GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[X] ORIGINAL [ ] REVISION NO. ______

Project No. E-19-605 GTRI/~~GIT~~ DATE 8 / 9 /83

Project Director: Dr. Miroslav Marek School/~~Lab~~ Chemical Engineering

Sponsor: Department of Commerce/National Bureau of Standards

Type Agreement: Grant No. NB83NADA4022

Award Period: From 6/1/83 To ~~5/31/84~~ ~~6-30-84~~ ~~8-31-84~~ 10-31-85 (Performance) 5/31/84 (Reports)

Sponsor Amount: This Change / Total to Date

Estimated: $ 40,003 $ 40,003

Funded: $ 40,003 $ 40,003

Cost Sharing Amount: $ ______ Cost Sharing No: ______

Title: "Corrosion of Austenitic Stainless Steels in Aqueous/Chloride Solutions - Data Compilation and Critical Evaluation"

ADMINISTRATIVE DATA

OCA Contact Frank Huff X4820

1) Sponsor Technical Contact:

Dr. J~~ohn~~ R. Rumble, Jr.
Office of Standard Reference Data
National Bureau of Standards
Washington, D.C. 20234
(301) 921-3441
Building 221, Room A323

2) Sponsor Admin/Contractual Matters:

Virgella E. Randolph
Deputy Grants Administrator
United States Department of Commerce
National Bureau of Standards
Washington, D.C. 20234

Defense Priority Rating: ______

Military Security Classification: ______
(or) Company/Industrial Proprietary: ______

RESTRICTIONS

See Attached ______ Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with Government for equipment having a unit cost of $1,000 or more.

COMMENTS:

Travel is restricted to $1,200.00 specifically to allow two (2) trips for P.I. to National Bureau of Standards.

COPIES TO:

Project Director	Procurement/EES Supply Services	GTRI
Research Administrative Network	Research Security Services	Library
Research Property Management	Reports Coordinator (OCA) ✓	Project File
Accounting	Research Communications (2)	Other I. Newton

GEORGIA INSTITUTE OF TECHNOLOGY OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION/CLOSEOUT SHEET

SP993 N-X-B 8

Date 12/12/86

Project No. E-19-605 School/~~Lab~~ Ch E

Includes Subproject No.(s) N/A

Project Director(s) M. I. Marek GTRC / ~~GIT~~

Sponsor Department of Commerce/National Bureau of Standards

Title "Corrosion of ~~Austeitic~~ Austenitic Stainless Steels in Aqueous/Chloride Solutions-
Data Compilation and Critical Evaluation"

Effective Completion Date: 10/31/85 (Performance) (Reports)

Grant/Contract Closeout Actions Remaining:

*If submitted directly to sponsor OCA needs copy.

- [ ] None
- [X] Final Invoice or Final Fiscal Report *
- [ ] Closing Documents
- [ ] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other

Continues Project No. Continued by Project No.

COPIES TO:

Project Director
Research Administrative Network
Research Property Management
Accounting
Procurement/GTRI Supply Services
Research Security Services
Reports Coordinator (OCA)
GTRI Services

Library
GTRC
Research Communications (2)
Project File
Other I. Lashley
A. Jones
R. Embry

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

METALLURGY PROGRAM
SCHOOL OF
CHEMICAL ENGINEERING

Project No. E-19-605 September 9, 1983
Sponsor:NBS
Grant No. NB83NADA4022
Title: "Corrosion of Austenitic Stainless Steels in Aqueous Chloride Solutions - Data Compilation and Critical Evaluation"
Project Director: Dr. Miroslav Marek

PROGRESS REPORT

Period Covered: 6/1/83-8/31/83

The main objective of the first phase of the program was to collect the pertinent literature, initiate the compilation of data, and define the scope of the program on the basis of data availability. To date, 59 published reports have been collected, including 46 reports containing experimental data for corrosion in aqueous chloride solutions of Type 304, 316, and closely related steels, and 13 reports on related subjects, such as examination of the effects of the testing techniques on the results. Out of the 46 data-containing reports, 32 reports have been at least partially analyzed, the data compiled and evaluated. The evaluation has been focused on the pitting corrosion data; the crevice corrosion literature mostly remains to be analyzed. The corrosion data and references have been computer-filed in a format which will allow an efficient retrieval and processing of the parameters.

On the basis of this initial data compilation it is apparent that sufficient data base exists for the evaluation of two corrosion parameters, the corrosion potential and the breakdown potential, as a function of the chloride ion concentration. The concentration range is from a few ppm to about 3.6M (high salinity brine), although most of the data is concentrated in a few narrow regions. Most of the data is for room temperature; other temperature regions, for which extensive data exist, include 37C (body temperature) and 200-300C (geothermal brines and BWR operating temperatures). Limited data are available for various other temperatures within the overall range The effect of pH has been examined in several reports.

Much more limited is the available literature on other corrosion parameters, such as protection potentials and passivation and passive current densities, and critical pitting temperature. The available data can be tabulated for the specific test conditions for which they have been reported, and some plots vs. electrolyte concentration and other parameters can be made, but the data may not be sufficient for a comprehensive analysis of the relationships. Most limited are the important corrosion rate data, such as the pit propagation rates (PPR curves), which are available only for a few specific conditions.

The research plan has been discussed in detail with the consultant, Dr. John C. Scully, during his visit on 7/17/83-7/21/83. The discussions were focused on the relative significance of the individual corrosion parameters and the data availability. The differences in the testing techniques, the variability of conditions, and the lack of corrosion rate data were recognized as the main obstacles.

In the next phase of the program the data compilation and analysis will continue and will include the crevice corrosion data. First efforts will be made to find suitable formats for the presentation of the relationships between the corrosion parameters and the main variables.

E-19-605
Miroslav Marek

Financial Statement

Period Covered: 6/1/83-8/31/83

Total Budget	$40,003
Expended	$10,730
Balance	$29,273

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA. GEORGIA 30332

METALLURGY PROGRAM
SCHOOL OF
CHEMICAL ENGINEERING

December 12, 1983

Virgella E. Randolph
Deputy Grants Administrator
U. S. Department of Commerce
National Bureau of Standards
Washington, D.C. 20234

Subject: Grant No. NB83NADA4022
"Corrosion of Austenitic Stainless Steels in Aqueous Chloride Solutions"
Project Director: Dr. Miroslav Marek

PROGRESS REPORT

Period Covered: 9/1/83 - 11/30/83

In the second quarter of the program the collection of literature and data compilation, to the extent of the original plan, has been virtually completed. It is estimated that the computer-stored database contains about 90% of the data available in U.S. and British corrosion journals and conference papers, as well as a substantial fraction of the data from German and French literature. The effort to complete the database will continue until the end of the program, and some extension beyond the original scope will be attempted, as described below. At this time, however, the main effort is changing from the building of the database to data processing, which already has been initiated.

Although limited data formatting has been attempted in the second quarter, such as plotting of the breakdown potential vs. chloride activity, the main focus of data processing has been in the areas of categorizing and preliminary statistical evaluation of the data. This is a necessary step before the formatting can be seriously attempted. This process includes a critical evaluation of the data with respect to the completness of the description of the materials and test conditions. A substantial fraction of the available data has been found to be to some extent deficient in this respect. The most common deficiencies include lack of information on the composition and state of the materials (e.g., impurities, percentage of work hardening, details of heat treatment, etc.). Although the data lacking this type of information still can be included in the primary formats, they have become useless when the effects of the particular variable are to be shown. The results of the evaluation to date show that in spite of the relative wealth of data for some of the parameters, such as the breakdown potential, the database is much smaller, and often quite insufficient, for a statistically meaningful evaluation of the effects of secondary parameters.

The database has been organized to contain the following information for alloys 304, 304L, 316, and 316L:

Data: Corrosion Potential
- Breakdown potential
- Protection Potential
- Pit Propagation Rate
- Crevice Corrosion Index
- Crevice Attack Rate

Independent Variables

- Chloride Concentration/Activity
- Temperature
- pH
- Concentration of other ions

Material Characterization

Composition

Percentage of cold work

Heat and other treatment

Test Characterization

Test Method

Test Parameters

The results of the categorization performed to date show that the data for Type 304 steel can be ranked as follows with respect to the availability:

1. Breakdown potential
2. Corrosion potential
3. Protection potential
4. Crevice Attack Rate
5. Pit Propagation Rate
6. Crevice Corrosion Index

Within this set, only the data for the breakdown potential are plentiful enough tho allow plotting vs. chloride activity and temperature. The availability of the other data is much less satisfactory; the same is true for Type 316 steel, except that the amount of data is considerably lower in general. Consequently, one of the main conclusions of this project will have to be the identification of the areas where data are lacking. Since, however, the lack of data creates difficulties in the development of suitable formats, an effort is now being made to increase the database by obtaining some data from industrial technical reports, which are not available in published papers.

The formatting of the data has been limited and on a trial basis only. The general approach has been to plot the data as a function of chloride concentration/activity and temperature, and to include the other parameters, such as concentration of ions, material parameters, and test parameters by using different symbols an/or colors. The qustion of pH as a variable is not yet quite clear, since much of the data shows lack of dependence on pH, except for (mainly) high pH solutions. Further analysis of this question is in progress.

The formatting and plotting of the data will be the main part of the work in the third quarter. The preliminary work has involved mainly the development of software for plotting and computer mapping.

FINANCIAL STATEMENT

Period Covered: 6/1/83 - 11/30/83

Total Budget	$40,003
Expended	$18,286
Balance	$21,717

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

METALLURGY PROGRAM
SCHOOL OF
CHEMICAL ENGINEERING

(404) 894-2380

Ms. Virgella E. Randolph
Deputy Grants Administrator
U. S. Department of Commerce
National Bureau of Standards
Washington, D. C. 20234

SUBJECT: Grant Number NB83NADA4022
"Corrosion of Austenitic Stainless Steels in Aqueous Chloride Solutions"
Project Director: Dr. Miroslav Marek

PROGRESS REPORT

Period Covered: December 1, 1983-February 28, 1984

In the third quarter of the program, the main effort was in the initial formatting of the data from the database established in the earlier phases. The literature and data compilation continued, but the additions to the database have been relatively minor.

In the initial data formatting, the following scheme was used:

1. The primary parameters of corrosion performance of the two steels are identified (Breakdown and protection potentials).

2. The primary independent variable is identified (chloride concentration).

3. The corrosion performance data are plotted as a function of the independent variable (E_b vs. Cl^-, E_{prot} vs. Cl^-).

4. Regression analysis is performed to obtain the functional parameters and error estimates. This allowes the data to be normalized with respect to the primary independent variable (E_b and E_{prot} for $Cl^- = 1$).

5. The secondary independent variable is selected (temperature T).

6. The normalized data from (4) are used to plot the corrosion performance parameters as a function of the secondary independent variable (E_b and E_{prot} vs. T).

7. The process is continued, i.e., the data are normalized with respect to the secondary independent variable, and the functional relationship is used to evaluate another independent variable, etc.

8. In principle, the same procedure can be used to format all other corrosion performance parameters.

In the actual application, the procedure could not be continued beyond the second independent variable because of the lack of systematic data. Only the data of E_b and E_{prot} vs. chloride concentration allowed a statistical analysis; the data for the other independent variables were insufficient to extract the functional parameters. A similar, but even more serious shortage of systematic data was found to exist for the other corrosion performance parameters, such as crevice corrosion index, pit propagation rate, etc.

Some of the difficulty is due to the large number of independent varibles, such as the presence and concentration of various ions, different cold-working parameters, etc. An effort will be made in the fourth quarter to reduce this complexity by identifying those variables which seem to affect the corrosion performance very little, so that the data can be included in the analysis. This requires a statistical analysis to determine if the data in question belong to the same population.

In the absence of systematic data for some of the independent variables, some of the effects of the independent variables can be shown by superimposing the data on the plot for the selected standard condition. The standard condition chosen in this case has been an annealed alloy exposed to sodium chloride solution at 25°C. This type of format has been used to show the effects of pH, cold work, and different test techniques.

The third format explored in this phase was a plot of pitting/no pitting data vs. two independent variables, one of them being the chloride concentration. The resulting plots are very useful for the user of the materials and their development deserves serious attention. Unfortunately, however, it is seldom possible to construct these diagrams on the basis of individual data from various sources. Thus, the database is limited to the results of studies in which this type of diagram was specifically sought.

Program for the Next Quarter

In the fourth quarter, further effort will be made to extract all the information from the database. Alternative formats will be considered, and new approaches to the overall objective will be explored.

Grant No. NB83NADA4022

FINANCIAL STATEMENT

Period Covered: 12/1/83 - 2/28/84

Total Budget	$40,003
Expended	$29,602
Balance	$10,401

GEORGIA INSTITUTE OF TECHNOLOGY
ATLANTA, GEORGIA 30332

METALLURGY PROGRAM
SCHOOL OF
CHEMICAL ENGINEERING

January 14, 1985

Dr. John Rumble, Jr.
Office of Standard Reference Data
A323 Physics Building
National Bureau of Standards
Gaithersburg, MD 20899

SUBJECT: Grant No. NB83NADA4022
"Corrosion of Austenitic Stainless Steels in Aqueous Chloride Solutions"
Project Director: Dr. Miroslav Marek

TECHNICAL REPORT

Period Covered: 9/1/84 to 12/31/84

On the basis of the evaluation of the data obtained and analyzed during the first project year (Annual Report for the period 6/1/83 - 8/31/84) a conclusion was made that the critical potential data for corrosion of austenitic stainless steels did not provide a suitable database for the purpose of the Corrosion Data Program. The main reasons were that the published data were not systematic enough to show the effects of the many corrosion conditions, and that the relationship between the critical potentials and the actual corrosion performance was not so clearly defined that the data could be used by users of the steels in practical applications.

Consequently, the decision was made to focus tha attention on other data, such as the pitting/no pitting information for various conditions of exposure, that could be formatted in simple graphs as a function of 2 - 3 variables, and could be used to predict the corrosion performance under conditions covered by the format.

Since few data of the above type are published in the academic literature, the program of work in the reported project period included a development of a list of companies that may have test data that could be included in the database. These sources would include manufacturers, fabricators, corrosion testing laboratories, and users of austenitic stainless steels. These companies would be systematically contacted and asked to provide available data.

Appendices 1 and 2 show the lists of manufacturers/-fabricators and corrosion testing laboratories, respectively, that were developed in this project period. Most of the companies in Appendix 1 have been contacted and asked to provide available data. The information of these contacts is included in the list. Although few data have been obtained by the end of this reporting period, some of the contacts may yet result in data acquisition.

In the next quarter the effort to obtain data will continue with the main focus on the corrosion testing laboratories.

NOTE: Because of the low overall effort rate of this project (funded 10% of PI's time, 9 months of Graduate Research Assistant, 1/3 time), the main effort in data analysis and formatting is planned for the Summer Quarter 1985.

APPENDIX 1

File: Mill.List
1
Report: Mill List 1.0
/85

AL Tech Specialty Steel Corp.
Dept TR
Willow Brook Ave.
-
Dunkirk, NY 14048
Randy Ortel, Product Metallurgist
(716)-366-1000
No current data
No data sent

Alaskan Copper Works
-
P.O. Box 3546-T
-
Seattle, WA 98134
-
(206)-623-5800
-
Fabricator

Allegheny-Ludlum Metals Group
-
2004 Oliver Bldg
-
Pittsburgh, Pa 15222
Mark Johnson
(412)-226-6211 or (412)-226-2000
Sending data
Have current data

Amsted Ind.
MacWhyte Wire Rope Co.
2947 14th Ave
-
Kenosha, WI 53141
-
(414)-654-5381
see next entry
-

Amsted Industries Inc.
Research Lab
-
-
Chicago, Il 60601
-
(312)-625-7813
No contact yet
-

ARMCO Inc.
Corpaorate Research Lab
-
-
Middleton, Oh
Bob Gaugh
(513)-425-2488
No contact yet

File: Mill.List
2
Report: Mill List 1.0
/85

Babcock and Wilcox, A McDermott Co.
Tubular Products Group
P.O. Box 401
-
Beaver Falls, Pa 15010
-
(412)-846-0100
No data
Primarialy boiler feed water

Berger Iron Works
-
1414-T Bonner St.
-
Houston, Tx 77007
-
(713)-869-7386
-
Fabricator

Carpenter Technology Corp
-
P.O Box 662
-
Reading, Pa 19603
Mr E. M. Gilbert, General Manager R. D.
(215)-371-2000
Need letter
Have data some maybe proprietary

Central Steel and Wire Co.
-
P.O. Bos 5310-A
-
Chicago, Il 60680
-
(312)-471-3800
Not called
-

Colt Industries
Crucible Research Center
P.O. Box
-
Pittsgurgh, Pa 11523
John Eckenrod
(412)-923-2955
Need a letter
Have data, maybe proprietary

Cyclops Corp.
Universial- Cyclops Specialty Steel Div.
653 Washington Rd.
-
Pittsburgh, Pa 15228
-
(412)-561-6300
No data

File: Mill.List
3
Report: Mill List 1.Ø
/85

Cyclops Corp.
Empire-Detroit Steel Div.
913 Bowman St.
-
Mansfield, OH 44901
-
(419)-755-3011
Not called
-

Eastern Stainless Steel, An Eastmet Co.
-
P.O. Box 1975
-
Baltimore, Md 21203
-
(3Ø1)-522-62ØØ
No contact
-

Electralloy Corporation
-
177 S Main St.
-
Oil City, Pa 163Ø1
Dr. George Redfern
(814)-676-1894
on vacation, call 25 Feb 85
-

EMCO Stainless Inc.
-
49-57 O'Brien Rd.
-
Kearny, NJ Ø7032
-
(2Ø1)-997-9ØØØ
No contact
-

Green River Steel Corp.
-
P.O. Box 119Ø
-
Owensboro, KY 423Ø2
-
(5Ø2)-926-44ØØ
No contact
-

Guterl Special Steel Corp.
-
695 Ohio St.
-
Lockport, NY 14Ø94
-
(716)-433-4411
See Allegheny Ludlum

Inland Steel Co.
-
30 W. MOnroe St.
-
Chicago, Ill. 60603
-
(312)-568-3535
Wrong number
-

Jessop Steel Co
-
Jessop Pl.
-
Washington, Pa. 15301
Ronald Hahn
(412)-222-4000
No data
Boiler feed water

Johnson & Co. Inc.
Ingersoll-Johnson Steel Co.
P.O. Box 370
SR 38 West
New Castle, IN 47362
Harold Shaw
(317)-529-0120
-
-

Latrobe Steel Co.
-
2628 Ligonier St.
-
Latrobe, Pa. 15650
-
(412)-537-7711
-
Fabricator

LTV Corp.
Jones and Laughlin Steel Corp.
-
-
Cleveland, OH
-
(216)-622-5000 also 800-323-0573
-
-

McInnes Steel Co.
-
400 East Main St.
-
Cory, Pa 16407-0901
-
(800)-458-0571/(814)-664-9664
-
Fabricator

File: Mill.List
5
Report: Mill List 1.0
/85

Mokes Steel Inc.
-
278 Cox St.
P.O. Box 266-T
Roselle, NJ 07203
-
(201)-241-5344
-
-

National Nickel Alloy Corp.
-
4641 Campbell Run Rd.
-
Pittsburgh, Pa. 15205
-
(412)-922-6503
-
-

Parker Steel Co.
-
Monroe at Wendover
-
Toledo, OH 43606
-
(800)-537-1980
-
-

Republic Steel Corporation
-
1441-C Republic Building
P.O. Box 6778
Clevelnad, OH 44101
-
(216)-622-5000
-
-

Sandmeyer Steel Co
-
One Sandmeyer Lane
-
Philadelphia, Pa 19116
-
(215)-464-7100
-
-

Sandvik Inc.
-
1702 Nevins Rd.
P.O. Box 428
Fairlawn, NJ 07410
-
(201)-797-6200
-
-

File: Mill.List
6
Report: Mill List 1.0
/85

Sharon Steel Corp
-
P.O. Box 291-T
-
Sharon, Pa 16146
-
(216)-448-4011
-
-

Slater Steel Inc.
Joslyn Stainless Steels Div.
P.O. Box 630
-
Fort Wayne, IN 46801
-
(219)-432-2561
-
-

Stainless Steel Products, Inc.
-
893 River Rd.
-
W. Conshohocken, Pa 19428
-
(215)-277-4142
-
-

Steel Heddle
Industrial Div.
P.O. Box 1867
-
Greenville, SC 29602
-
(803)-244-4110
-
-

Steelite Inc.
-
1010 Ohio River Blvd.
-
Pittsburgh, Pa 15202
-
(412)-734-2600
-
-

Techalloy Co. Inc.
-
Oak Rd.
-
Rahns, Pa 19426
-
(215)-489-7211
-

File: Mill.List
7
Report: Mill List 1.0
/85

Teledyne Columbia-Summerill
-
Box 1557-B
-
Pittsburgh, Pa. 15230
-
(412)-923-2040
-
-

Teledyne Rodney Metals
-
1357 E. Rodney French Blvd
-
New Bedford, Ma 02742
-
(617)-996-5691
-
-

Teledyne Vasco
-
P.O. Box 151
-
Latrobe, Pa 15650
-
-
-
-

Uddeholm Corp.
-
721 Union Blvd
-
Totowa, NJ 07511
-
(201)-785-8500
-
-

Ulbrich Stainless Steels and Special Metals Inc.
-
57 Dodge Ave.
-
North Haven, CT 06473
-
(203)-239-4481
-
-

UNA Corp
U. N. Alloy Steel Div
Federals Reserve Plaza
600 Atlantic Ave.
Boston, Ma 02210
-
(617)-973-9600
-
-

File: Mill.List
8
Report: Mill List 1.0
/85

United States Steel
U. S. Steel Special Products
600 Grant St.
-
Pittsburgh, Pa 15230
-
(412)-433-3607
-
-

Utensco
-
66 Yennicock Ave.
-
Port Washington, NY 11050
-
(516)-883-7300
-
-

Washington Steel Corp.
-
Woodlands and Griffiths Aves
-
Washington, Pa 15301
-
(412)-222-8000
-
-

White Consolidated Industries
Duraloy Blaw-Knox
Bridge St.
-
Scottdale, Pa 15683
-
(412)-887-5100
-
-

APPENDIX 2

File: Corrosion.Labs
Report: Lab List

Allied Corrosion Industries

6180 Atlantic Blvd.
Suite O
Norcross, Georgia 30092
(404)-441-5566

Bass Engineering

P.O. Box 5279

Longview, Tx 75608
(214)-759-1633

C. P. Dillon & Associates Corrosion Control Consultants

940 Park St.

St Albans, W. Va. 25177
(304)-727-2020

Caproco Corrosion Prevention LTD.

Box 5858 Sta. "L"

Edmonton, Alberta, Canada
(403)-468-2878

Corrosion Engineering Specialists
Tim Arndt
1343 Beach Parkway #1

Laciwood, OH 44107
(216)-221-1842

Corrosion Service Company Limited

369 Rimrock Rd.

Downsview, Ontario, Canada, M3J 3G2
(416)-630-2600

File: Corrosion.Labs
Report: Lab List

Corrpro Companies, Inc.

P.O. Box 1179

Medina, Ohio 44258
(216)-723-5082

CorTest Laboratories, Inc

11115 Mills Road
Suite 102
Cypress, Texas 77429
(713)-890-7575

Dixie Testing & Products, Inc.

9723 Honeywell

Houston, Texas 77074
(713)-270-7353

Henkels and McCoy, Inc.

Jolly Rd.

Blue Bell, Pa 19422
(215)-283-7600

Holloway Shunts

P.O. Box 727
410 S. Wells
Edna, Texas 77957
(512)-782-3471

JRM Associates
Dr. James R. Myers, PE
4198 Merlyn Drive

Franklin, OH 45005
(513)-422-0465

File: Corrosion.Labs
Report: Lab List

LaQue Center for Corrosion Technology (LCCT Inc)

P.O. Box 656

Wrightsville Beach, NC 28480
(919)-256-2271

Norton Corrosion Limited

22327 89th Avenue S.E.

Wooodinville, WA 98072
(206)-483-1616

Petro-Chemical Associates

P.O. Box 227

Hawthorne, NJ 07507
(201)-427-8540

Porter Corrosion Control Services Inc.

10601 Grand Rd.

Houston, TX 77070
(713)-955-1499

PSG A. V. Smith Engineering Co

Essex Bldg.

Narbeth, Pennsylvania, 19072
(215)-664-3900

PSG Ocean City Research

Ocean City, NJ 08226
(609)-399-2417

File: Corrosion.Labs
Report: Lab List

PSG The Hinchman Company

1605 Mutual Building

Detroit, MI 48226
(313)-962-5272

PSG Waters Consultants

7807 Convoy Court
Suite 110
San Diego, California 92111
(619)-565-6580

Richard B. Bender Corrosion Associates

P.O. Box 11302

Ft. Worth, TX 76110
(817)-926-4881

Sealand Corrosion Control

7010 Northwest 100 Drive
Suite 101, Building A
Houston, Texas 77092
(713)-690-1391 & 1392

Stuart Steel Protection Corp

P.O. Box 476

S. Bound Brook, NJ 08880
(201)-468-5544

GEORGIA TECH 1885-1985

DESIGNING TOMORROW TODAY

Georgia Institute of Technology
Metallurgy Program
School of Materials Engineering
Atlanta, Georgia 30332-0100
(404) 894-

April 3, 1985

Dr. John Rumble, Jr.
Office of Standard Reference Data
A323 Physics Building
National Bureau of Standards
Gaithersburg, MD 20899

SUBJECT: Grant No. NB83NADA4022
"Corrosion of Austenitic Stainless Steels in Aqueous Chloride Solutions"
Project Director: Dr. Miroslav Marek

TECHNICAL REPORT

Period Covered: 1/1/85 to 3/31/85

During the reported project period the effort, started in the previous quarter, continued; it involved contacts with companies that may have corrosion data for austenitic stainless steel exposed to aqueous chloride solutions. In the reported period the main effort was focused on corrosion testing laboratories. Each contacted company was asked to provide available corrosion data that are not confidential. All type of corrosion data have been sought, i.e., results of electrochemical tests, such as pitting and protection potentials, as well as exposure test data, such as pitting/no pitting information for various conditions, crevice attack data, etc.

Appendix 1 show a list of the companies contacted, and the response obtained to date. The response has been generally disappointing; the most common response has been that publishable data have been published, and the remaining data are confidential. However, several companies have promised data that are yet to be received.

In the next quarter a data search will continue. Several other companies will be added to the list, and the search will be extended to include unclassified reports of the governmental agencies, such as DOD.

NOTE: Because of the low overall effort rate of this project (funded 10% of PI's time, 9 months of Graduate Research Assistant, 1/3 time), the main effort in data analysis and formatting is planned for the Summer Quarter 1985.

APPENDIX 1

AL Tech Specialty Steel Corp.
Dept TR
Willow Brook Ave.
Dunkirk, NY 14048
Randy Ortel, Product Metallurgist
(716)-366-1000
No current data
No data sent

Alaskan Copper Works
P.O. Box 3546-T
Seattle, WA 98134
(206)-623-5800
Fabricator, no data

Allegheny-Ludlum Metals Group
2004 Oliver Bldg
Pittsburgh, Pa 15222
Mark Johnson
(412)-226-6211 or (412)-226-2000
Sending data
Have current data

Allied Corrosion Industries
6180 Atlantic Blvd.
Suite O
Norcross, Georgia 30092
(404)-441-5566
No data

ARMCO Inc.
Corpaorate Research Lab
Middleton, Oh
Bob Gaugh
(513)-425-2488
No data
Contact International Nickel

ASVT Stainless
Dennis Rahoi
(800)-631-0343
Will return call

Babcock and Wilcox, A McDermott Co.
Tubular Products Group
P.O. Box 401
Beaver Falls, Pa 15010
(412)-846-0100

No data
Primarialy boiler feed water

Berger Iron Works
1414-T Bonner St.
Houston, Tx 77007
(713)-869-7386
Fabricator, no data

Carpenter Technology Corp
P.O Box 662
Reading, Pa 19603
Mr E. M. Gilbert, General Manager R. D.
(215)-371-2000
Need letter
Have data some maybe proprietary

Colt Industries
Crucible Research Center
P.O. Box
Pittsgurgh, Pa 11523
John Eckenrod
(412)-923-2955
Need a letter
Have data, maybe proprietary

Corrpro Companies, Inc.
P.O. Box 1179
Medina, Ohio 44258
(216)-723-5082
Checking
May call back if any data found

Cyclops Corp.
Universial- Cyclops Specialty Steel Div.
653 Washington Rd.
Pittsburgh, Pa 15228
(412)-561-6300
No data

Henkels and McCoy, Inc.
Jolly Rd.
Blue Bell, Pa 19422
(215)-283-7600
Nothing original
Confirm the literature

International Nickel Co.
J. Anderson
(201)-843-8600
Publish all data, unless proprietary

Jessop Steel Co
Jessop Pl.
Washington, Pa. 15301
Ronald Hahn
(412)-222-4000
No data
Boiler feed water

LaQue Center for Corrosion Technology (LCCT Inc)
P.O. Box 656
Wrightsville Beach, NC 28480
(919)-256-2271
Returned call, publish or proprietary

Latrobe Steel Co.
2628 Ligonier St.
Latrobe, Pa. 15650
(412)-537-7711
Fabricator, no data

McInnes Steel Co.
400 East Main St.
Cory, Pa 16407-0901
(800)-458-0571/(814)-664-9664
Fabricator, no data

Mokes Steel Inc.
278 Cox St.
P.O. Box 266-T
Roselle, NJ 07203
(201)-241-5344
No data

Parker Steel Co.
Monroe at Wendover
Toledo, OH 43606
(800)-537-1980
No data

Petro-Chemical Associates
P.O. Box 227
Hawthorne, NJ 07507

(201)-427-8540
Cathodic Protection
Recommend AVST Stainless

PSG Ocean City Research
Ocean City, NJ 08226
(609)-399-2417
Will return call

Sandmeyer Steel Co
One Sandmeyer Lane
Philadelphia, Pa 19116
(215)-464-7100
Fabricator, no data

Sharon Steel Corp
P.O. Box 291-T
Sharon, Pa 16146
(216)-448-4011
No longer make, very old data

CORROSION OF AUSTENITIC STAINLESS STEELS IN AQUEOUS CHLORIDE SOLUTIONS- DATA COMPILATION AND CRITICAL EVALUATION

by

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TABLE OF CONTENTS

I. OBJECTIVES

The objective of the study is to compile and critically evaluate corrosion rate data for AISI Type 304 and 316 austenitic stainless steels in aqueous chloride solutions, and organize the data in a suitable form for retrieval. The study is a pilot project for the proposed NBS/NACE Corrosion Data Program, and has the following specific aims:

1. To compile, examine, and critically evaluate the academic literature on corrosion of Type 304 and 316 steels in aqueous chloride solutions;

2. To identify corrosion parameters that describe the corrosion behavior of austenitic stainless steels in aqueous chloride solutions;

3. To collect, analyze, and critically evaluate the reported data;

4. To organize the data in formats suitable for retrieval.

II. PROCEDURE

The work on this project was organized as follows:

a. Relevant academic literature was compiled and examined. The main source were corrosion journals, conference proceedings, and monographs published over the past 20 years. Papers containing experimental data were flagged.

b. Independent variables (material, environment, and test conditions) and dependent variables (corrosion parameters) were identified on the basis of significance and availability of data.

c. Flagged papers containing data were reexamined and reliable data were compiled in a computerized database.

d. Data in the database were processed and initial formatting was performed.

III. RESULTS

A. GENERAL SUMMARY OF LITERATURE

Austenitic stainless steels Type 304 and 316 are highly resistant to general corrosion in unpolluted atmospheres, fresh waters, and many environments that are corrosive to carbon and low-alloyed steels. They exhibit substantial uniform corrosion only in concentrated non-oxidizing acids, especially at high temperatures, and some special environments. In the presence of chloride ions in aqueous electrolytes the steels are susceptible to localized forms of corrosion, such as electrochemical pitting and crevice corrosion.

In addition to pitting and crevice corrosion, austenitic stainless steels may suffer severe degradation if they are sensitized, i.e., if carbide precipitation along grain boundaries depletes the grain boundary regions in chromium and makes then susceptible to corrosion. The resulting degradation is in the form of intergranular corrosion. Sensitization of Type 304 and 316 steels can be avoided by proper heat treatment, or by lowering the carbon content (low carbon steels Type 304L and 316L).

Another form of degradation of austenitic stainless steels in corrosive environments is stress corrosion cracking (SCC). Type 304 and 316 stainless steels are susceptible to SCC in aqueous chloride solutions, especially at elevated temperatures.

The scope of this study was limited to corrosion of non-sensitized steels of Type 304, 304L, 316, and 316L, in the absence of stress. Consequently, the forms of corrosion for which corrosion data were evaluated included only pitting, crevice corrosion, and uniform dissolution.

B. CORROSION PARAMETERS

1-a. Pitting Resistance/Rate Parameters

Electrochemical pitting is an electrode potential - dependent process. A critical potential can be identified above which pitting is observed. Although several different critical potentials can be defined to make a finer distinction between different stages of pitting initiation and propagation, practically significant volume of data exists only for critical potentials identified as breakdown (rupture, pitting) potential (identified in this study as E_b), and protection (repassivation) potential (identified in this study as E_{prot}). Generally, E_b represents the potential of a passive electrode above which the passive film locally breaks down and pits develop. E_{prot} represents a potential value below which the potential of an electrode must be lowered to repassivate existing pits.

Although critical potential data in the academic literature on pitting far outweigh other parameters, several other measures of pitting corrosion susceptibility have been described and data reported in sufficient quantity to warrant examination. These include pitting/no pitting data, that describe the presence or absence of pitting after a period of free corroion exposure; pit density data, determined either after periods of free corrosion exposure or following an exposure at a constant potential; pit propagation rate, representing the rate of deepening of an active pit, either in free corrosion, or under potentiostatic conditions as a function of the potential (PPR curves).

1-b. Testing Techniques

For each parameter, with the possible exception of the PPR curve measurements, the reported results have been obtained using different test conditions, or even different techniques in different laboratories. The most voluminous data for pitting, those for the breakdown potential, have been determined using either a potentiodynamic technique (anodic polarization at a moderate to high potential scanning rate), a potentiostatic technique (long exposures at constant potential), a quasi-potentiostatic technique (stepwise scanning with relatively long waiting periods), or a scratching technique (local destruction of the passive film by mechanical means). There are substantial differences in reported values obtained by different techniques, and even differences in the test conditions (such as the potential scanning rate) for the same technique affect the results. Therefore, the information on the test technique and conditions must be included in the database.

Critical potentials E_b and E_{prot} are truly significant as predictors of susceptibility to pitting only when compared with the corrosion potential (E_{corr}) of the electrode. Unfortunately, E_{corr} data are seldom reported; in addition, E_{corr} varies with time for most electrode - electrolyte combinations, and there is no agreement on a standard exposure time. The relative usefulness of the reported E_b and E_{prot} data is based on the relatively narrow range of E_{corr} for alloys of the same type in spite of material and environment variations that affect E_b and E_{prot}.

2a. Crevice Corrosion Parameters

Compared with pitting corrosion, crevice corrosion results present an even less well defined database. With the exception of the protection potential (E_{prot}), that is often considered to be also a predictor of resistance to crevice corrosion initiation, there is no widely accepted parameter of crevice corrosion susceptibility for which there would be a substantial body of data. A polarization test with an artificial crevice, in which repassivation potential is determined after initiation of pitting or crevice corrosion at +0.8 V (SCE), has been developed into a recommended practice (ASTM F 746 - 81) for testing of materials for medical implants with respect to susceptibility to pitting and crevice corrosion, but reported data are sparse. Somewhat more voluminous data have been reported for tests with a Multiple Crevice Assembly, but the multitude of different parameters (number of observed crevice corrosion sites, number of attacked sides, max. depth of attack, average depth of attack, initiation time), in addition to the uncertain effects of test conditions (contact pressure or torque) make the data difficult to use. Only recently there has been an effort to simplify the data by defining a Crevice Corrosion Index (CCI) as a product of Number of sides attacked (S) and Max. depth of attack (D). CCI data remain sparse, however.

3. Uniform Corrosion Rate Parameters

Uniform corrosion - dissolution - is easily described by weight loss data. Since corrosion of austenitic stainless steels in aqueous chloride solutions almost always has the form of localized attack, only a small number of data exists in the academic literature for weight loss rates in some unique environments, such as concentrated hydrochloric acid at elevated temperatures.

C. IDENTIFICATION OF VARIABLES

1. Independent variables

(Material, environment, and test conditions)

Although many more variables may affect corrosion behavior, only those conditions that have been reported in the academic literature as identifiable independent variables were included individually in the database. Other variables, such as details of the composition of both the materials and the electrolytes, and details of test conditions, were included in the files in the form of bulk descriptions. To date, the following major independent variables were identified and used as fields in the database:

a. Alloy Type (304. 304L, 316, 316L)
b. State of cold-work (annealed, cold-worked, cold worked and stress relieved
c. Electrolyte (basic identification)
d. Temperature
e. pH
f. Chloride ion concentration
g. Test method
h. Surface condition
i. Direction of the test specimen with respect to the forming axis
j. Percentage of cold work
k. Mode of cold working (rolling, darwing, etc.)
1. Temperature of cold working
m. Atmosphere during the test
n. Preexposure

Additional information was stored in fields containing detailed information on the material, detailed information on the electrolyte, detailed information on the test, and general notes.

2. Dependent Variables

Dependent variables are the corrosion test results, i.e., the corrosion parameters. At the end of the reported period the following parameters were identified:

a. Breakdown potential
b. Protection potential
c. Corrosion potential
d. Pitting/No pitting results
e. Pit density
f. Pit propagation rate

g. Crevice Corrosion Index
h. Critical temperature for crevice corrosion
i. Repassivation potential in the artificial crevice test

The decision to use the first two parameters in the initial data processing and formatting was based mainly on the relative availability of reported data rather than on the scientific merit of the parameters.

D. DATABASE DESIGN

Data from the literature were examined for validity; this consisted of a critical examination of the reported procedures for possible invalidating flaws. As a matter of fact, however, few data were excluded on this basis. A more serious deficiency of a relatively large number of published data was the inadequacy of the description of the material, environment, or test conditions. Poorly described conditions made the data useless in the examination of relationships between variables.

Although all the valid data were stored initially in a single masterfile, subfiles containing only a single dependent variable were developed as excerpts from the masterfile. The two subfiles that contained, at the end of the reporting period, sufficient amount of information to allow some preliminary formatting, are files EBREAK and EPROT, containing breakdown and protection potential data, respectively.

Initially, data were stored using a Commodore 64 microcomputer and a Delphi Oracle (Batteries Included, Inc.) filesystem. Lately, data were transferred into a dBaseIII (Ashton-Tate) format, making them accessible to users of IBM

PC and compatible microcomputers. A computer malfunction during the data transfer made some of the data temporarily inaccessible or scrambled; correction of this situation is in progress.

The subfiles EBREAK and EPROT have identical field structure except for the field of the corrosion parameter (result). Table 1 shows the structure of the file EBREAK.

E. INITIAL DATA PROCESSING AND FORMATTING

Files EBREAK and EPROT were used in the initial data processing and formatting. The general procedure was as follows:

a. Data were converted to a uniform set of units. These were degrees C for temperature, Volts vs. SCE (Saturated Calomel Electrode) for electrode potentials, moles per liter for concentration.

b. Data were flagged for conditions that provided a sufficient volume of data for graphical formatting. The initial examination resulted in the following arbitrary "standard" set of conditions:

i. Electrolyte: aqueous NaCl

ii. Temperature: 20 - 25 ^{o} C

iii. Annealed material

iv. pH 4-8

v. Method: potentiodynamic

c. Chloride ion concentration was identified as the major independent variable.

d. Flagged data for the standard conditions were plotted in graphs showing the critical potentials as a function of chloride ion concentration. Linear regression lines were determined.

e. Data showing the effect of other independent variables, such as pH (in groups of pH 1-3 and pH 9-19), cold-worked condition, other test techniques than potentiodynamic, etc., were plotted in graphs of E_b or E_{prot} vs. Cl^- concentration, superimposed on the regression lines for the standard conditions.

f. The dataset for alloy 304 and the standard conditions was normalized with respect to chloride ion concentration, i.e., the regression value for concentration 1.0 M was determined.

g. Plots of the critical potentials vs. other major variables, such as temperature, were attempted using normalized values. The formatting process was interrupted at this point because of lack of data.

F. RESULTS

Table 2 shows the list of records in datafile EBREAK, omitting the less significant fields. Table 3 shows a similar list for datafile EPROT.

The results of the initial data processing and formatting for the breakdown potential E_b and alloy 304 (groupped with 304L) are shown in Figures 1 to 6; Figure 7 shows all E_b data for Type 316, and Figure 8 data for Type 316 and standard conditions, superimposed on the regression lines for Type 304. There were insufficient data for allloy 316 to display the effects of variables other than chloride ion concentration.

Figures 9 to 11 show E_{prot} data for Type 304 steel, and Figure 12 a comparison of E_b with E_{prot}. Figure 13 shows the normalized data for alloy 304 as a function of temperature.

IV. DISCUSSION

Even a cursory examination of the plot of all breakdown potential data vs. chloride ion concentration (Figure 1) shows that many variables other than Cl^- concentration affect the critical potential. This result has been, of course, expected, because the data are for various temperatures and test methods, and these variables are known to affect E_b. The breakdown potential data compiled to date for arbitrarily chosen "standard conditions" (Fig. 2) have shown that for a moderately large dataset the results from different laboratories are in relatively good agreement, i.e., can be considered to belong to the same population. Linear regression of E_b vs. $[Cl^-]$ for the selected "standard conditions," using data reported by several different laboratories, yielded a relationship

$$E_b = 0.319 - 0.0843\ [Cl^-]$$

which is in reasonable agreement with results reported in the literature from individual studies. This outcome is encouraging with regard to the possibility of using data reported in the literature in the database of the corrosion data program. On the other hand, data dispersion in small datasets was too high for a fine differentiation between similarly behaving systems.

The large number of variables affecting corrosion behavior makes it difficult to obtain a sufficient database that could be used to predict the behavior under widely varied conditions. Breakdown potential E_b is the most commonly reported parameter for corrosion of austenitic stainless steels in aqueous chloride solutions. The fact that not even this common paramater has provided a database sufficient for description of the effects of more than one variable (chloride ion concentration) is a reason for concern regarding the feasibility of a corrosion data bank for this material/environment combination, based only on data from academic literature.

Another difficulty concerns the choice of parameters that describe the susceptibility to corrosion. Breakdown and protection potentials have a sound basis in theoretical and experimental work, can be determined using relatively short, straightforward, and well controlled tests, and test data have been widely reported. On the other hand, critical potentials are not easily used to predict the corrosion behavior under field conditions. Following are some of the difficulties:

a. The correct criterion for occurrence or lack of pitting is the relationship between the corrosion potential and the breakdown or protection potential, i.e., whether

E_{corr} is above or below E_b or E_{prot}. Even if the critical potentials are known for a given material/environment combination, E_{corr} also would have to be known. E_{corr}, however, depends strongly on sometimes small variations in solution chemistry as well as time, and cannot be predicted on the basis of tests performed under simplified laboratory conditions. Consequently, E_{corr} would have to be established in each case in field tests. If field tests are necessary, however, then it is just as easy, and more direct, to test for the occurrence of pitting than to determine potentials and base the prediction on them.

b. Although critical potentials E_b and E_{prot} can be used to establish the relative susceptibility of materials of the same type to localized corrosion, data compiled from the literature are not suitable enough for this purpose. Dispersion of corrosion data is relatively high even for results from the same laboratory, and much higher for data from different laboratories. Figure 8 illustrates that published breakdown potential data did not show a difference in susceptibility to pitting between Type 304 and 316 steels, although the difference is well established by experience in the field. Although a better differentiation may be shown by E_{prot} data, it must be considered that a difference in the true values of critical potentials that is of the same magnitude as data dispersion can make a significant difference in the corrosion susceptibility. In other words, materials that are truly different in susceptibility may not show statistically significant difference in measured critical potentials because of a large data dispersion.

Therefore, a tentative conclusion is made that while critical potentials and other similar data are important and useful to researchers, users of materials susceptible to localized corrosion need a different set of data. So far, most promising type of data seems to be the pitting/no pitting information for various conditions, such as solution chemistry. Data of this type directly predict if pitting will occur under given conditions, without the interpretation involved in dealing with critical potentials. Pitting/no pitting information can be presented in graphs that show the effects of variables, as shown schematically in Figure 14.

There are some potentially serious difficulties in setting a databank of pitting/no pitting information. These data are seldom reported in academic literature and would have to be obtained mainly from users and manufacturers of the materials and other industrial sources. There is no standard practice for running the tests, and data from different sources may be incompatible. The large diversity of conditions affecting corrosion would still present a problem in data formatting. On the other hand, incomplete datasets would be more useful than in case of critical potentials.

V. CONCLUSIONS AND RECOMMENDATIONS

1. Critical potential data, especially breakdown potentials, are the most commonly reported corrosion parameters for evaluation of the susceptibility of austenitic stainless steels to pitting in aqueous chloride solutions.

2. Critical potential data that have been reported in the academic literature are not systematic and voluminous enough to allow prediction of the effects of the many variables that affect localized corrosion.

3. Critical potential data, although scientifically sound and useful for research purposes, are not suitable for prediction of localized corrosion under given field conditions.

4. Pitting/no pitting data may provide a useful basis for predicting localized corrosion in the field. The development of a database of this type will be explored.

5. The present database of critical potentials and other corrosion data will be further expanded and different approaches to data formatting and retrieval will be explored.

TABLE 1

STRUCTURE OF FILE EBREAK.DBF

Field	Field name	Type	Width	Dec
1	ALLOY	Character	5	
2	CW	Character	2	
3	ELLYTE	Character	13	
4	TEMP_C	Character	3	
5	PH	Character	4	
6	CL_M	Numeric	8	6
7	ACT	Character	1	
8	EB_VSCE	Numeric	6	3
9	METHOD	Character	3	
10	REF_NO	Numeric	3	
11	ALLOY_NO	Numeric	2	
12	ELLYTE_NO	Numeric	2	
13	METHOD_NO	Numeric	2	
14	SURFACE	Character	10	
15	DIR	Character	1	
16	CW_PC	Character	3	
17	CW_MODE	Character	7	
18	CW_TEMP	Character	3	
19	ATMOSPHERE	Character	10	
20	PREEXP	Character	12	
21	NOTE	Character	20	

TABLE 2
BREAKDOWN POTENTIALS FILE

ALLOY	AN CW SR	ELLYTE	TEMP [C]	PH	Cl Conc [M]	Eb [V,SCE]	METH	REF NO	DIR	CW [%]	CW MODE
304	AN	NaCl	0	N	0.100000	0.510	QPS	32		0	
304	AN	NaCl	5	N	0.100000	0.570	QPS	38		0	
304	AN	NaCl	-1	N	0.100000	0.680	QPS	38		0	
304	AN	NaCl	15	N	0.100000	0.290	QPS	38		0	
304	CW	NaCl	20	N	0.171000	0.420	PD	3		?	rolling
304	CW	NaCl	20	N	0.855000	0.080	PD	3		?	rolling
304	CW	NaCl	20	N	1.710000	0.070	PD	3		?	rolling
304	AN	NaCl	22	1.0	0.000282	0.950	PD	52		0	
304	AN	NaCl	22	2.0	0.000282	0.990	PD	52		0	
304	AN	NaCl	22	4.0	0.000282	0.730	PD	52		0	
304	AN	NaCl	22	6.4	0.000282	0.680	PD	52		0	
304	AN	NaCl	22	8.0	0.000282	0.770	PD	52		0	
304	AN	NaCl	22	10.0	0.000282	0.930	PD	52		0	
304	AN	NaCl	22	N	0.000282	0.650	PD	52		0	
304	AN	NaCl	22	N	0.000282	0.700	PD	52		0	
304	AN	NaCl	22	N	0.000705	0.650	PD	52		0	
304	AN	NaCl	22	N	0.000705	0.620	PD	52		0	
304	AN	NaCl	22	N	0.001410	0.500	PD	52		0	
304	AN	NaCl	22	N	0.001410	0.600	PD	52		0	
304	AN	NaCl	22	2.0	0.002820	0.720	PD	52		0	
304	AN	NaCl	22	4.0	0.002820	0.590	PD	52		0	
304	AN	NaCl	22	6.4	0.002820	0.580	PD	52		0	
304	AN	NaCl	22	8.0	0.002820	0.600	PD	52		0	
304	AN	NaCl	22	10.0	0.002820	0.580	PD	52		0	
304	AN	NaCl	22	N	0.002820	0.550	PD	52		0	
304	AN	NaCl	22	N	0.002820	0.630	PD	52		0	
304	AN	NaCl	22	N	0.005640	0.450	PD	52		0	

TABLE 2
BREAKDOWN POTENTIALS FILE

ALLOY	AN CW SR	ELLYTE	TEMP [C]	PH	Cl Conc [M]	Eb [V,SCE]	METH	REF NO	DIR	CW [%]	CW MODE
304	AN	NaCl	22	N	0.014100	0.400	PD	52		0	
304	AN	NaCl	22	1.0	0.028200	0.370	PD	52		0	
304	AN	NaCl	22	2.0	0.028200	0.420	PD	52		0	
304	AN	NaCl	22	4.0	0.028200	0.350	PD	52		0	
304	AN	NaCl	22	6.0	0.028200	0.350	PD	52		0	
304	AN	NaCl	22	8.0	0.028200	0.570	PD	52		0	
304	AN	NaCl	22	10.0	0.028200	0.510	PD	52		0	
304	AN	NaCl	22	N	0.028200	0.300	PD	52		0	
304	AN	NaCl	22	N	0.028200	0.400	PD	52		0	
304	CW	NaCl	22	N	0.034000	0.730	PD	2		?	rolling
304	CW	NaCl	22	N	0.034000	0.690	PD	2		?	rolling
304	AN	NaCl	22	N	0.056400	0.460	PD	2		0	
304	AN	NaCl	22	N	0.056400	0.430	PD	2		0	
304	CW	NaCl	22	N	0.069000	0.660	PD	2		?	rolling
304	CW	NaCl	22	N	0.069000	0.620	PD	2		?	rolling
304	CW	NaCl	22	N	0.100000	0.243	PD	6		?	rolling
304	CW	NaCl	22	N	0.138000	0.640	PD	2		?	rolling
304	CW	NaCl	22	N	0.138000	0.600	PD	2		?	rolling
304	CW	NaCl	22	N	0.138000	0.690	PD	2		?	rolling
304	CW	NaCl	22	N	0.138000	0.620	PD	2		?	rolling
304	AN	NaCl	22	N	0.141000	0.400	PD	52		0	
304	AN	NaCl	22	N	0.141000	0.250	PD	52		0	
304	AN	NaCl	22	1.0	0.282000	0.100	PD	52		0	
304	AN	NaCl	22	4.0	0.282000	0.300	PD	52		0	
304	AN	NaCl	22	6.3	0.282000	0.370	PD	52		0	
304	AN	NaCl	22	8.0	0.282000	0.300	PD	52		0	
304	AN	NaCl	22	10.0	0.282000	0.380	PD	52		0	

TABLE 2
BREAKDOWN POTENTIALS FILE

ALLOY	AN CW SR	ELLYTE	TEMP [C]	PH	Cl Conc [M]	Eb [V,SCE]	METH	REF NO	DIR	CW [%]	CW MODE
304	AN	NaCl	22	N	0.282000	0.350	PD	52		0	
304	AN	NaCl	22	N	0.282000	0.400	PD	52		0	
304	CW	NaCl	22	N	0.340000	0.510	PD	2		?	rolling
304	CW	NaCl	22	N	0.340000	0.460	PD	2		?	rolling
304	CW	NaCl	22	N	0.340000	0.480	PD	2		?	rolling
304	AN	NaCl	22	N	0.564000	0.250	PD	52		0	
304	AN	NaCl	22	N	0.564000	0.220	PD	52		0	
304	CW	NaCl	22	N	0.600000	0.420	PD	2		?	rolling
304	CW	NaCl	22	N	0.600000	0.450	PD	2		?	rolling
304	AN	NaCl	22	N	1.128000	0.290	PD	52		0	
304	AN	NaCl	22	N	1.128000	0.210	PD	52		0	
304	AN	NaCl+bor.acid	25	7.0	0.000430	0.740	PD	11		0	
304	AN	NaCl+bor.acid	25	7.0	0.004200	0.670	PD	11		0	
304	AN	NaCl+bor.acid	25	7.0	0.009400	0.630	PD	11		0	
304	AN	NaCl	25	N	0.010000	0.110	PS	38		0	
304	AN	NaCl+bor.acid	25	7.0	0.043000	0.520	PD	11		0	
304	AN	NaCl+NaHCO3	25	8.0	0.072000	0.610	S	16		0	
304	AN	NaCl+bor.acid	25	7.0	0.091000	0.480	PD	11		0	
304	AN	NaCl + HCl	25	1.2	0.100000	0.110	QPS	38		0	
304	AN	NaCl + HCl	25	2.8	0.100000	0.110	QPS	38		0	
304	AN	NaCl + HCl	25	6.3	0.100000	0.120	QPS	38		0	
304	AN	NaCl+ NaOH	25	7.7	0.100000	0.140	QPS	38		0	
304	AN	NaCl+ NaOH	25	8.5	0.100000	0.240	QPS	38		0	
304	AN	NaCl+ NaOH	25	9.3	0.100000	0.340	QPS	38		0	
304	AN	NaCl+ NaOH	25	10.3	0.100000	0.700	QPS	38		0	
304	AN	NaCl	25	N	0.100000	0.020	PS	38		0	
304	AN	NaCl	25	N	0.100000	0.120	QPS	32		0	

TABLE 2
BREAKDOWN POTENTIALS FILE

ALLOY	AN CW SR	ELLYTE	TEMP [C]	PH	Cl Conc [M]	Eb [V,SCE]	METH	REF NO	DIR	CW [%]	CW MODE
304	AN	NaCl	25	N	0.100000	0.110	QPS	38		0	
304	AN	NaCl+bor.acid	25	7.0	0.410000	0.330	PD	11		0	
304	CW	NaCl	25	N	0.500000	0.467	PD	8		?	rolling
304	CW	NaCl	25	N	0.500000	0.475	PD	8		?	rolling
304	AN	NaCl	25	N	0.500000	-0.020	PS	38		0	
304	CW	NaCl	25	N	0.500000	0.283	PD	8		?	rolling
304	AN	NaCl+NaHCO3	25	N	0.500000	0.390	S	16		0	
304	AN	NaCl+NaHCO3	25	N	0.500000	0.424	S	16		0	
304	CW	NaCl	25	N	0.500000	0.500	PD	8		?	rolling
304	CW	NaCl	25	N	0.500000	0.283	PD	8		?	rolling
304	CW	NaCl	25	N	0.500000	0.258	PD	8		?	rolling
304	AN	NaCl+NaHCO3	25	N	0.500000	0.384	S	16		0	
304	AN	NaCl	25	N	0.500000	-0.010	QPS	20		0	
304	CW	NaCl+NaHCO3	25	N	0.500000	0.260	S	16		30	rolling
304	AN	NaCl	25	N	0.600000	0.000	PD	21		0	
304	AN	NaCl+NaHCO3	25	8.0	0.680000	0.350	S	16		0	
304	AN	NaCl+bor.acid	25	7.0	0.880000	0.290	PD	11		0	
304	AN	NaCl	25	N	1.000000	-0.060	PS	38		0	
304	AN	NaCl	25	N	1.000000	-0.050	QPS	20		0	
304	AN	NaCl+NaHCO3	25	8.0	3.530000	0.250	S	16		0	
304	AN	NaCl+bor.acid	25	7.0	4.660000	0.230	PD	11		0	
304	?	NaCl	30	N	0.513000	0.055	?	4		?	
304	CW	NaCl	40	N	0.100000	0.175	?	6		?	rolling
304	AN	NaCl	40	N	0.100000	0.090	QPS	38		0	
304	AN	NaCl+NaHCO3	40	N	0.500000	0.334	S	16		0	
304	AN	NaCl	50	N	0.100000	0.080	QPS	38		0	
304	?	NaCl	50	N	0.513000	0.006	?	4		?	

TABLE 2
BREAKDOWN POTENTIALS FILE

ALLOY	AN CW SR	ELLYTE	TEMP [C]	PH	Cl Conc [M]	Eb [V,SCE]	METH	REF NO	DIR	CW [%]	CW MODE
304	?	NaCl	60	N	0.100000	0.093	?	6		?	
304	AN	NaCl+NaHCO3	60	N	0.500000	0.144	S	16		0	
304	AN	NaCl+NaHCO3	60	N	0.500000	0.164	S	16		0	
304	CW	NaCl	64	N	0.003400	0.640	PD	2		?	rolling
304	CW	NaCl	64	N	0.003400	0.550	PD	2		?	rolling
304	CW	NaCl	64	N	0.003400	0.660	PD	2		?	rolling
304	CW	NaCl	64	N	0.008500	0.460	PD	2		?	rolling
304	CW	NaCl	64	N	0.008500	0.420	PD	2		?	rolling
304	CW	NaCl	64	N	0.017000	0.370	PD	2		?	rolling
304	CW	NaCl	64	N	0.017000	0.360	PD	2		?	rolling
304	CW	NaCl	64	N	0.034000	0.390	PD	2		?	rolling
304	CW	NaCl	64	N	0.034000	0.380	PD	2		?	rolling
304	CW	NaCl	64	N	0.034000	0.350	PD	2		?	rolling
304	CW	NaCl	64	N	0.066000	0.260	PD	2		?	rolling
304	CW	NaCl	64	N	0.066000	0.300	PD	2		?	rolling
304	CW	NaCl	64	N	0.066000	0.280	PD	2		?	rolling
304	CW	NaCl	64	N	0.131000	0.260	PD	2		?	rolling
304	CW	NaCl	64	N	0.131000	0.230	PD	2		?	rolling
304	CW	NaCl	64	N	0.131000	0.300	PD	2		?	rolling
304	CW	NaCl	64	N	0.600000	0.120	PD	2		?	rolling
304	CW	NaCl	64	N	0.600000	0.150	PD	2		?	rolling
304	CW	NaCl	64	N	0.600000	0.100	PD	2		?	rolling
304	?	NaCl	65	N	0.513000	-0.042	?	4		?	
304	CW	NaCl	80	N	0.100000	0.026	?	6		?	rolling
304	?	NaCl	80	N	0.513000	-0.095	?	4		?	
304	AN	NaCl+NaHCO3	90	N	0.500000	0.084	S	16		0	
304	AN	NaCl	90	N	0.500000	-0.100	QPS	20		0	

TABLE 2
BREAKDOWN POTENTIALS FILE

ALLOY	AN CW SR	ELLYTE	TEMP [C]	PH	Cl Conc [M]	Eb [V,SCE]	METH	REF NO	DIR	CW [%]	CW MODE
304	AN	NaCl+NaHCO3	90	N	0.500000	0.064	S	16		0	
304	AN	NaCl	90	N	1.000000	-0.150	QPS	20		0	
304	AN	HCl	RT	2.0	0.010000	0.563	QPS	1		0	
304	AN	NaCl+sulfate	RT	2.0	0.015000	0.275	QPS	1		0	
304	AN	NaCl+sulfate	RT	2.0	0.030000	0.079	QPS	1		0	
304	AN	NaCl+sulfate	RT	2.0	0.050000	-0.004	QPS	1		0	
304	AN	NaCl+sulfate	RT	2.0	0.080000	-0.004	QPS	1		0	
304	AN	NaCl+sulfate	RT	2.0	0.100000	-0.150	QPS	1		0	
304	AN	NaCl+sulfate	RT	2.0	0.300000	-0.171	QPS	1		0	
304	?	NaCl	RT	2.2	0.513000	-0.046	?	4		?	
304	AN	NaCl+sulfate	RT	2.0	1.000000	-0.195	QPS	1		0	
304	?	NaCl	100	N	0.513000	-0.153	?	4		?	
304	CW	NaCl	?RT	N	0.250000	0.260	PD	9		?	rolling
304	?	NaCl	?RT	2.5	0.513000	-0.027	?	4		?	
304	?	NaCl	?RT	5.9	0.513000	0.004	?	4		?	
304	?	NaCl	?RT	7.0	0.513000	0.046	?	4		?	
304	?	NaCl	?RT	10.0	0.513000	0.056	?	4		?	
304	?	NaCl	?RT	11.5	0.513000	0.100	?	4		?	
304	?	NaCl	?RT	12.0	0.513000	0.405	?	4		?	
304L	?	NaCl + HCl	23	4.0	1.000000	0.263	PK	15		?	
304L	?	NaCl + HCl	23	4.0	1.000000	0.255	PK	15		?	
304L	?	NaCl + HCl	23	4.0	1.000000	0.264	PK	15		?	
304L	?	NaCl + HCl	23	4.0	1.000000	0.243	PK	15		?	
304L	?	NaCl + HCl	23	4.0	1.000000	0.250	PK	15		?	
304L	CW	NaCl	25	N	0.003000	0.557	PD	13		?	rolling
304L	AN	HCl	25	N	0.100000	0.101	PD	17	T	0	
304L	CW	HCl	25	N	0.100000	-0.079	PD	17	L	30	drawing

TABLE 2
BREAKDOWN POTENTIALS FILE

ALLOY	AN CW SR	ELLYTE	TEMP [C]	PH	Cl Conc [M]	Eb [V,SCE]	METH	REF NO	DIR	CW [%]	CW MODE
304L	CW	HCl	25	N	0.100000	-0.105	PD	17	T	30	drawing
304L	CW	HCl	25	N	0.100000	0.230	PD	17	L	10	rolling
304L	CW	HCl	25	N	0.100000	-0.119	PD	17	L	50	rolling
304L	CW	HCl	25	N	0.100000	-0.093	PD	17	T	30	rolling
304L	CW	HCl	25	N	0.100000	-0.074	PD	17	T	10	rolling
304L	AN	HCl	25	N	0.100000	0.047	PD	17	T	0	
304L	CW	HCl	25	N	0.100000	-0.115	PD	17	T	10	drawing
304L	CW	HCl	25	N	0.100000	-0.067	PD	17	L	30	rolling
304L	CW	HCl	25	N	0.100000	-0.132	PD	17	T	50	rolling
304L	AN	HCl	25	N	0.100000	0.051	PD	17	T	0	
304L	CW	HCl	25	N	0.100000	-0.079	PD	17	L	50	drawing
304L	CW	HCl	25	N	0.100000	-0.115	PD	17	T	50	drawing
304L	CW	HCl	25	N	0.100000	-0.074	PD	17	T	10	rolling
304L	AN	HCl	25	N	0.100000	0.301	PD	17	L	0	
304L	AN	HCl	25	N	0.100000	0.282	PD	17	L	0	
304L	CW	HCl	25	N	0.100000	-0.075	PD	17	L	10	drawing
304L	CW	Physiolog.sol	38	7.0	0.150000	0.126	PD	25	T	15	tension
304L	CW	Physiolog.sol	38	7.0	0.150000	0.150	PD	25	T	10	tension
304L	AN	Physiolog.sol	38	7.0	0.150000	0.276	PD	25	L	0	
304L	CW	Physiolog.sol	38	7.0	0.150000	0.248	PD	25	L	30	tension
304L	AN	Physiolog.sol	38	7.0	0.150000	0.195	PD	25	T	0	
304L	CW	Physiolog.sol	38	7.0	0.150000	0.123	PD	25	T	30	tension
304L	CW	Physiolog.sol	38	7.0	0.150000	0.251	PD	25	L	30	tension
304L	AN	Physiolog.sol	38	7.0	0.150000	0.195	PD	25	T	0	
304L	CW	Physiolog.sol	38	7.0	0.150000	0.251	PD	25	L	15	tension
304L	CW	Physiolog.sol	38	7.0	0.150000	0.226	PD	25	L	10	tension
304L	CW	NaCl	90	N	0.003000	0.336	PD	13		?	rolling

TABLE 2
BREAKDOWN POTENTIALS FILE

ALLOY	AN CW SR	ELLYTE	TEMP [C]	PH	Cl Conc [M]	Eb [V,SCE]	METH	REF NO	DIR	CW [%]	CW MODE
304L	CW	NaCl	150	N	0.003000	-0.139	PD	13		?	rolling
304L	CW	NaCl	220	N	0.003000	-0.244	PD	13		?	rolling
304L	CW	NaCl	289	N	0.003000	-0.271	PD	13		?	rolling
316	CW	NaCl	20	N	0.171000	0.560	PD	3		?	rolling
316	CW	NaCl	20	N	0.513000	0.370	PD	3		?	rolling
316	CW	NaCl	20	N	0.855000	0.300	PD	3		?	rolling
316	CW	NaCl	20	N	1.710000	0.300	PD	3		?	rolling
316	CW	NaCl	22	N	0.100000	0.388		6		?	rolling
316	CW	NaCl+NaHCO3	25	N	0.500000	0.340	S	6		30	rolling
316	CW	NaCl	25	N	0.500000	0.483	PD	8		?	rolling
316	AN	NaCl+NaHCO3	25	N	0.500000	0.430	S	6		0	
316	CW	NaCl	25	N	0.500000	0.417	PD	8		?	rolling
316	CW	NaCl	25	N	0.500000	0.525	PD	8		?	rolling
316	CW	NaCl	25	N	0.500000	0.617	PD	8		?	rolling
316	CW	NaCl	25	N	0.500000	0.525	PD	8		?	rolling
316	CW	NaCl	25	N	0.500000	0.525	PD	8		?	rolling
316	AN	NaCl	25	N	0.600000	0.100		21		0	
316	?	NaCl	30	N	0.513000	0.260		4		?	
316	?	NaCl	30	N	0.513000	0.258		4		?	
316	?	NaCl	38	N	0.513000	0.206		4		?	
316	?	NaCl	38	N	0.513000	0.163		4		?	
316	?	NaCl	40	N	0.100000	0.290		6		?	
316	?	NaCl	43	N	0.513000	0.158		4		?	
316	?	NaCl	43	N	0.513000	0.109		4		?	
316	?	NaCl	50	N	0.513000	0.109		4		?	
316	CW	NaCl	60	N	0.100000	0.181		6		?	rolling
316	?	NaCl	60	N	0.513000	0.057		4		?	

TABLE 2
BREAKDOWN POTENTIALS FILE

ALLOY	AN CW SR	ELLYTE	TEMP [C]	PH	Cl Conc [M]	Eb [V,SCE]	METH	REF NO	DIR	CW [%]	CW MODE
316	?	NaCl	65	N	0.513000	0.055		4		?	
316	CW	NaCl + HCl	70	2.0	0.694000	-0.094	PK	10		?	rolling
316	?	NaCl	75	N	0.513000	0.006		4		?	
316	CW	NaCl	80	N	0.100000	0.083		6		?	rolling
316	?	NaCl	85	N	0.513000	0.006		4		?	
316	?	NaCl	95	N	0.513000	0.006		4		?	
316	?	NaCl	100	N	0.513000	0.003		4		?	
316	?	NaCl	?RT	2.0	0.513000	0.253		4		?	
316	?	NaCl	?RT	2.6	0.513000	0.257		4		?	
316	?	NaCl	?RT	3.0	0.513000	0.257		4		?	
316	?	NaCl	?RT	4.2	0.513000	0.258		4		?	
316	?	NaCl	?RT	7.0	0.513000	0.260		4		?	
316	?	NaCl	?RT	9.3	0.513000	0.306		4		?	
316	?	NaCl	?RT	10.0	0.513000	0.309		4		?	
316	?	NaCl	?RT	11.0	0.513000	0.459		4		?	
316	?	NaCl	?RT	11.8	0.513000	0.551		4		?	
316L	CW	HCl	25	N	0.100000	-0.136	PD	17	T	50	drawing
316L	AN	HCl	25	N	0.100000	0.301	PD	17	L	0	
316L	CW	HCl	25	N	0.100000	-0.133	PD	17	T	10	drawing
316L	CW	HCl	25	N	0.100000	0.232	PD	17	L	50	drawing
316L	CW	HCl	25	N	0.100000	0.291	PD	17	L	10	drawing
316L	AN	HCl	25	N	0.100000	-0.079	PD	17	T	0	
316L	CW	HCl	25	N	0.100000	0.152	PD	17	L	30	drawing
316L	CW	HCl	25	N	0.100000	-0.133	PD	17	T	30	drawing
316L	CW	Tyrode's sol.	37	N	0.142000	0.311	PD	24		?	rolling
316L	CW	Tyrode's sol.	37	N	0.142000	0.387	FPD	24		?	rolling
316L	CW	Tyrode's sol.	37	N	0.142000	0.416	FPD	24		?	rolling

TABLE 2
BREAKDOWN POTENTIALS FILE

ALLOY	AN CW SR	ELLYTE	TEMP [C]	PH	Cl Conc [M]	Eb [V,SCE]	METH	REF NO	DIR	CW [%]	CW MODE
316L	SR	Tyrode's sol.	37	N	0.142000	0.378	CP	18			
316L	AN	Tyrode's sol.	37	N	0.142000	0.346	CP	18		0	
316L	CW	Tyrode's sol.	37	N	0.142000	0.422	FPD	24		?	rolling
316L	CW	Tyrode's sol.	37	N	0.142000	0.466	FPD	24		?	rolling
316L	CW	Tyrode's sol.	37	N	0.142000	1.147	FPD	24		?	rolling
316L	CW	Tyrode's sol.	37	N	0.142000	0.291	PD	24		?	rolling
316L	CW	Tyrode's sol.	37	N	0.142000	0.421	CP	18		?	rolling
316L	CW	Tyrode's sol.	37	N	0.142000	0.409	FPD	24		?	rolling
316L	AN	Ringer's sol.	37	7.4	0.155000	0.350	PD	23		0	
316L	CW	Physiolog.sol	38	7.0	0.150000	0.253	PD	25		?	tension
316L	CW	Physiolog.sol	38	7.0	0.150000	0.404	PD	25		?	tension
316L	CW	Physiolog.sol	38	7.0	0.150000	0.198	PD	25		?	tension
316L	CW	Physiolog.sol	38	7.0	0.150000	0.204	PD	25		?	tension
316L	AN	Physiolog.sol	38	7.0	0.150000	0.403	PD	25		0	
316L	AN	Physiolog.sol	38	7.0	0.150000	0.379	PD	25		0	
316L	AN	Physiolog.sol	38	7.0	0.150000	0.330	PD	25		0	
316L	AN	Physiolog.sol	38	7.0	0.150000	0.373	PD	25		0	
316L	CW	Physiolog.sol	38	7.0	0.150000	0.178	PD	25		?	tension
316L	CW	Physiolog.sol	38	7.0	0.150000	0.403	PD	25		?	rolling
316L	CW	Physiolog.sol	38	7.0	0.150000	0.303	PD	25		?	rolling
316L	CW	Physiolog.sol	38	7.0	0.150000	0.327	PD	25		?	rolling
316L	CW	Physiolog.sol	38	7.0	0.150000	0.000	PD	25		?	rolling
316L	CW	Physiolog.sol	38	7.0	0.150000	0.204	PD	25		?	rolling

TABLE 3
PROTECTION POTENTIALS FILE

ALLOY	AN CW SR	ELLYTE	TEMP [C]	PH	Cl Conc [M]	Eprot [V,SCE]	METH	REF NO	DIR	CW [%]	CW MODE
304	?	NaCl	20	3.0	0.100000	-0.108	PDH	27			
304	?	NaCl	20	5.0	0.100000	0.059	PDH	27			
304	?	NaCl	20	7.0	0.100000	-0.144	PDH	27			
304	?	NaCl	20	9.0	0.100000	-0.278	PDH	27			
304	CW	NaCl	22	N	0.009000	0.080	PDH	2			rolling
304	CW	NaCl	22	N	0.009000	0.060	PDH	2			rolling
304	CW	NaCl	22	N	0.017000	0.060	PDH	2			rolling
304	CW	NaCl	22	N	0.017000	0.080	PDH	2			rolling
304	CW	NaCl	22	N	0.034000	0.040	PDH	2			rolling
304	CW	NaCl	22	N	0.034000	0.070	PDH	2			rolling
304	CW	NaCl	22	N	0.069000	0.010	PDH	2			rolling
304	CW	NaCl	22	N	0.069000	0.070	PDH	2			rolling
304	CW	NaCl	22	N	0.138000	0.090	PDH	2			rolling
304	CW	NaCl	22	N	0.138000	0.040	PDH	2			rolling
304	CW	NaCl	22	N	0.138000	-0.060	PDH	2			rolling
304	CW	NaCl	22	N	0.138000	0.070	PDH	2			rolling
304	CW	NaCl	22	N	0.340000	-0.080	PDH	2			rolling
304	CW	NaCl	22	N	0.340000	-0.090	PDH	2			rolling
304	CW	NaCl	22	N	0.340000	-0.110	PDH	2			rolling
304	CW	NaCl	22	N	0.340000	-0.120	PDH	2			rolling
304	CW	NaCl	22	N	0.600000	-0.200	PDH	2			rolling
304	CW	NaCl	22	N	0.600000	-0.190	PDH	2			rolling
304	AN	NaCl+bor.acid	25	7.0	0.000430	-0.190	PD	11			
304	AN	NaCl+bor.acid	25	7.0	0.004200	-0.300	PD	11			
304	AN	NaCl+bor.acid	25	7.0	0.009400	-0.220	PD	11			
304	AN	NaCl+bor.acid	25	7.0	0.043000	-0.280	PD	11			
304	AN	NaCl+bor.acid	25	7.0	0.410000	-0.360	PD	11			

TABLE 3
PROTECTION POTENTIALS FILE

ALLOY	AN CW SR	ELLYTE	TEMP [C]	PH	Cl Conc [M]	Eprot [V,SCE]	METH	REF NO	DIR	CW [%]	CW MODE
304	CW	NaCl	64	N	0.003400	-0.060	PDH	2			rolling
304	CW	NaCl	64	N	0.003400	0.010	PDH	2			rolling
304	CW	NaCl	64	N	0.008500	0.000	PDH	2			rolling
304	CW	NaCl	64	N	0.008500	-0.060	PDH	2			rolling
304	CW	NaCl	64	N	0.016600	-0.020	PDH	2			rolling
304	CW	NaCl	64	N	0.016600	-0.040	PDH	2			rolling
304	CW	NaCl	64	N	0.034000	0.010	PDH	2			rolling
304	CW	NaCl	64	N	0.034000	0.000	PDH	2			rolling
304	CW	NaCl	64	N	0.034000	-0.030	PDH	2			rolling
304	CW	NaCl	64	N	0.034000	0.000	PDH	2			rolling
304	CW	NaCl	64	N	0.066000	0.000	PDH	2			rolling
304	CW	NaCl	64	N	0.066000	-0.120	PDH	2			rolling
304	CW	NaCl	64	N	0.066000	-0.050	PDH	2			rolling
304	CW	NaCl	64	N	0.131000	-0.080	PDH	2			rolling
304	CW	NaCl	64	N	0.131000	-0.030	PDH	2			rolling
304	CW	NaCl	64	N	0.131000	-0.150	PDH	2			rolling
304	CW	NaCl	64	N	0.600000	-0.120	PDH	2			rolling
304	CW	NaCl	64	N	0.600000	-0.150	PDH	2			rolling
304	CW	NaCl	64	N	0.600000	-0.160	PDH	2			rolling
304	CW	NaCl	64	N	0.600000	-0.240	PDH	2			rolling
304	CW	NaCl	64	N	0.600000	-0.090	PDH	2			rolling
304	CW	NaCl	64	N	0.600000	-0.280	PDH	2			rolling
316L	AN	Tyrode's sol.	37	N	0.142000	0.249	CP	18			
316L	CW	Tyrode's sol.	37	N	0.142000	0.130	CP	24			
316L	CW	Tyrode's sol.	37	N	0.142000	0.019	CP	24			
316L	CW	Tyrode's sol.	37	N	0.142000	-0.020	CP	24			
316L	CW	Tyrode's sol.	37	N	0.142000	0.052	CP	24			

TABLE 3
PROTECTION POTENTIALS FILE

ALLOY	AN CW SR	ELLYTE	TEMP [C]	PH	Cl Conc [M]	Eprot [V,SCE]	METH	REF NO	DIR	CW [%]	CW MODE
316L	CW	Tyrode's sol.	37	N	0.142000	0.144	PD	24			
316L	CW	Tyrode's sol.	37	N	0.142000	0.177	CP	24			
316L	CW	Tyrode's sol.	37	N	0.142000	0.122	CP	24			
316L	CW	Tyrode's sol.	37	N	0.142000	0.249	CP	18			
316L	CW	Tyrode's sol.	37	N	0.142000	0.093	CP	18			
316L	CW	Tyrode's sol.	37	N	0.142000	0.098	CP	24			

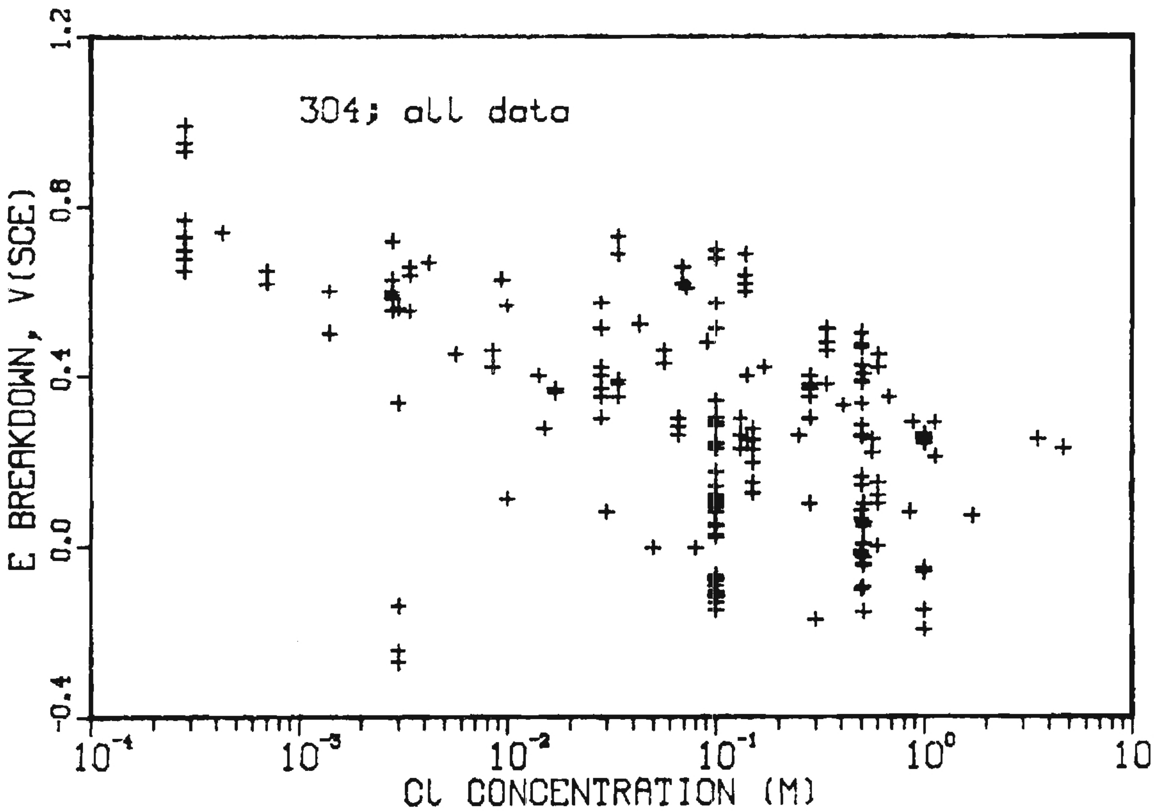

Fig. 1 - Breakdown potential data for Type 304 steel in aqueous chloride solutions; all data as a function of chloride ion concentration.

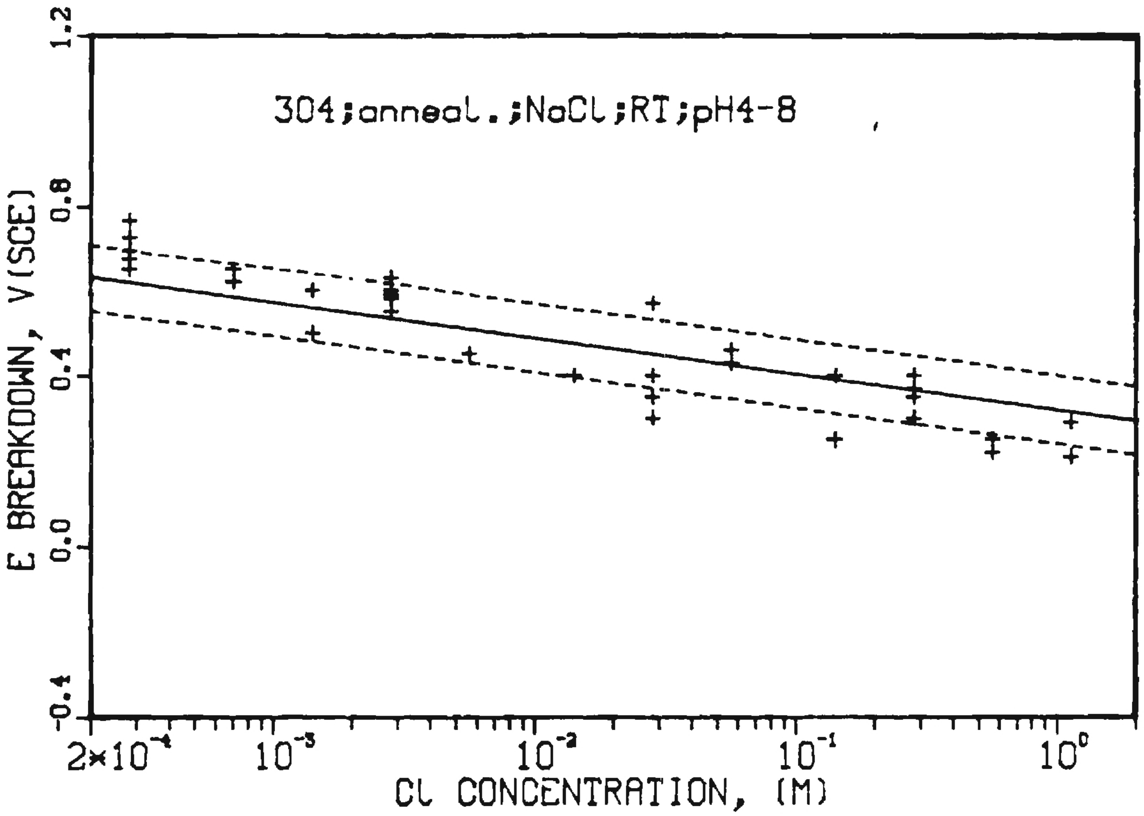

Fig. 2 - Breakdown potential data for Type 304 steel in aqueous chloride solutions; data for standard conditions as a function of chloride ion concentration; regression lines.

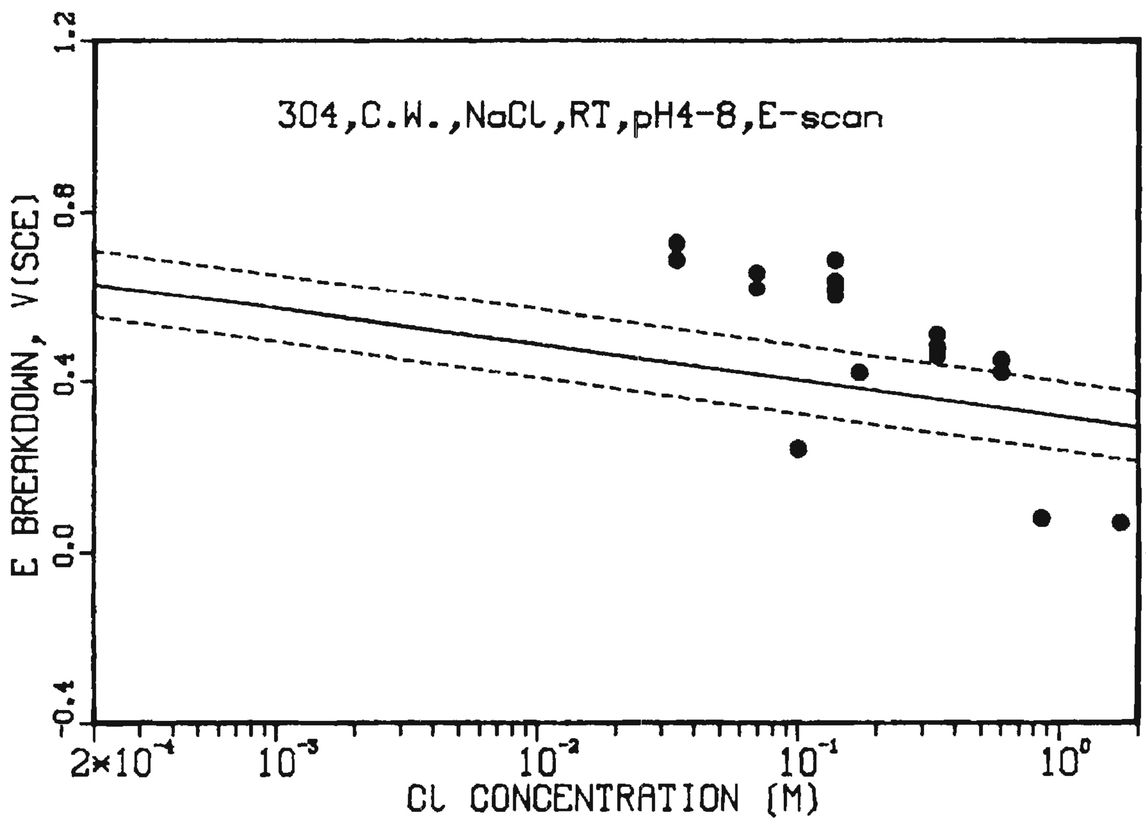

Fig. 3 - Breakdown potential data for Type 304 steel in aqueous chloride solutions; data for cold-worked materials superimposed on regression lines for standard conditions (annealed materials).

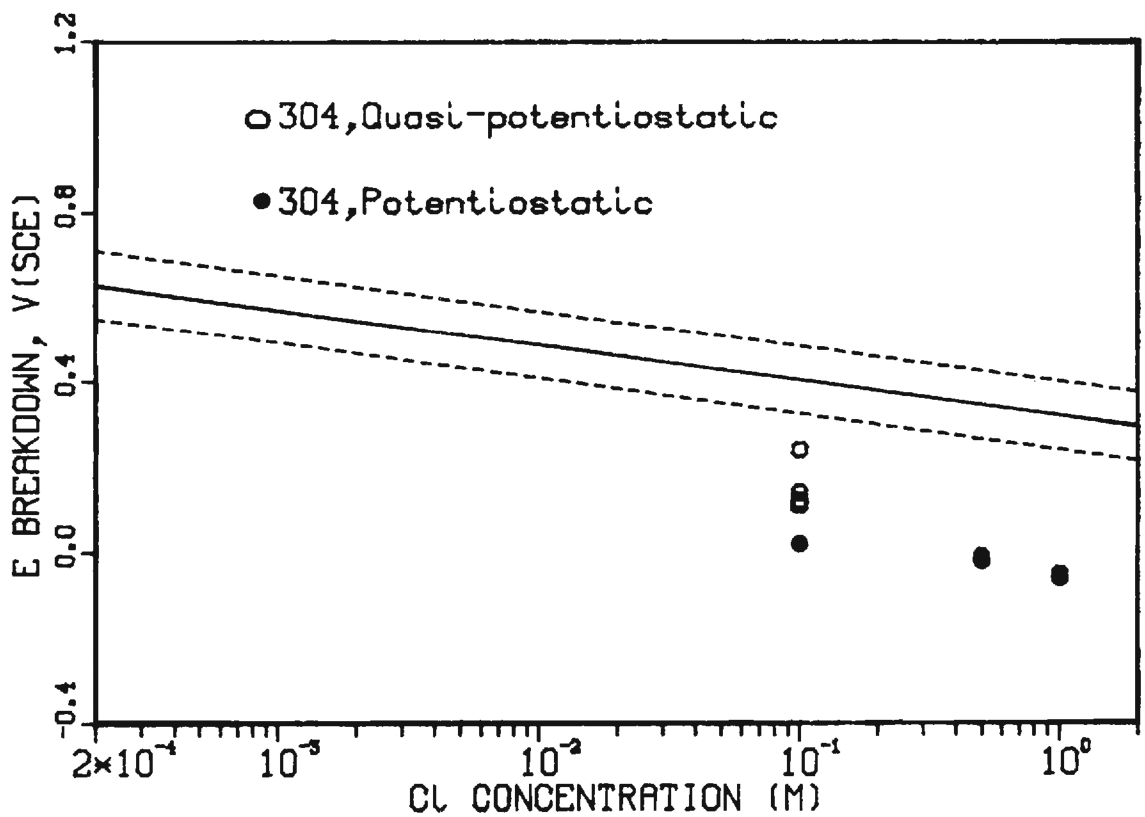

Fig. 4 - Breakdown potential data for Type 304 steel in aqueous chloride solutions; data obtained by potentiostatic and quasipotentiostatic techniques, superimposed on regression lines for standard conditions (potentiodynamic techniques).

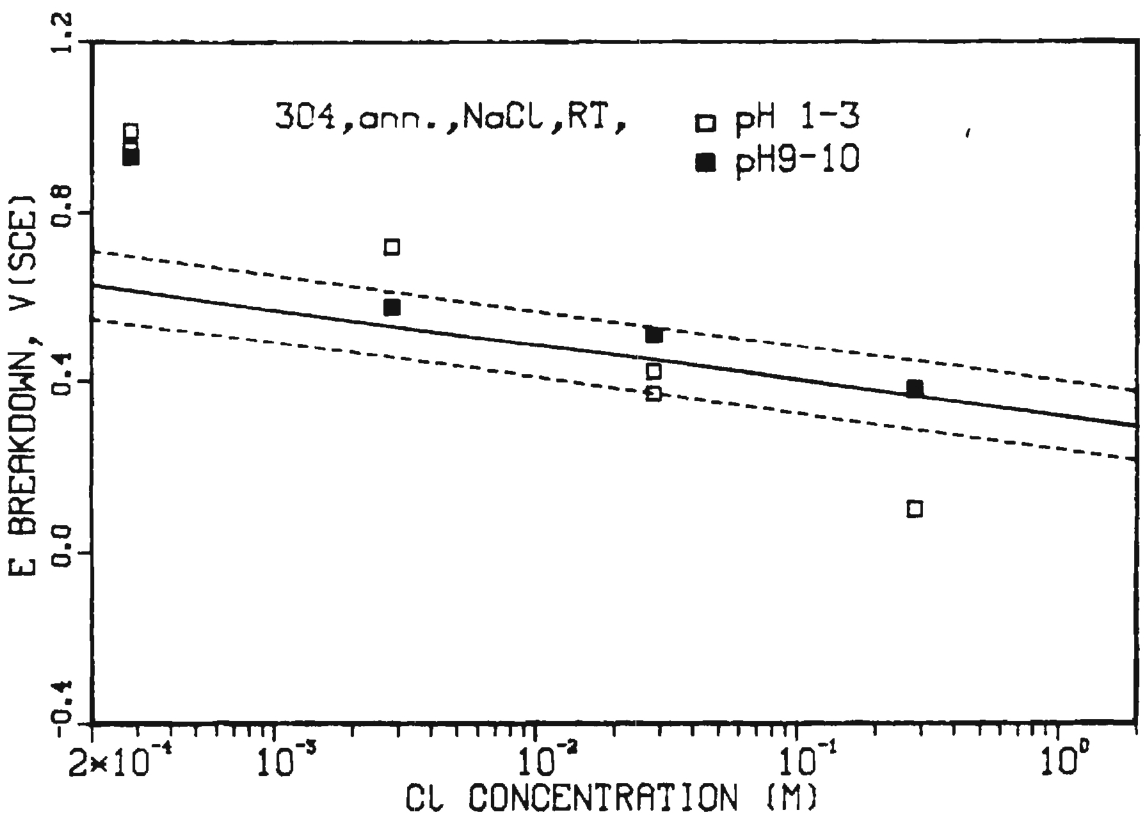

Fig. 5 - Breakdown potential data for Type 304 steel in aqueous chloride solutions; data for low and high pH solutions, superimposed on regression lines for standard conditions (pH 4 - 8).

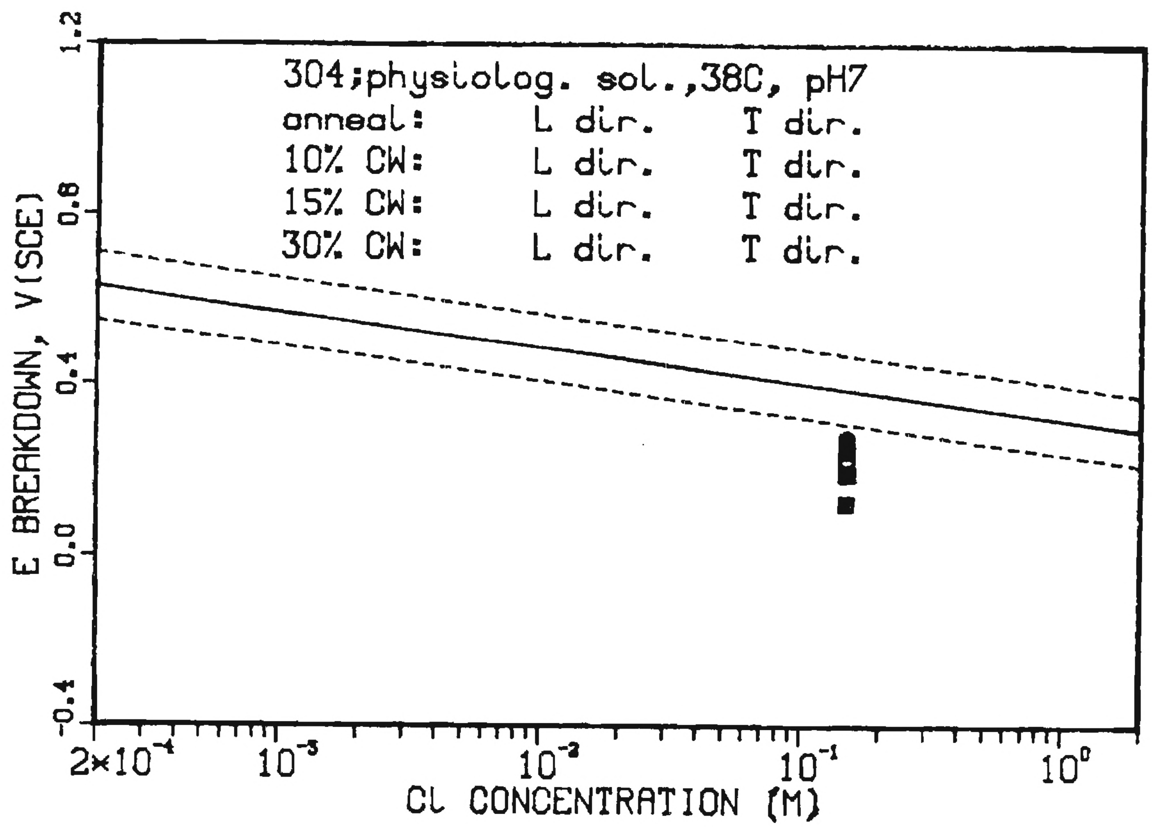

Fig. 6 - Breakdown potential data for Type 304 steel in aqueous chloride solutions; data for physiological solution, 38°C, and different amounts and directions of cold-work, superimposed on regression lines for standard conditions (aqueous NaCl, room temperature, annealed).

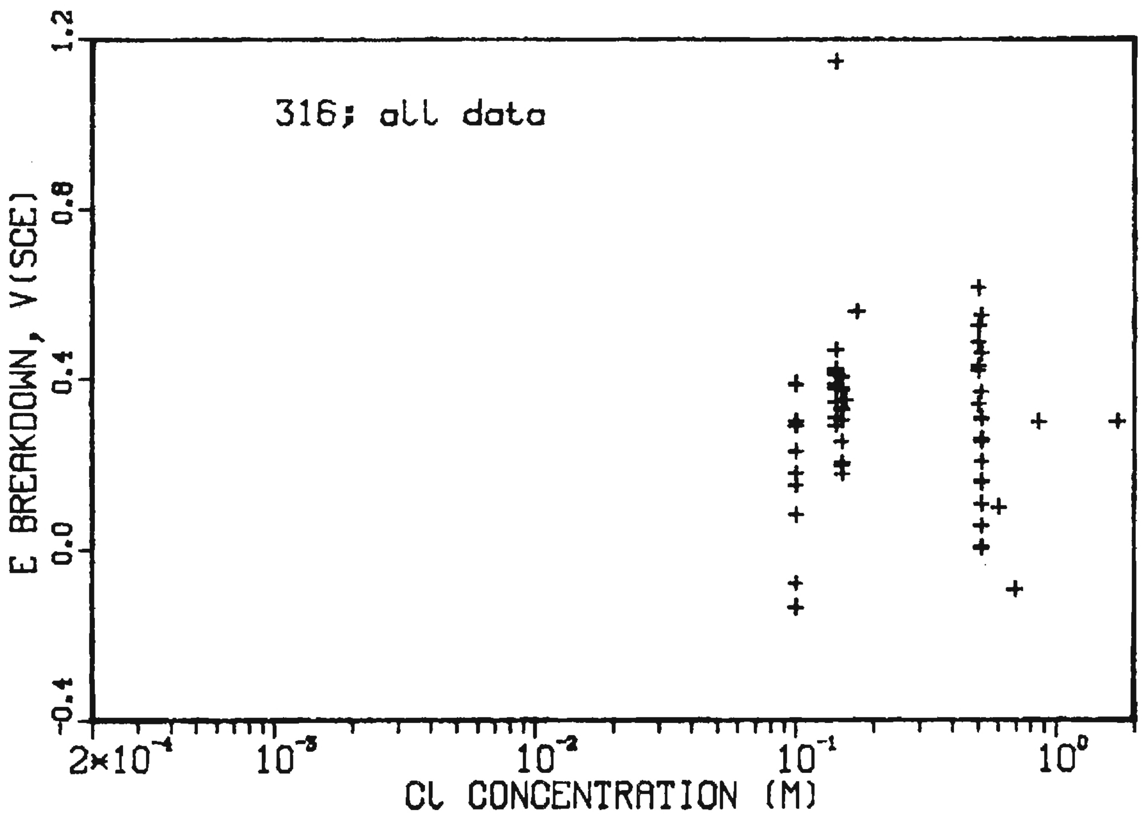

Fig. 7 - Breakdown potential data for Type 316 steel in aqueous chloride solutions; all data as a function of chloride ion concentration.

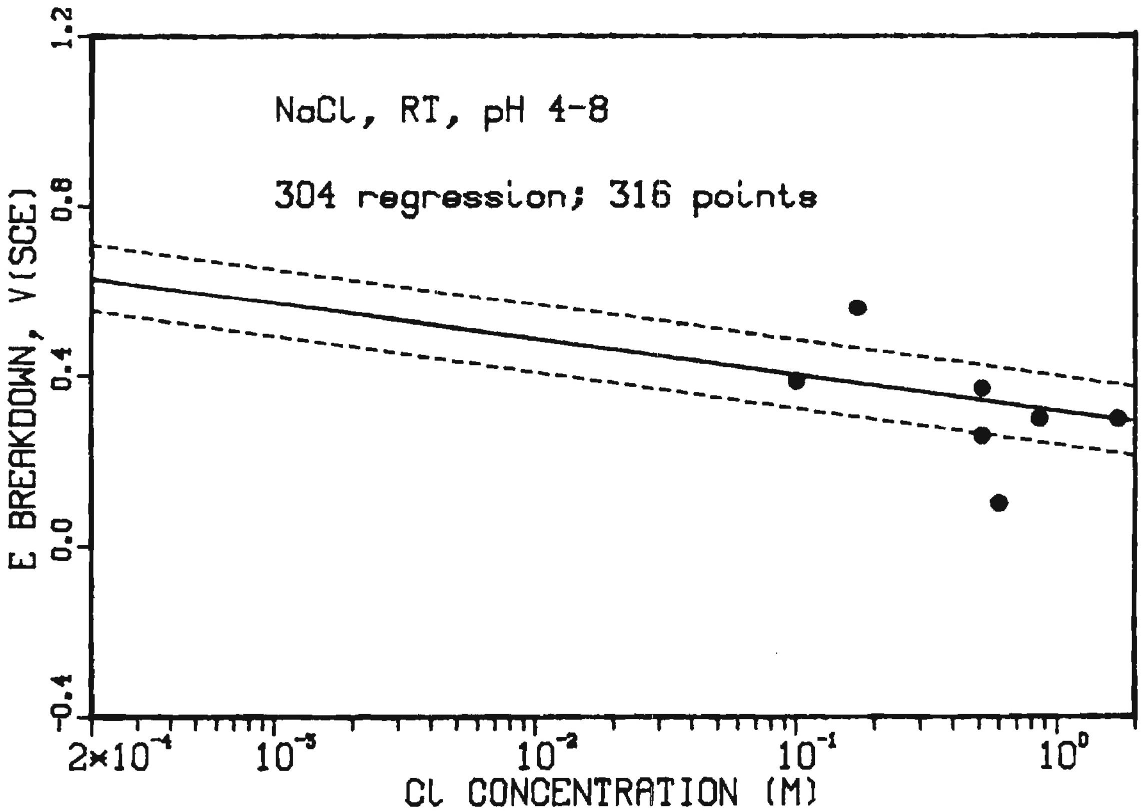

Fig. 8 - Breakdown potential data for Type 316 steel in aqueous chloride solutions; data for standard conditions, superimposed on regression lines for Type 304 steel data, standard conditions.

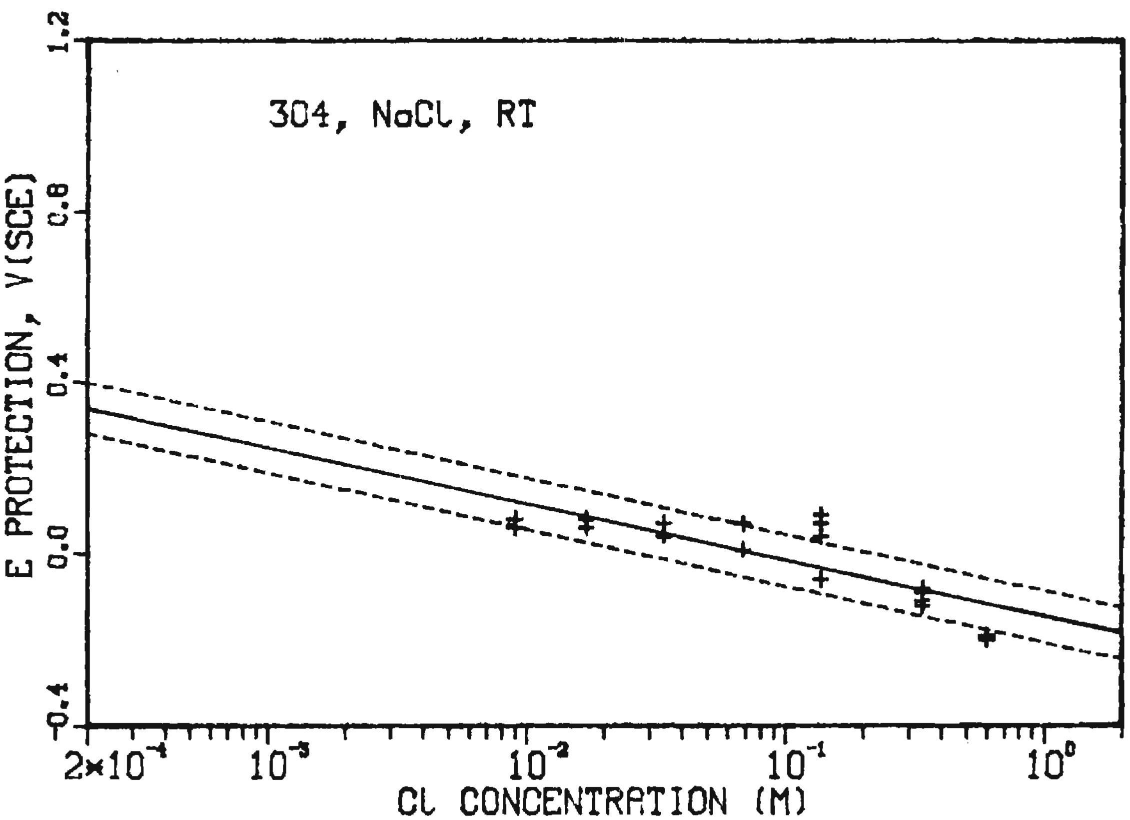

Fig. 10 - Protection potential data for Type 304 steel; data for standard conditions as a function of chloride ion concentration, regression lines.

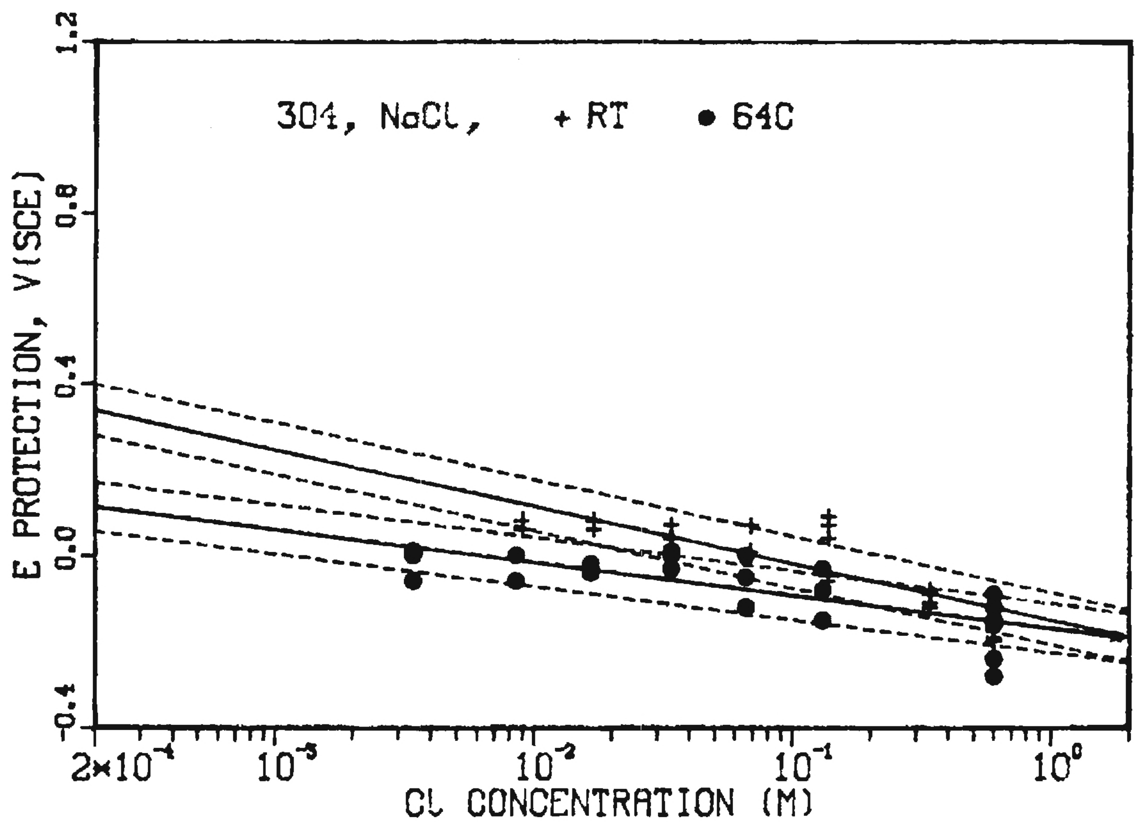

Fig. 11 - Protection potential data for Type 304 steel; standard conditions, room temperature and 64°C, regression lines.

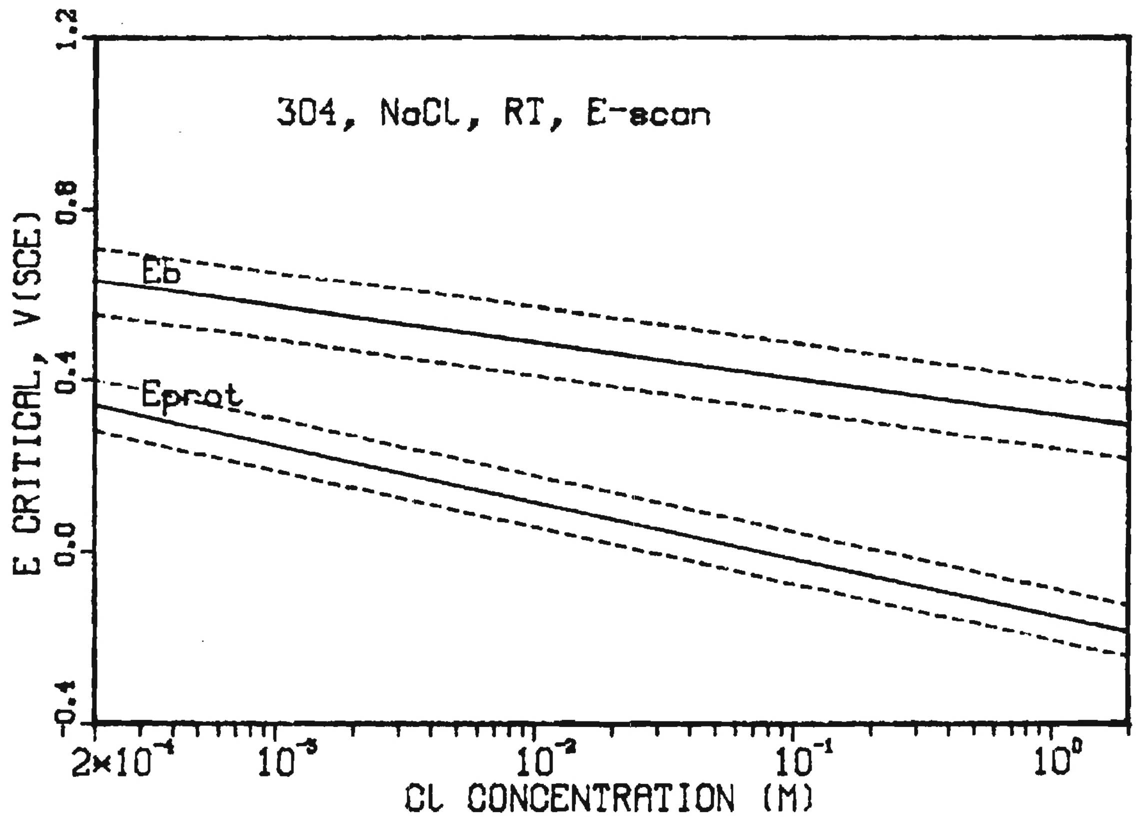

Fig. 12 - Regression lines for breakdown and protection potential data for Type 304 steel, standard conditions.

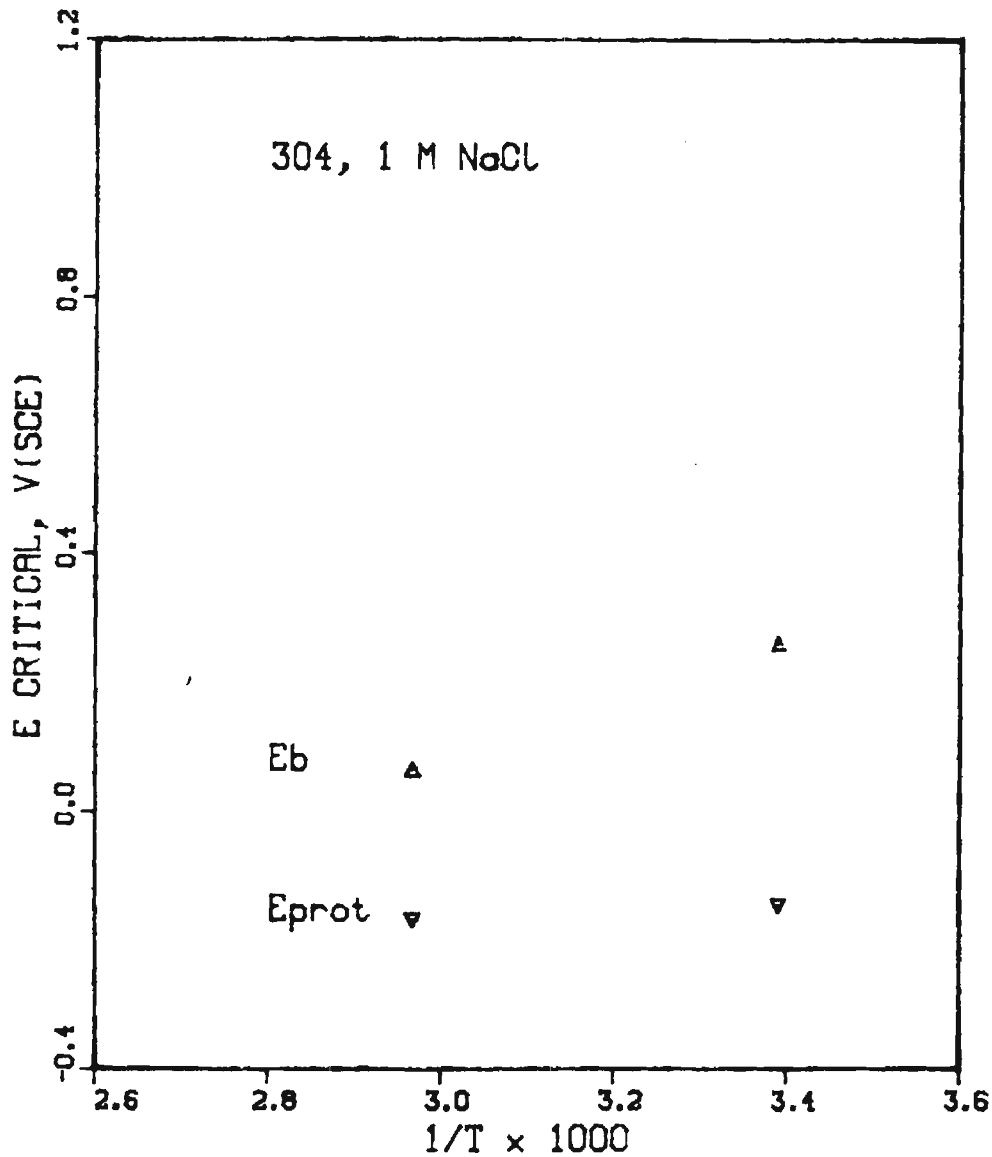

Fig. 13 - Breakdown and protection potential data for Type 304 steel, standard conditions, normalized to 1 M concentration, as a function of absolute temperature.

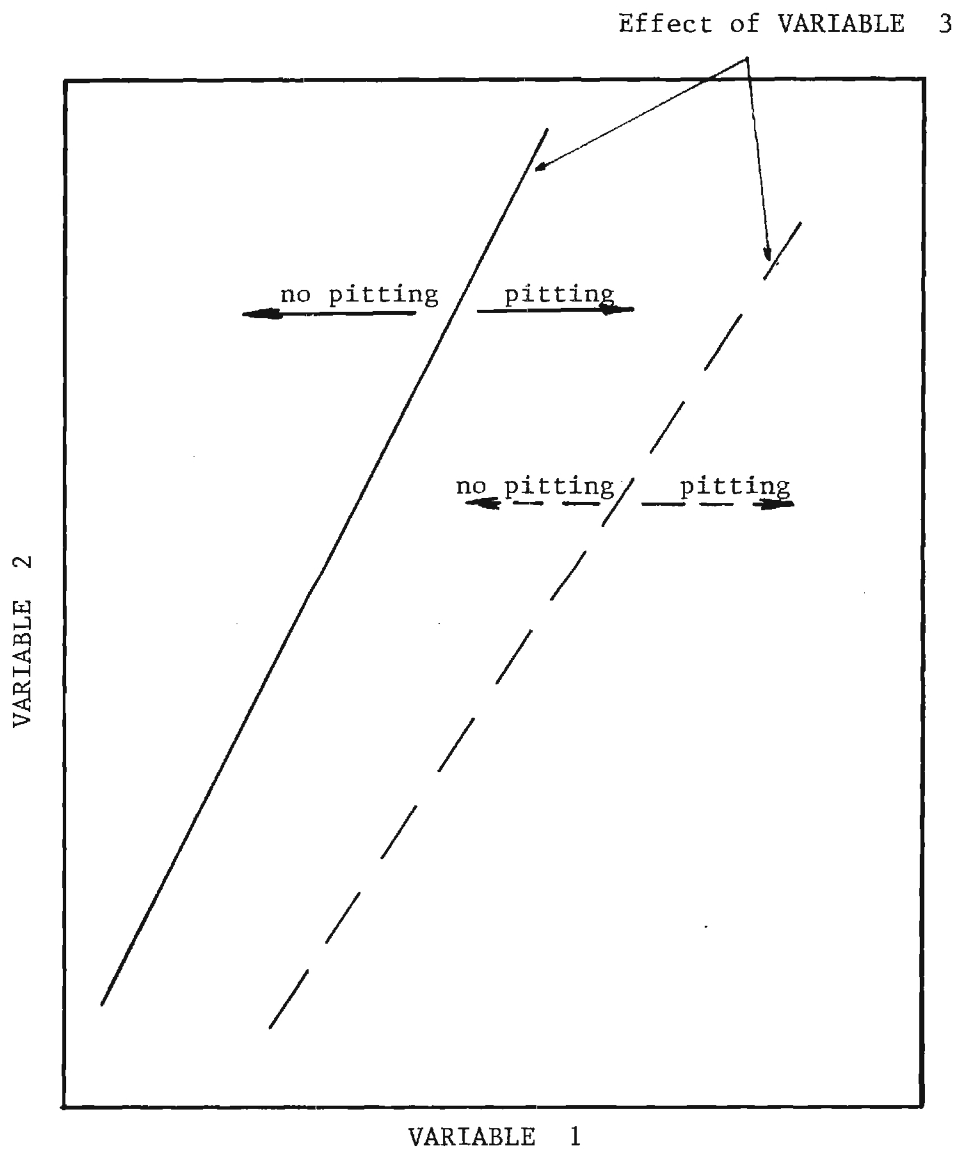

Fig. 14 - Schematic illustration of a format for presenting pitting/no pitting data as a function of three independent variables.