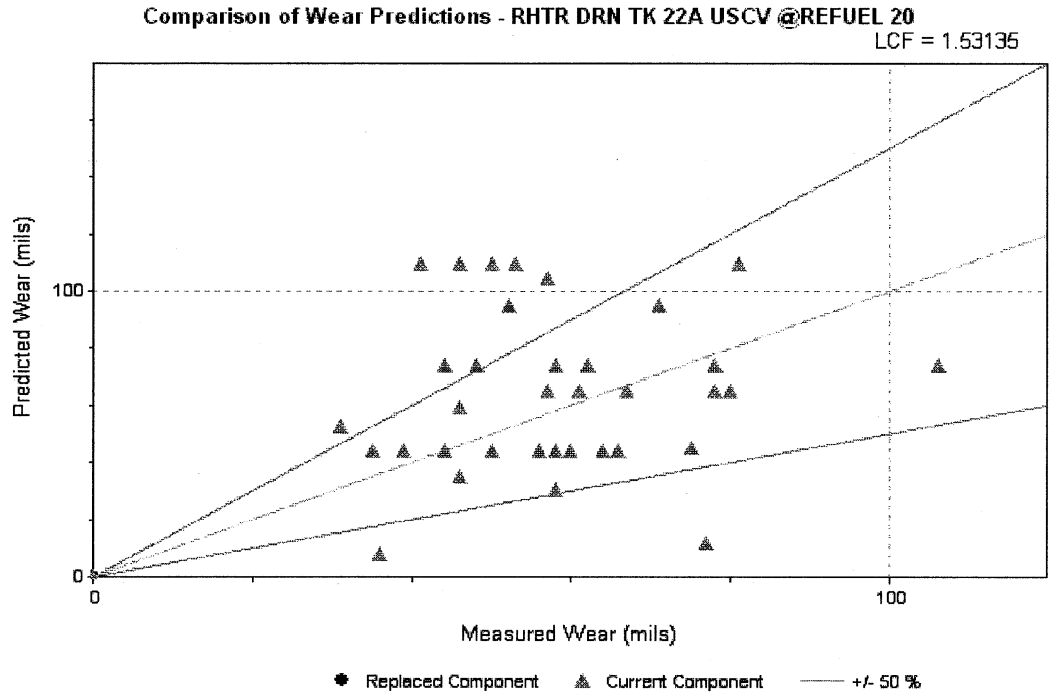
Plot J.31: RHTR DRN TK 21A USCV



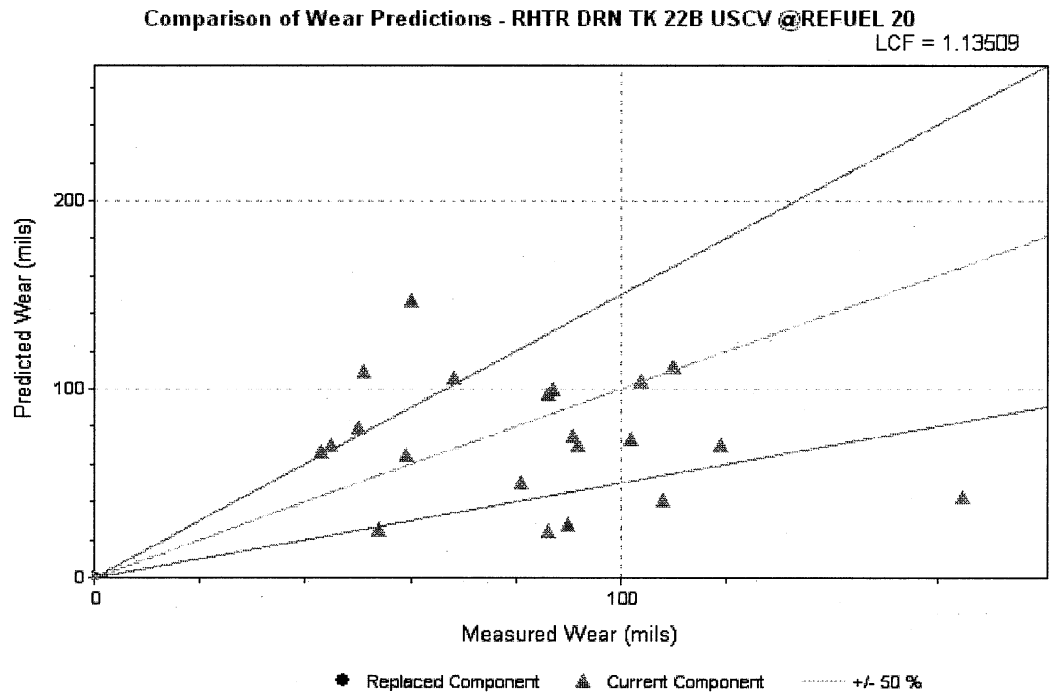
Plot J.32: RHTR DRN TK 21B USCV



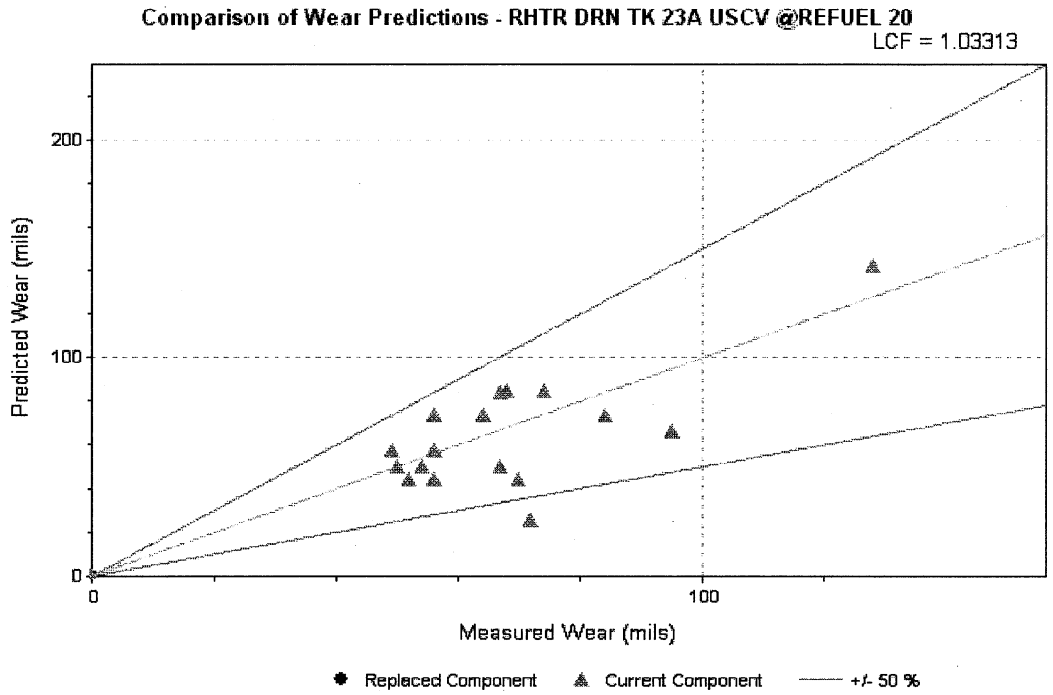
Plot J.33: RHTR DRN TK 22A USCV



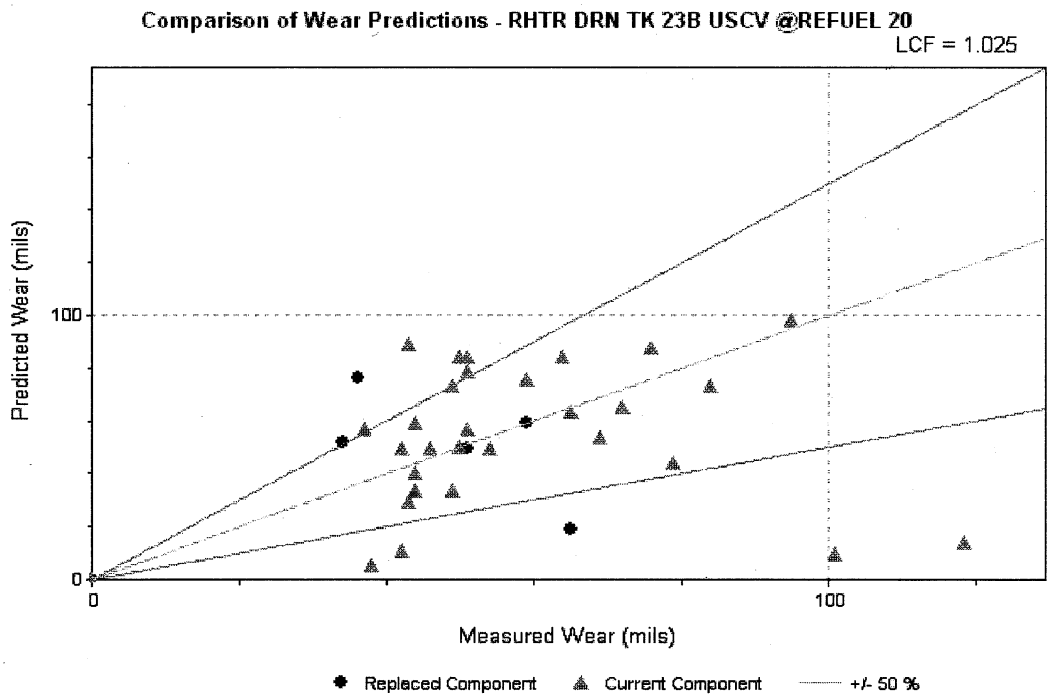
Plot J.34: RHTR DRN TK 22B USCV



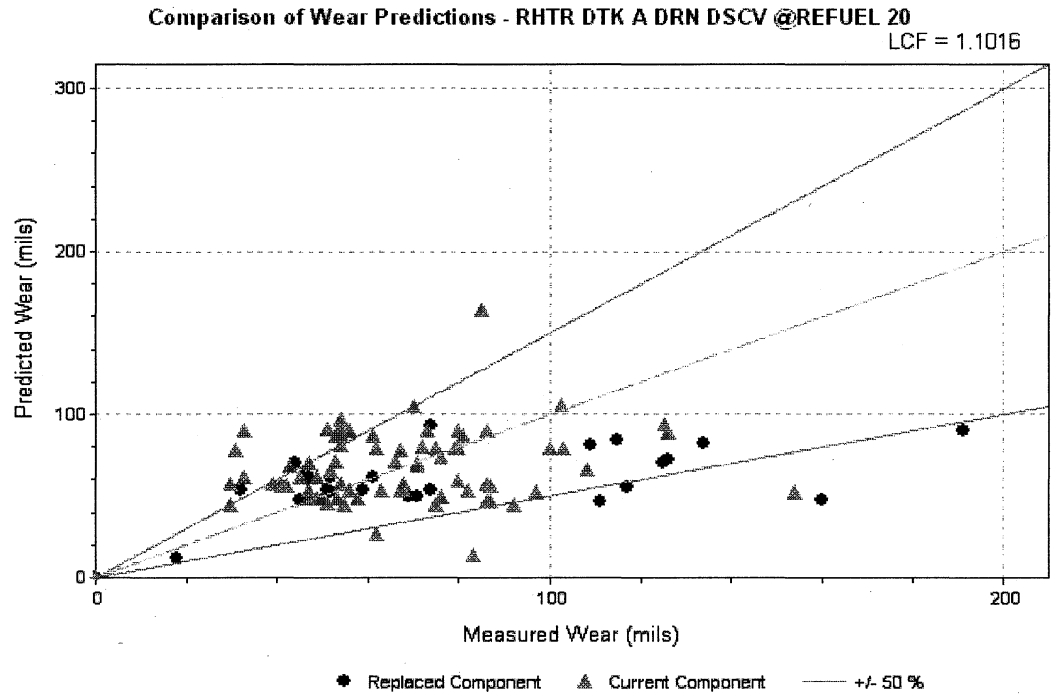
Plot J.35: RHTR DRN TK 23A USCV



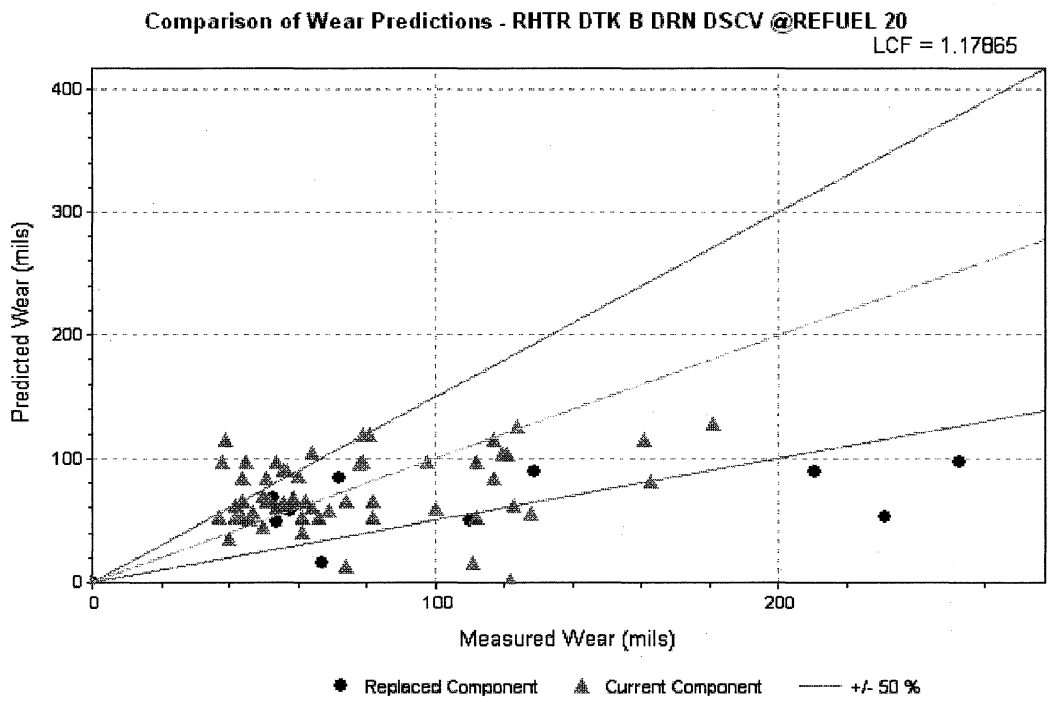
Plot J.36: RHTR DRN TK 23B USCV



Plot J.37: RHTR DTK A DRN DSCV



Plot J.38: RHTR DTK B DRN DSCV



Plot J.39: RHTR TO RHTR DRN TK