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CANMET
Canada Centre for Mineral and Energy Technology
Centre canadien de la technologie des minéraux et de l'énergie

SPOC
Simulated Processing of Ore and Coal

Chapter 8 Utility Programs

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The SPOC Manual

Chapter 8 Utility Programs

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THE SPOC MANUAL

The **SPOC*** manual consists of eighteen chapters, published separately. Their numbers and short titles are as follows:

1. Summary
2. Sampling Methodology
2.1 SAMBA Computer Program
2.2 Grinding Circuit Sampling
3. Material Balance
3.1 BILMAT Computer Program
3.2 MATBAL Computer Program
4. Modelling and Simulation
4.1 Industrial Ball Mill Modelling
5. Unit Models: Part A
5.1 Unit Models: Part B
5.2 Unit Models: Part C
6. Flowsheet Simulators
7. Model Calibration
7.1 STAMP Computer Program
7.2 FINDBS Computer Program
7.3 RTD and MIXERS Computer Programs
8. Miscellaneous Computer Programs

These chapters are available from: CANMET, Energy, Mines and Resources Canada
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Ottawa, Ontario

* Simulated Processing of Ore and Coal

FOREWORD

High energy costs and depleting ore reserves combine to make process evaluation and optimization a challenging goal in the 80's. The spectacular growth of computer technology in the same period has resulted in widely available computing power that can be distributed to the most remote mineral processing operations. The SPOC project, initiated at CANMET in 1980, has undertaken to provide Canadian industry with a coherent methodology for process evaluation and optimization assisted by computers. The SPOC Manual constitutes the written base of this methodology and covers most aspects of steady-state process evaluation and simulation. It is expected to facilitate industrial initiatives in data collection and model upgrading.

Creating a manual covering multidisciplinary topics and involving contributions from groups in universities, industry and government is a complex endeavour. The reader will undoubtedly notice some heterogeneities resulting from the necessary compromise between ideals and realistic objectives or, more simply, from oversight. Critiques to improve future editions are welcomed.

D. Laguitton
SPOC Project Leader
Canada Centre for Mineral and Energy Technology

AVANT-PROPOS

La croissance des coûts de l'énergie et l'appauvrissement des gisements ont fait de l'évaluation et de l'optimisation des procédés un défi des années 80 au moment même où s'effectuait la dissémination de l'informatique jusqu'aux concentrateurs les plus isolés. Le projet SPOC, a été lancé en 1980 au CANMET, en vue de développer pour l'industrie canadienne, une méthodologie d'application de l'informatique à l'évaluation et à l'optimisation des procédés minéralurgiques. Le Manuel SPOC constitue la documentation écrite de cette méthodologie et en couvre les différents éléments. Les retombées devraient en être une vague nouvelle d'échantillonnages et d'amélioration de modèles.

La rédaction d'un ouvrage couvrant différentes disciplines et rassemblant des contributions de groupes aussi divers que les universités, l'industrie et le gouvernement est une tâche complexe. Le lecteur notera sans aucun doute des ambiguïtés ou contradictions qui ont pu résulter de la diversité des sources, de la traduction ou tout simplement d'erreurs. La critique constructive est encouragée afin de parvenir au format et au contenu de la meilleure qualité possible.

D. Laguitton
Chef du projet SPOC,
Centre canadien de la technologie des minéraux et de l'énergie

ABSTRACT

This chapter contains sample runs of several programs that were developed during the course of the SPOC project either for mineral processing laboratory calculations (metallurgical recoveries, particle size distribution tabulation, Bond work index formula, non-SI to SI physical units conversion, etc.) or for graphic data display (x-y plots, flowsheet drawing, etc.).

RÉSUMÉ

Ce chapitre décrit plusieurs programmes développés au cours du projet SPOC soit pour des calculs de laboratoire (calculs de récupérations, tables de granulométries, indice de Bond, conversions d'unités de mesure non-métriques à métriques, etc.) ou pour des représentations graphiques (graphes x-y, dessin de flowsheets, etc.).

ACKNOWLEDGEMENTS

The SPOC project has benefited from such a wide range of contributions throughout the industry, the university, and the government sectors that a nominal acknowledgement would be bound to make unfair omissions. The main groups that contributed are: the various contractors who completed project elements; the Industrial Steering Committee members who met seven times to provide advice to the project leader; the various users of project documents and software who provided feedback on their experience; the CANMET Mineral Sciences Laboratories staff members who handled the considerable in-house task of software development, maintenance, and documentation; the EMR Computer Science Centre staff who were instrumental in some software development; and the CANMET Publications Section. Inasmuch as in a snow storm, every flake is responsible, their contributions are acknowledged.

CONTENTS

1. INTRODUCTION

Several programs have been developed during the course of the SPOC project, which either do not belong to the predefined themes or have been developed too late to be integrated into the chapters covering a given theme. Their general applicability, however, warrants presentation in a special chapter titled "Utility Programs".

These programs range from routine laboratory applications, such as the calculation of recoveries from ore fraction analysis or particle-size distribution tabulations, to more exotic subjects, such as time series analysis, paired data analysis, and graphics.

Most programs in this chapter require very little information and can be used without a detailed user's guide. The sample run includes a copy of a condensed information file on how to use the program. Some programs have been described in their initial version in several CANMET Division Reports, listed in the brief documentation presented in Section 2.

All programs are in FORTRAN Extended 4.8 as implemented on the department's CDC CYBER computer. IBM-PC versions, executable under the MS-DOS operating system, have also been prepared on diskettes.

Enquiries should be directed to:

CANMET
Energy, Mines and Resources
Technology Information Division
555 Booth Street
Ottawa, Ontario
K1A 0G1.

UTILITY PROGRAMS

2. USER'S GUIDE

2.1 METCAL

2.1.1 Program Identification

Author:	D. Laguitton (CANMET, EMR).
Last Update:	August 1984.
Purpose:	To calculate and tabulate distributions and metal contents in up to nine fractions of an ore.
Usage:	Execute as a main program. See "User's Manual", CANMET Division Report MRP/MSL 79-120(IR).
Remarks:	None.
Subroutines and Functions Required:	METIN, METOUT.

2.1.2 Engineering Documentation

METCAL is a program for performing laboratory metallurgical calculations. Absolute or relative weights, and assay values of a feed material are read. Recoveries and metal contents of each fraction and any combination of fractions are computed and tabulated, followed by those of the calculated feed (sum of all fractions).

The following variables are used in the program:

TITLE - Job title (max. 30 characters).
M - Number of fractions (max. 20 including combinations).
N - Number of assays (max. 5). If N 2, the output requires 132 characters/line.
NC - Number of combinations (max. 9).
INAME - Fraction name (max. 10 characters) e.g., Cl.Conc.
JNAME - Assay name (max. 6 characters) e.g., CU%.
GR - Assay values.
IW - Combination vector. Combinations are numbered in sequence after the last fraction.
- The calculated feed is always added internally as the last combination.

To test METCAL, enter the following data when prompted:

JOB TITLE: **DEMO**

COAL DATA (Y/N)?: **N**

FRACTION, ASSAY AND COMBINATION NAMES ALREADY ENTERED (Y/N)?: **N**
(For a second job on a similar set, save entries — ENTER: Y.)

NUMBER OF FRACTIONS, ASSAYS AND COMBINATIONS (M, N, NC): **3 2 1**
(For coal data, enter only M)

ENTER FRACTION NAMES:
FRACTION 1: **CONC**
FRACTION 2: **MIDS**
FRACTION 3: **TAILS**

ENTER 3 WEIGHTS: **10 20 30**

ENTER ASSAY NAMES: **CU%, FE%**
(Coal assays are Ash% and S% by default)

ENTER ASSAY VALUES
CONC: **2 3**
MIDS: **4 5**
TAILS: **6 7**

ENTER COMBINATION NUMBERS (e.g., 14 to combine fractions 1 and 4)
COMBINATION 1: **23**

ORDER OF TABLE (99 = DASHED LINE, 55 = SPACE) (e.g., 01 55 02)
01 02 03 99 04 05
(01 02 03 are the three fractions, 04 is the combination, 05 is the calculated feed and 99 is the dashed line.)
(Note: Combinations and table order are not entered for coal data.)

2.1.3 Sample Run

```
JOB TITLE : DEMO METCAL
COAL DATA (Y OR N)? : N

NUMBER OF FRACTIONS,ASSAYS AND COMBINATIONS (M,N,NC) : 3 2 1
ENTER FRACTION NAMES
FRACTION  1 : CONC
FRACTION  2 : MIDS
FRACTION  3 : TAILS
ENTER  3 WEIGHTS : 10 20 30
ENTER ASSAY NAMES
ASSAY  1 : %CU
ASSAY  2 : %FE
ENTER ASSAY VALUES
CONC       : 2 3
MIDS       : 4 5
TAILS      : 6 7
ENTER COMBINATION NUMBERS (EX.1456)
COMBINATION  1 : 23
ORDER OF TABLE,(99=DASH LINE,55=SPACE)EX:01 55 02
01 02 03 99 04 05
MOVE PAPER OR CLEAR SCREEN, ENTER BLANK & RETURN.

################################################################################
  DEMO METCAL                                ASSAY          DISTRIBUTION

  PRODUCTS       WEIGHT  WEIGHT %     %CU        %FE          %CU        %FE

1_CONC           10.000     16.667     2.000      3.000        7.143      8.824
2_MIDS           20.000     33.333     4.000      5.000       28.571     29.412
3_TAILS          30.000     50.000     6.000      7.000       64.286     61.765

C:23             50.000     83.333     5.200      6.200       92.857     91.176
C:CAL.FEED       60.000    100.000     4.667      5.667      100.000    100.000
################################################################################


################################################################################
  DEMO METCAL                        METAL CONTENT

  PRODUCTS     WEIGHT %     %CU        %FE

1_CONC           16.667       .333       .500
2_MIDS           33.333      1.333      1.667
3_TAILS          50.000      3.000      3.500

C:23             83.333      4.333      5.167
C:CAL.FEED      100.000      4.667      5.667
################################################################################x


ENTER NEW TABLE ORDER,(99=DASH,55=SPACE) OR 0 : 0
ANOTHER RUN (Y OR N)Y
```

```
JOB TITLE : HLS OF LINGAN COAL
COAL DATA (Y OR N)? : Y
FRACTION,ASSAY & COMBINATION NAMES ALREADY IN (Y/N)?  : N
NUMBER OF FRACTIONS (M) : 7
ENTER FRACTION NAMES
FRACTION  1 : -1.25
FRACTION  2 : -1.3
FRACTION  3 : -1.4
FRACTION  4 : -1.6
FRACTION  5 : -1.8
FRACTION  6 : -2.2
FRACTION  7 : +2.2
ENTER  7 WEIGHTS : 5 60 8 4 2 2 19
COAL ASSAYS ARE ASH% & S% BY DEFAULT
ENTER ASSAY VALUES
-1.25       : .7 .7
-1.3        : 1.4 .8
-1.4        : 6.6 3.1
-1.6        : 22 5
-1.8        : 36 5
-2.2        : 53 5
+2.2        : 84 5
MOVE PAPER OR CLEAR SCREEN, ENTER BLANK & RETURN.
```

HLS OF LINGAN COAL

PRODUCTS	WEIGHT	WEIGHTS %	WEIGHTS % CUM	ANALYSIS ASH %	ASH % CUM	S %	S % CUM	DISTRIBUTION ASH %	ASH % CUM	S %	S % CUM
1_-1.25	5.000	5.000	5.000	.700	.700	.700	.700	.175	.175	1.656	1.656
2_-1.3	60.000	60.000	65.000	1.400	1.346	.600	.792	4.195	4.370	22.717	24.373
3_-1.4	8.000	8.000	73.000	8.600	1.922	3.100	1.045	2.637	7.007	11.737	36.110
4_-1.6	4.000	4.000	77.000	22.000	2.965	5.000	1.251	4.395	11.402	9.465	45.575
5_-1.8	2.000	2.000	79.000	36.000	3.801	5.000	1.346	3.598	14.998	4.733	50.308
6_-2.2	2.000	2.000	81.000	53.000	5.016	5.000	1.436	5.294	20.292	4.733	55.040
7_+2.2	19.000	19.000	100.000	84.000	20.023	5.000	2.113	79.708	100.000	44.960	100.000
C:CAL.FEED	100.000	100.000	100.000	20.023	20.023	2.113	2.113	100.000	100.000	100.000	100.000

```
ANOTHER RUN (Y OR N)N

     STOP
     022000 MAXIMUM EXECUTION FL.
      0.905 CP SECONDS EXECUTION TIME.
```

2.2 UCONV

2.2.1 Program Identification

Author:	R. Pilgrim (CANMET, EMR).
Last Update:	June 4, 1984.
Purpose:	Interactive program to convert from non-SI units to SI units, and vice versa.
Usage:	Execute as a main program.
Remarks:	The selected conversion factor is returned as X through the labelled COMMON /CC/.
Subroutines and Functions Required:	AREA, CONC, CONNEC, DENS, ENER, FLOW, FORC, LENG, MASS, PRES, VELO, VISC, VOLU.
Source:	Metric Practice Guide for the Canadian Mining and Metallurgical Industries. Published by the Mining Association of Canada, in co-operation with the Coal Association of Canada; February 1978.

2.2.2 Engineering Documentation

UNCONV is an interactive program to convert from non-SI units (e.g., lb, ft) to SI units (e.g., kg, M,) and vice versa. The program consists of a driver and twelve subroutines, one for each of the unit categories (e.g., length, area, volume).

Conversion factors for the various options within each unit category are stored in the subroutines. Interactively, the program is menu-driven, permitting selection of category and option, and entry of amounts to be converted.

2.2.3 Sample Run

```
                    CONVERSION OF UNITS TO AND FROM SI


 LIST OF CATEGORIES
   1 - LENGTH
   2 - AREA
   3 - VOLUME
   4 - VELOCITY & ACCELERATION
   5 - MASS
   6 - DENSITY
   7 - CONCENTRATION
   8 - FORCE
   9 - PRESSURE
  10 - VISCOSITY
  11 - FLOWRATE
  12 - ENERGY & WORK
   0 - EXIT

 SELECT CATEGORY : 1

 LIST OF OPTIONS FOR LENGTH

          1 - IN - CM
          2 - FT - M
          3 - YD - M
          4 - MI - KM
          0 - EXIT


           SELECT DESIRED OPTION :
        +VE TO CONVERT FROM NON-SI TO SI UNITS
        -VE TO CONVERT FROM SI TO NON-SI UNITS
1

           THE CONVERSION FACTOR FOR IN > CM              IS

         ***    2.540000000      ***


 ENTER AMOUNT OF UNIT TO BE CONVERTED, AND REPEAT
 OR ENTER 0 TO SELECT NEW OPTION


10
10. 25.4

20
20. 50.8

0

 LIST OF OPTIONS FOR LENGTH

          1 - IN - CM
          2 - FT - M
          3 - YD - M
          4 - MI - KM
          0 - EXIT
```

```
          SELECT DESIRED OPTION :
        +VE TO CONVERT FROM NON-SI TO SI UNITS
        -VE TO CONVERT FROM SI TO NON-SI UNITS
-1

           THE CONVERSION FACTOR FOR CM > IN              IS

          ***    .3937007874      ***


 ENTER AMOUNT OF UNIT TO BE CONVERTED, AND REPEAT
 OR ENTER 0 TO SELECT NEW OPTION


25.4
25.4 10.

0

 LIST OF OPTIONS FOR LENGTH

           1 - IN - CM
           2 - FT - M
           3 - YD - M
           4 - MI - KM
           0 - EXIT


           SELECT DESIRED OPTION :
        +VE TO CONVERT FROM NON-SI TO SI UNITS
        -VE TO CONVERT FROM SI TO NON-SI UNITS
0

 LIST OF CATEGORIES
   1 - LENGTH
   2 - AREA
   3 - VOLUME
   4 - VELOCITY & ACCELERATION
   5 - MASS
   6 - DENSITY
   7 - CONCENTRATION
   8 - FORCE
   9 - PRESSURE
  10 - VISCOSITY
  11 - FLOWRATE
  12 - ENERGY & WORK
   0 - EXIT

 SELECT CATEGORY : 0

     STOP  PROCESSING COMPLETE
     020500 MAXIMUM EXECUTION FL.
      0.373 CP SECONDS EXECUTION TIME.
```

2.3 BONDWI

2.3.1 Program Identification

Authors:	D. Laguitton, A. Boire, R. Pilgrim (CANMET, EMR).
Last Update:	February 14, 1984.
Purpose:	Calculation of BOND work index.
Usage:	Execute as a main program.
Subroutines and Functions Required:	None.

2.3.2 Engineering Documentation

This program calculates the BOND work index in a ball-mill experiment according to the BOND formula:

```
WI = 4.45 / ((P1**.23) * (G**.82) * (1./SQRT(P)
     - 1./SQRT(F)))
```

where:

P1 = finest opening of the mesh size tested in microns
G = grams of material passing the size P1 per revolution of the mill
P = size in microns which 80% of the product passes
F = size in microns which 80% of the feed passes

Reference: Bond, F.C. "Crushing and Grinding Calculations"; Part 1, British Chem. Eng 6:6:378-385; 1961.

Example: ENTER: P1, G, P, F: 74, 1.4673, 52, 1850.
THE BOND WORK INDEX: 10.46

2.3.3 Sample Run

```
          ***** BONDWI *****
TO CALCULATE THE BOND WORK INDEX,
 ENTER P1,G,P,F :
74 1.4673 52 1850


THE BOND WORK INDEX : WI =  10.5

 ANOTHER PROBLEM (Y/N)?N

     STOP
     016200 MAXIMUM EXECUTION FL.
      0.228 CP SECONDS EXECUTION TIME.
```

2.4 SBOND

2.4.1 Program Identification

Authors:	D. Laguitton, A. Boire, R. Pilgrim (CANMET, EMR).
Last Update:	February 14, 1984.
Purpose:	Calculation of BOND work index by a simplified equation using a reference.
Usage:	Execute as a main program.
Subroutines and Functions Required:	None.

2.4.2 Engineering Documentation

The program SBOND calculates the BOND work index for an unknown ore from the known work index of a reference ore. The equation used is:

```
WI = WIR * (1./SQRT(PR) - 1./SQRT(FR)) /
     (1./SQRT(P) - 1./SQRT(F))
```

where:

WIR = work Index of the Reference Ore
FR = 80% passing size in microns of the reference ore feed
PR = 80% passing size in microns of the reference ore product
F = 80% passing size in microns of the unknown ore feed
P = 80% passing size in microns of the unknown ore product

Reference: Canadian Mining Journal pp. 63-65; July 1966.

Example: ENTER: WIR,FR,PR,F,P: 19.5, 1130, 960, 133, 123
THE BOND WORK INDEX: WI = 14.3

2.4.3 Sample Run

```
          ***** SBOND *****
TO CALCULATE THE BOND WORK INDEX,
 ENTER WIR,FR,PR,P,F :
19.5 1130 960 133 123


THE BOND WORK INDEX : WI =  14.3

 ANOTHER PROBLEM (Y/N)?N

     STOP
     015700 MAXIMUM EXECUTION FL.
      0.230 CP SECONDS EXECUTION TIME.
```

2.5 PARTSZ

2.5.1 Program Identification

Authors:	D. Laguitton and R. Pilgrim (CANMET, EMR).
Last Update:	March 1, 1984.
Purpose:	To compute particle-size distributions in various units.
Usage:	Execute as a main program. See "User's Manual", CANMET Division Report MRP/MSL 79-120(IR).
Remarks:	None.
Subroutines and Functions Required:	SZFORM, MESHMU, TABS, TABL, CUMR, CUMP.

2.5.2 Engineering Documentation

The interactive program PARTSZ permits size distribution data to be entered or displayed in several selected units. The type of conversion is identified by the two variables: NATURI (for input data) and NATURO (for output data). These can have the following values:

1. Non-cumulative weight fraction
2. Cumulative weight fraction retained
3. Cumulative weight fraction passing
4. Non-cumulative weight per cent
5. Cumulative weight per cent retained
6. Cumulative weight per cent passing

NATURI = 7. Raw weights in grams are input
NATURO = 7. Table in units 4, 5, and 6 is produced

Variables used:

TITLE: Problem descriptor (maximum — 28 characters).
N: Number of size values, including pan.
SIZ: Vector of size values (negative if size in mesh; 0 if non-SQRT (2) series). The head size, or SIZ(1), is entered.
X: Vector of weights or weight fractions.

To test PARTSZ, try the following data (or one of the test data sets given in the reference).

ENTER TITLE: **DEMO**
ENTER NATURI, NATURO, N: **7, 7, 4**
ENTER SIZ(1): **-28**
ENTER THE 4 WEIGHTS OR WEIGHT FRACTIONS: **20, 20, 20, 20**

2.5.3 Sample Run

```
ENTER TITLE: DEMO PARTSZ
ENTER NATURI,NATURO,N: 7 7 4
HEAD SIZE (NEG.IF MESH,0 IF NON SQRT(2) SERIES): -28
ENTER THE  4 WEIGHTS OR WEIGHT FRACTIONS : 20 20 20 20

####################################################################
DEMO PARTSZ

SIZE(MICRONS)      ENTRY        NON-CUM%     CUM.RET%     CUM.PASS%

 1_   600.00         20.00         25.00        25.00         75.00
 2_   424.26         20.00         25.00        50.00         50.00
 3_   300.00         20.00         25.00        75.00         25.00
 4_   212.13         20.00         25.00       100.00          0.00
####################################################################

ANOTHER PROBLEM?N

     STOP
     023400 MAXIMUM EXECUTION FL.
      0.309 CP SECONDS EXECUTION TIME.
```

2.6 NPRD

2.6.1 Program Identification

Author:	D. Laguitton (CANMET, EMR).
Date Written:	February 1982.
Major Update:	January 1984.
Purpose:	An interactive program for material balance by the N-product formula.
Remarks:	Subroutine SIMQ solves the system of equations described by matrices D and E, and returns the results as calculated stream flow rates in matrix E. For runs using the Monte Carlo iterative method, function GNOISE is used to compute a pseudo-random number belonging to a Gaussian distribution, specified by its mean and standard deviation, and is used for assay and flow rate adjustments. Function URAND is a uniform random-number generator based on the theory put forth by D.E. Knuth (1969).
Subroutines and Functions Required:	SIMQ, GNOISE, URAND, CSTD.

2.6.2 Engineering Documentation

NPRD is a general purpose N-product formula program; i.e., it calculates the flow rates around a process unit or a circuit when assays of species for which mass conservation around the unit are given. The generalization consists of allowing not only units with one feed and N products, but also any number of feeds and products connected to the same unit.

Any of the streams can be chosen as a reference flow rate of any given value, fixed or measured, with a given precision (%). The program can also perform a Monte-Carlo simulation of pseudo-assays centered around the experimental assays with a standard deviation as given by the user. This permits a calculation of the sensitivity of the calculated flow rates to the sampling errors.

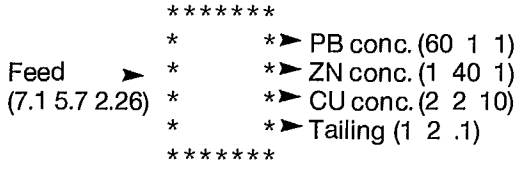
The data entry is prompted at the terminal and in free field format; i.e., numbers are separated by blanks or commas.

If the number of streams is NSTR, the method requires NSTR-2 different assays for each of the streams. If more than NSTR-2 assay types are entered, the user is asked to decide which subset of assays to use. A comparison of the results obtained for various assays can, therefore, be made.

Note also that for the sensitivity analysis, the reference flow rate may be a measured value with its own precision taken into consideration.

For further details, consult: *Taggart Handbook of Mineral Dressing*, pp. 19-189; or "The SPOC Manual, Chapter 3.1", CANMET, Energy, Mines and Resources Canada.

As an example, you can try the following circuit balance:



This diagram represents a five-stream circuit, assayed for three species: Pb, Zn, and Cu. It can be represented by a mass balance equation, entered as 1 -2 -3 -4 -5.

This indicates that, after numbering (arbitrarily) the streams from 1 to 5, stream 1 enters the unit (or circuit); streams 2 to 5 are outputs.

Note that there is no extra assay type, over the three required to solve this problem using the N-product formula.

2.6.3 Sample Run

```
************* PROGRAM NPRD **************

COMPUTATION OF FLOW RATES  BY
THE N-PRODUCT FORMULA
DATA ENTRY IS FREE FIELD FORMAT (BLANK OR COMMA SEPARATORS)


NUMBER OF STREAMS (1 -  10) ?5

NUMBER OF ASSAY TYPES (  3 TO  10) ?3

ENTER ( 5, 3) ASSAY VALUES
ONE ROW PER STREAM

7.1 5.7 2.26
60 1 1
1 40 1
2 2 10
1 2 .1

ENTER NUMBER OF THE REFERENCE STREAM ? 1

REFERENCE FLOW RATE AND STD.DEV.% ?100 5

ENTER MASS CONSERVATION EQUATION
IN ASCENDING NUMBERS, I.E. 1 -2 -3 .. ?1 -2 -3 -4 -5

DO YOU WISH A MONTE-CARLO CALCULATION
OF THE PRECISION Y OR N ?Y

HOW MANY RANDOM SAMPLES ?MIN=10,MAX= 50
50

SELECT OPTION TO GENERATE ASSAY STD. DEVIATIONS
1 = SAME RELATIVE STD % FOR ALL ASSAYS
2 = ( 5, 3) RELATIVE STD % (1 ROW PER STREAM)
3 =  3 RELATIVE STD % (1 PER ASSAY TYPE)

1

ENTER % STD DEV APPLIED TO ALL ASSAYS

7

CLEAR SCREEN/ADVANCE PAPER
ENTER A BLANK AND CARRIAGE RETURN
```

```
**************************************************************************
RESULTS OF THE  4 PRODUCT FORMULA

USING ASSAY(S)
 1 2 3

 STREAM NUMBER       FLOW RATE

REFERENCE  1           100.00
           2            10.00
           3            10.00
           4            20.00
           5            60.00
**************************************************************************
RESULTS OF 50 MONTE-CARLO SIMULATIONS

STREAM NUMBER       FLOW RATE           STD DEV

REFERENCE  1           100.00
           2            10.19        +-        1.38
           3            10.35        +-        1.32
           4            20.64        +-        2.50
           5            59.62        +-        4.64
**************************************************************************

ANOTHER RUN ,Y OR N ? N

     STOP
     025100 MAXIMUM EXECUTION FL.
      0.825 CP SECONDS EXECUTION TIME.
```

2.7 GYFORM

2.7.1 Program Identification

Authors: G. Lambert and D. Tremblay.

Date Written: December 1983.

Purpose: To compute the values of SIGMA, MS, ML, D, and/or C, parameters of Gy's simplified formula.

Last Update: April 1985; (by F. Flament).

2.7.2 Engineering Documentation

To compute SIGMA(FE), MS, ML, or D from GY's formula:

$$SIGMA(FE)^2 = (1/MS - 1/ML) * C * L * F * G * D^3$$

where:

SIGMA (FE) = standard deviation of the fundamental error of the critical component (Default, 0.18E-3; Unit, none)

MS = sample mass (Default, 100; Unit, g)

ML = lot mass (Default, infinite; Unit, g)

C = composition factor (Default, 0.5; Unit, g/cm^3)

L = liberation factor (Default, 1.0; Unit, none)

F = particle shape factor (Default, 0.5; Unit, none)

G = size distribution factor (Default, 0.25; Unit, none)

D = maximum particle diameter (Default, 0.02; Unit, cm)

The composition factor may be computed from:

$$C = ((1-AL) / AL)*((1-AL)*RHOC + AL*RHOG)$$

where:

AL = fractional concentration of the critical component (Default, 0.5; Unit, none)

RHOC = density of the critical component (Default, 4.0; Unit, g/cm^3)

RHOG = mean density of the non-critical components (Default, 2.5; Unit, g/cm^3).

Reference: "The SPOC Manual, Chapter 2"; CANMET, Energy, Mines and Resources Canada.

2.7.3 Sample Run

```
                    GY'S SIMPLIFIED FORMULA
                    =======================
                  2                                        3
          SIGMA(FE)   =  (1/MS - 1/ML) * C * L * F * G * D

             C        =  ((1-AL)/AL) * ((1-AL)*RHOC+AL*RHOG))

    USAGE:  FOLLOWING THE TABLE ORDER, ENTER THE PARAMETER VALUES
                                       ( OR 0  TO USE THE DEFAULT VALUE
                                        OR -1  TO COMPUTE THE CORRESPONDING
                                               PARAMETER VALUE)
```

PARAM.	$SIGMA*10^3$	MS	ML	D	C	L	F	G	AL	RHOC	RHOG
DEFAULT	0.1803	100.	INFINITE	0.02	3.25	1.	0.5	0.25	0.5	4.0	2.5
DESIRED	-1	0	0	0	-1	0	0	0	0	3	2
RESULT	.158				2.500						

```
DO YOU NEED MORE SIGNIFICANT DIGITS (Y/N)?Y

SIGMA(FE) =    .1581139E-03
MS        =    100.0000
ML        =   INFINITE
D         =    .2000000E-01
C         =    2.500000
L         =    1.000000
F         =    .5000000
G         =    .2500000


ANOTHER COMPUTATION (Y/N) ?N

     STOP
     022500 MAXIMUM EXECUTION FL.
      0.173 CP SECONDS EXECUTION TIME.
```

2.8 FADESN

2.8.1 Program Identification

Author: J. Leung (CANMET, EMR).

Date Written: September 1984.

Last Update: None. (Version 0.)

Purpose: FADESN is an interactive program used in factorial design to determine the regression coefficients, to test the significance of the main and interaction effects with F-ratio, and to determine the experimental error.

Usage: Used as main program.

Remarks: Maximum numbers for total tests, factor/interaction and levels per factor are 32, 16, and 4, respectively. The number of levels should be the same for all factors.

Subroutines and Functions Required:
- FADN1 - conversion of T to X.
- FADN2 - calculate experimental error.
- FADN3 - calculate regression coefficients.
- FADN4 - output.
- FADN5 - estimate experimental error.

Methods:
1) Enter, or choose, X-values.
2) Read Y values.
3) Estimate experimental error.
4) Calculate regression coefficients.
5) Calculate sum of squares.
6) Perform F-test.
7) Output results.

2.8.2 Engineering Documentation

FADESN analyzes the results of factorial experiments. It calculates the sum of squares, regression coefficients, the experimental error (either from replicate measurements or from interaction effects that are insignificant and negligible) and, finally, performs the F-test to determine the significance of each effect.

The method of evaluation for the experimental designs aims to relate the quantity measured, (i.e., the observation) to the variables of the design (i.e., the factors).

This dependence is usually in the form of a regression equation:

$$Y = BO + B1*X1 + ... + BN*X1*...*XN$$

where:

Y is the response or test result
BO,...,BN are the regression coefficients
X1,...,XN are the main factors
X1*...*XN is their (N-1)th degree interaction.

The user has to know the number of levels, the design matrix (information matrix), and the test results of the experiments. Either the user's own design matrix can be entered, or one of the five supplied by the program can be used.

They are coded as: L4(2**3), L8(2**7), L16(2**15), L9(3**4), and L16(4**5).
(L4(2**3) indicates a design with four observations or rows; three effects or columns, and all factors at 2-levels.)

Reference: Leung, J., "An Analysis of the Results of Factorial Experiments in Mineral Processing with Computer," CANMET Division Report 84-150(IR).

Example: A 2^2 factorial design with four observations; two factors X1 and X2; interaction X1*X2; all factors at two levels -1 (lower level) and +1 (higher level); the design matrix (with dimension 4×3) is available as design No. 1 in this program:

Test No.	X1	X2	X1*X2
1	-1	-1	1
2	1	-1	-1
3	-1	1	-1
4	1	1	1

The test results are: 100, 120, 200 and 230.

The regression equation becomes:

$$Y = BO + B1*X1 + B2*X2 + B3*X1*X2$$

The experimental error can be estimated from the interaction effect X1*X2 because it has the least sum of squares. The result shows that only the X2 factor has a significant effect on Y.

2.8.3 Sample Run

(This example is taken from the "SPOC Manual", Chapter 4.)

A major porphyry copper mine in British Columbia wanted to improve the performance PW of its grinding circuit. From a preliminary survey, the three variables believed to have the most effect were identified, and each variable was set at two levels:

Variable	low	high
F (rod mill feed rate, stph)	320	340
W (pump box water addition rate, USGPM)	1000	1150
A (cyclone apex size, in.)	6	7

To include all the interaction effects, the regression equation can be written as:

$$PW(\$ \times 10^{-6}) = b_0 + b_1F^* + b_2W^* + b_3A^* + b_4F^*W^* + b_5F^*A^* \; F + b_6W^*A^* + b_7F^*W^*A^*$$

where F*, W* and A* are coded as -1 for low level and + 1 for high level.

The design matrix is as follows, with tests 9 to 12 as replicate tests done at the midpoint of the design.

Design Matrix

Test No.	F*	W*	A*	F*W*	F*A*	W*A*	F*W*A*	PW ($ × 10⁻⁶)
1	-1	-1	-1	+1	+1	+1	-1	35.522
2	+1	-1	-1	-1	-1	+1	+1	36.184
3	-1	+1	-1	-1	+1	-1	+1	35.921
4	+1	+1	-1	+1	-1	-1	-1	37.125
5	-1	-1	+1	+1	-1	-1	+1	35.599
6	+1	-1	+1	-1	+1	-1	-1	36.106
7	-1	+1	+1	-1	-1	+1	-1	35.46
8	+1	+1	+1	+1	+1	+1	+1	37.433
9								36.334
10	0	0	0	0	0	0	0	36.759
11								36.616
12								36.227

```
**************FACTORIAL DESIGN***************

HERE IS A LIST OF EXPERIMENTAL DESIGNS AVAILABLE IN
THIS PROGRAM :

                                    DESIGN MATRIX                POSSIBLE
   DESIGN NO.   NO. OF LEVELS   DIMENSIONS (ROW X COLUMN)   NO. OF FACTORS
   ----------   -------------   --------------------------   --------------
      1              2               4  X  3                 2 OR 3
      2              2               8  X  7                 3,4,5,6 OR 7
      3              2              16 X 15                  4,5,6,7 OR 8
      4              3               9  X  4                 2,3 OR 4
      5              4              16 X  5                  2,3,4 OR 5

WHICH DESIGN YOU WANT (1,2,...OR 5,0 IF NONE OF THESE)?0
YOU ARE TO ENTER YOUR OWN EXPERIMENTAL DESIGN
ENTER THE NUMBERS OF LEVELS, ROWS AND COLUMNS: 2,8,7
THE LEVELS ARE TO BE REPRESENTED BY:
         -1,  1            (2-LEVEL)
         -1,  0, 1         (3-LEVEL)
         -3, -1, 1, 3      (4-LEVEL)
MAXIMUM NO. OF LEVELS = 4

ENTER THE MATRIX ONE COLUMN AT A TIME:
    COLUMN( 1) =-1,1,-1,1,-1,1,-1,1
    COLUMN( 2) =-1,-1,1,1,-1,-1,1,1
    COLUMN( 3) =-1,-1,-1,-1,1,1,1,1
    COLUMN( 4) =1,-1,-1,1,1,-1,-1,1
    COLUMN( 5) =1,-1,1,-1,-1,1,-1,1
    COLUMN( 6) =1,1,-1,-1,-1,-1,1,1
    COLUMN( 7) =-1,1,1,-1,1,-1,-1,1

IS THIS THE DESIGN YOU WANT (Y/N) ?Y

INPUT  8 TEST RESULTS: 35.522,36.184,35.921,37.125,35.599,36.106
35.46,37.433

ANY REPEAT MEASUREMENTS (Y/N) ?Y
ENTER THE NUMBER OF NO. 1 REPEAT MEASUREMENT (ENTER 0 TO FINISH): 4
ENTER THE TEST RESULTS FROM THIS REPEAT: 36.334,36.759,36.616,36.227
ENTER THE NUMBER OF NO. 2 REPEAT MEASUREMENT (ENTER 0 TO FINISH): 0

THE VARIANCE OF EXPERIMENTAL ERROR =     .0605
THE NUMBER OF DEGREES OF FREEDOM   =        3

WHICH CONFIDENCE LIMIT 90 OR 95 ?95
```

```
                    ---------------------------------

                                                        CRITICAL F( 1, 3)
                                                          10.128 @95. %C.L.
REGRESSION       SUM OF    DEGREES      MEAN      F-RATIO  SIGNIFICANCE
COEFF.           SQUARES   OF FREEDOM   SQUARES
----------       -------   ----------   -------   -------  ------------
B 0:   36.169    10465.428

B 1:     .543        2.361   1            2.361  .3900E+02      YES

B 2:     .316         .799   1             .799  .1320E+02      YES

B 3:    -.019         .003   1             .003  .4897E-01      NO

B 4:     .251         .504   1             .504  .8326E+01      NO

B 5:     .077         .047   1             .047  .7785E+00      NO

B 6:    -.019         .003   1             .003  .4771E-01      NO

B 7:     .116         .107   1             .107  .1763E+01      NO

                    ---------------------------------
WANT TO EXIT THE PROGRAM (Y/N) ?Y

     STOP
     026000 MAXIMUM EXECUTION FL.
      0.508 CP SECONDS EXECUTION TIME.
```

2.9 TIMESR

2.9.1 Program Identification

Author: J. Leung (CANMET, EMR).

Date Written: November 1984.

Last Update: None. Version 0.

Purpose: To calculate mean, variance and variogram for time or space dependent data.

Remarks: The program was originally written for Hewlett Packard 41C calculator by J. Merks and rewritten in FORTRAN language by J. Leung.

Reference: Merks, J.W. "Sampling and weighing of bulk solids"; Trans Tech Publications; February 1985.

2.9.2 Engineering Documentation

TIMESR calculates mean, variance, and variogram for time- or space-dependent data, entered by the user. The program prints out each consecutive pair of data and the difference between the two, followed by the statistical values of all the data.

Time series variance is also calculated from all pairs of data with J spacing(s) (J=1,2,... max=N, until the sequential variance exceeds the classical variance).

The formulae used are:

$$\text{Classical variance} = \sum_{I=1}^{N} (X(I)-XBAR)^2/(N-1)$$

$$\text{Time series variance} = \sum_{I=1}^{N-j} (X(I)-X(I+J))^2/(2(N-J))$$

where:

XBAR = mean of all X
N = total number of X
J = spacing (min.=1, max.=N).

2.9.3 Sample Run

```
---------------------------------TIME SERIES---------------------------------

THIS PROGRAM CALCULATES MEAN, VARIANCE AND VARIOGRAM FOR
TIME OR SPACE DEPENDENT DATA


ENTER THE NUMBER OF DATA (MAX=100): 28

ENTER  28 DATA (IN FREE FIELD FORMAT) : 4.02,5.37,6.93,7.07,7.1,7.22
8.11,5.54,4.31,5.22,4.51,4.22,5.51,5.23,5.14,5.97,5.16,5.68,5.07,5.21
5.16,5.75,4.9,5.42,4.92,4.71,4.54,4.77
```

NO.	X(I)	X(I+1)	DIFF
1	4.020	5.370	-1.350
2	5.370	6.930	-1.560
3	6.930	7.070	-.140
4	7.070	7.100	-.030
5	7.100	7.220	-.120
6	7.220	8.110	-.890
7	8.110	5.540	2.570
8	5.540	4.310	1.230
9	4.310	5.220	-.910
10	5.220	4.510	.710
11	4.510	4.220	.290
12	4.220	5.510	-1.290
13	5.510	5.230	.280
14	5.230	5.140	.090
15	5.140	5.970	-.830
16	5.970	5.160	.810
17	5.160	5.680	-.520
18	5.680	5.070	.610
19	5.070	5.210	-.140
20	5.210	5.160	.050
21	5.160	5.750	-.590
22	5.750	4.900	.850
23	4.900	5.420	-.520
24	5.420	4.920	.500
25	4.920	4.710	.210
26	4.710	4.540	.170
27	4.540	4.770	-.230

```
MEAN =                5.456
VARIANCE =             .996566
STD. DEV. =            .998282
COEF. OF VAR. =     18.297908
```

SPACING	VARIANCE
1	.372117
2	.672715
3	.779436

```
                ---------------------------------

ANOTHER RUN (Y/N)?N
```

2.10 STATPD

2.10.1 Program Identification

Author: J. Leung (CANMET, EMR).

Date Written: November 1984.

Last Update: None. (Version 0.)

Purpose: To calculate the means, the variances, the standard deviations, the correlation coefficients and the regression coefficients from a set of paired data.

Remarks: The program was originally written for Hewlett Packard 41C calculator by J. Merks and rewritten in FORTRAN language by J. Leung.

Reference: Merks, J.W. "Sampling and weighing of bulk solids"; Trans Tech Publications; February 1985.

2.10.2 Engineering Documentation

STATPD calculates from a pair of data (X and Y), the mean, the variance, the standard deviation, the coefficient of variation, the difference, and the absolute difference.

It also correlates X and Y with a regression equation, Y = A + B*X, by finding coefficients A and B. Finally, it compares their T-values with the student T-distribution approximation.

2.10.3 Sample Run

```
---------------------------------STATPD---------------------------------

THIS PROGRAM CALCULATES THE STATISTICAL VALUES FOR
A SET OF PAIRED DATA


HOW MANY PAIRS OF DATA ALL TOGETHER (MAX=100)?15
ENTER  15  PAIRS OF DATA (PAIR BY PAIR IN FREE FIELD FORMAT) :
58.3,57.5 58.1,57.4 57.3,56.3 58.4,57.7 55.6,55.2 57.4,56.9 59,59.4
58.6,59.5 60,59.9 59.5,59.3 60.1,59.3 59.3,58.4 58.4,58.2 59,58.1
59.4,58.9


NO.         X            Y           X-Y
----     -------      -------     ---------

  1       58.3000      57.5000       .8000
  2       58.1000      57.4000       .7000
  3       57.3000      56.3000      1.0000
  4       58.4000      57.7000       .7000
  5       55.6000      55.2000       .4000
  6       57.4000      56.9000       .5000
  7       59.0000      59.4000      -.4000
  8       58.6000      59.5000      -.9000
  9       60.0000      59.9000       .1000
 10       59.5000      59.3000       .2000
 11       60.1000      59.3000       .8000
 12       59.3000      58.4000       .9000
 13       58.4000      58.2000       .2000
 14       59.0000      58.1000       .9000
 15       59.4000      58.9000       .5000

             SUM        MEAN      VARIANCE    STD DEVIATION  COEF. OF VARIATION
          ----------  ----------  ----------   -------------  ------------------
    X       878.4000    58.5600     1.356857     1.164842         1.989143
    Y       872.0000    58.1333     1.756667     1.325393         2.279919
  X-Y         6.4000      .4267      .276381      .525719          .901027
MEAN(X-Y)                          .018425      .135740          .232644
ABS(X-Y)      9.0000      .6000      .282743      .531736          .911339


REGRESSION EQUATION : Y = INTERCEPT + SLOPE*X

CORRELATION COEFFICIENT =      .918839
INTERCEPT =                  -3.090166
SLOPE =                       1.045483

STANDARD DEVIATION OF INTERCEPT  =     7.294238
                   OF SLOPE      =      .124537
                   OF ESTIMATE   =      .542787

              T-VALUE                DEGREES OF FREEDOM
              -------                ------------------
 INTERCEPT      -.423645                    13
 SLOPE          8.394956                    14
 MEAN(X-Y)      3.143260
T (  14), 95 %:    2.14          T (  14), 99 %:    2.98
T (  13), 95 %:    2.16          T (  13), 99 %:    3.01
                   ----------------------------------
ANOTHER RUN (Y/N)?N

     STOP
     023000 MAXIMUM EXECUTION FL.
      0.350 CP SECONDS EXECUTION TIME.
```

2.11 ANOVA

2.11.1 Program Identification

Author:	J. Leung (CANMET, EMR).
Date Written:	January 1985.
Last Update:	None. (Version 0.)
Purpose:	To perform a one-way and two-way analysis of variance for a maximum of nine treatments of data. It also calculates the statistical values of every two treatments and compares the relationship between the two.
Remarks:	The program was originally written in CBASIC language by J. Merks and rewritten in FORTRAN language by J. Leung.
Reference:	Merks, J.W. "Sampling and weighing of bulk solids"; Trans Tech Publications; February 1985.
Subroutines and Functions Required:	None.

2.11.2 Engineering Documentation

ANOVA performs the analysis of variance for an experiment with more than two treatments (maximum=9). The user enters the observations of each treatment in a column. All treatments should have the same numbers of observations (i.e., same row numbers, maximum=50).

The program first prints the data entered by the user in columns. Under each column it prints their mean, variance, standard deviation, and coefficient of variation.

In one-way (or single-classification) analysis, the amounts of variation are calculated *between* columns and *within* columns. The F-ratio is given to test the null hypothesis that the means of all columns are equal. If the F-ratio is significantly greater than the value from the F-table, then the hypothesis is discredited; i.e., the means of all columns are not equal.

In two-way (or cross-classification) analysis, each observation can be classified independently with respect to all sources of variation. Two factors occur: the treatment (or column) effect, and the block (or row) effect. The two F-ratio values can be tested separately for the variability of the means of the columns and rows.

Finally, the program calculates the statistical values of every paired column and correlates the two columns with a regression equation (Y = A + B*X) where the higher order column is the *dependent* variable Y and the lower column is the *independent* variable X.

The regression coefficients A, B, and their T-values, will be calculated if the correlation coefficient R:XY is greater than the R-value approximation. Then, the T-values of A and B can be compared with the student T-distribution approximation for the significance test.

2.11.3 Sample Run

```
****** ANOVA ******


JOB TITLE : BIAS TEST
DESCRIPTION OF DATA (40 CH. MAX.) : DRY ASH FROM ROTATING HAMMER SAMPLER
ENTER THE NUMBER OF COLUMNS : 3
ENTER THE NUMBER OF ROWS : 29

HEADING OF COLUMN 1: REFEREE INCREMENT A
DATA FOR COLUMN 1: 5.17,5.11,7.96,8.25,10.14,7.46,6.01,6.26,7.11,6.19
5.63,5.21,6.5,6.5,5.77,6.99,7.02,6.19,5.66,5.83,6.1,8.34,7.25,6.65
5.31,5.45,6.86,6.09,6.06

HEADING OF COLUMN 2: REFEREE INCREMENT B
DATA FOR COLUMN 2: 5.24,4.97,7.93,8.1,9.97,7.69,5.96,6.04,6.95,6.19
5.64,5.25,6.65,6.54,5.55,7.03,7,6.19,5.59,5.85,6.21,8.52,7.5,6.91
5.24,5.63,7.01,6.08,5.97

HEADING OF COLUMN 3: MECHANICAL INCREMENT
DATA FOR COLUMN 3: 5.2,4.99,8.25,8.27,9.37,7.74,6.25,6.37,7.45,6.19
5.53,5.14,6.55,6.8,5.97,6.89,7.07,5.89,5.62,6.02,6.26,8.97,7.49
7.01,5.33,5.57,6.86,5.93,5.92
```

ROW NO.	COLUMN 1	COLUMN 2	COLUMN 3
1	5.1700	5.2400	5.2000
2	5.1100	4.9700	4.9900
3	7.9600	7.9300	8.2500
4	8.2500	8.1000	8.2700
5	10.1400	9.9700	9.3700
6	7.4600	7.6900	7.7400
7	6.0100	5.9600	6.2500
8	6.2600	6.0400	6.3700
9	7.1100	6.9500	7.4500
10	6.1900	6.1900	6.1900
11	5.6300	5.6400	5.5300
12	5.2100	5.2500	5.1400
13	6.5000	6.6500	6.5500
14	6.5000	6.5400	6.8000
15	5.7700	5.5500	5.9700
16	6.9900	7.0300	6.8900
17	7.0200	7.0000	7.0700
18	6.1900	6.1900	5.8900
19	5.6600	5.5900	5.6200
20	5.8300	5.8500	6.0200
21	6.1000	6.2100	6.2600
22	8.3400	8.5200	8.9700
23	7.2500	7.5000	7.4900
24	6.6500	6.9100	7.0100
25	5.3100	7.2400	5.3300
26	5.4500	5.6300	5.5700
27	6.8600	7.0100	6.8600
28	6.0900	6.0800	5.9300
29	6.0600	5.9700	5.9200
MEAN	6.5197	6.5310	6.5828
VAR	1.2742	1.2952	1.2950
STD	1.1288	1.1381	1.1380
CV	17.3136	17.4254	17.2874

ONE-WAY ANALYSIS OF VARIANCE

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SUM OF SQUARES	F-RATIO
COLUMNS	.0656	2	.0328	0.025
ROWS	108.2021	84	1.2881	
TOTAL	108.2678	86		

TWO-WAY ANALYSIS OF VARIANCE

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SUM OF SQUARES	F-RATIO
COLUMNS	.0656	2	.0328	1.419
ROWS	106.9079	28	3.8181	165.203
RESIDUAL	1.2943	56	.0231	
TOTAL	108.2678	86		

WANT T-VALUES FOR PAIRED COLUMNS (Y/N) ?Y

STUDENT'S T-VALUE FOR PAIRED COLUMNS

COL	MD	CV	SD:MD	TV:MD	R:XY	B	SD:B	TV:B	A	SD:A	TV:A
1-2	-.0114	2.10	.0255	.447	.9927	1.00	.0234	42.91	.01	.1546	.04
1-3	-.0631	3.87	.0471	1.341	.9750	.98	.0431	22.82	.17	.2849	.61
2-3	.0517	3.60	.0438	1.181	.9785	.98	.0397	24.66	.19	.2629	.73

T (28), 95%: 2.05 T (28), 99%: 2.76
T (27), 95%: 2.05 T (27), 99%: 2.77

R (27), 95%: .37 R (27), 99%: .47

----------EXPLANATION FOR SYMBOLS----------

MD	: MEAN DIFFERENCE	CV	: COEFFICIENT OF VARIATION
SD	: STANDARD DEVIATION	TV	: STUDENT'S T-VALUE
A	: INTERCEPT	B	: SLOPE
R:XY	: CORRELATION COEFFICIENT		

ANOTHER RUN (Y/N) ?N

```
     STOP
     024100 MAXIMUM EXECUTION FL.
      0.506 CP SECONDS EXECUTION TIME.
```

2.12 COMPLOT

2.12.1 Program Identification

Author:	W. Feader.
Last Update:	F. Flament, November 1984.
Purpose:	To generate Calcomp plot jobs interactively, allowing the user the widest range of plotting options and defaults.
Remarks:	This program is called to execution by the CCL procedure, COMPLOT. The various routines accept: - plotting parameters - plotting data - requests for manipulation of plotting data.
Subroutines and Functions Required:	CENTER, SYMBOL, LINTYP, GETPT, XYFUNC, GETFIL, TITLE, PAIRS, SORT.
Library Required:	EMRLIB (from Computer Science Centre, EMR).

2.12.2 Engineering Documentation

COMPLOT is a conversational plotting program for the creation of X/Y plots in interactive mode. The user is presented with a list of default values divided into several groups: axes characteristics, curves characteristics, hard copy characteristics, labels, and titles.

Up to 1000 data points can be plotted and divided into a maximum of nine different curves. The graph can be previewed on a graphic terminal and, if unsatisfactory, can be modified by changing interactively any, or all, the tabulated options. When the user is satisfied with the displayed graph, a hard copy can be obtained on the Calcomp plotter using the pen type, size, and colour specified by the user.

For demonstration, a typical X/Y graph is presented; the size distribution obtained by simulation of a grinding circuit are plotted. (This demo was set up on a tektronix 4016 terminal, operated at 9600 bauds, and may present technical difficulties for remote operation from different terminals at lower speeds.) The following messages will appear on the screen, and require the appropriate entry by the user:

MESSAGE	REPLY
START OF TAPE OPTION?	**W**
WHERE WOULD YOU LIKE ORIGIN?	**0,0**
0,0 ENTER SIZE (WIDTH, HEIGHT)?	(See below)

The reply to this last message depends on your terminal size, since it is used to fit the original plot within the window of your screen and to maintain the original proportions.

Default graph size = 6×6 in.

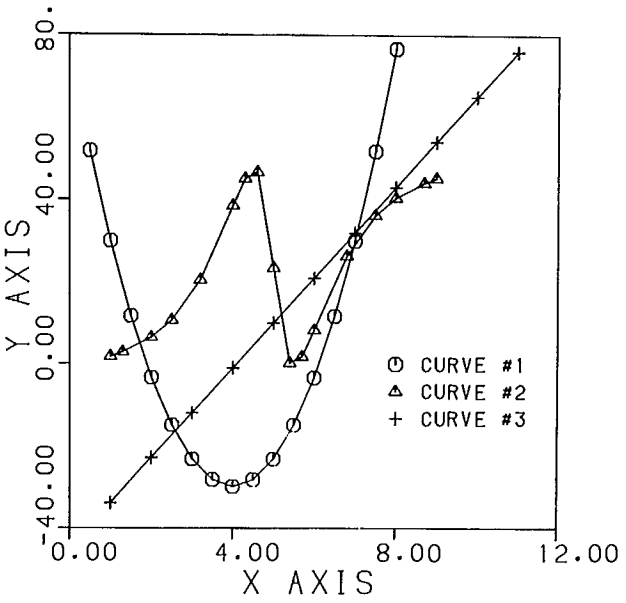
General window:	TEKTRONIX 4010	16/12
	DIGITAL VT640	16/12
	VGT 100	16/12

However, to avoid distortion on the VT640, a factor of 11/8 can be applied to the X-dimension of the window. For instance, 16/12 window on TEK, can be seen in the same proportion with a window of 22/12 on VT640; a full screen image with a window of 22/12 on VT640 can be seen with same proportion with a window of 22/16 on TEK. If you do not know...try numbers around these.

After entering the size by a carriage return, the terminal waits for a final command: **EC**. This will erase the screen and display the graph. Entering **C** will terminate the demo.

2.12.3 Sample Run

A typical graph obtained with COMPLOT is shown below:



2.13 URANDT

2.13.1 Program Identification

Author: D. Laguitton.

Date Written: November 1981.

Last Update: January 1984.

Purpose: Program to test random number generation of a sample of a Gaussian population of given mean and standard deviation. For each run, NN samples can be generated.

Usage: Executes as a main program.

File Description: System input and output are used for free format user input. No fixed record formats are used.

2.13.2 Engineering Documentation

The URANDT program uses a random-number generator to produce series of numbers that belong to a normal population of given mean and given standard deviation. It is used to simulate the sampling of a lot by increments (cuts) and to illustrate the Central Limit theorem.

As the number of increments that form this sample increases, the standard deviation of the mean of a composite sample decreases.

In practice, since a large part of the sampling error occurs at the cut of an increment, the more increments there are, the better it is.

The program requires the mean and standard deviation in each cut (e.g., the CU% grade of the sampled stream and the absolute error on that grade in each increment) and the number of increments collected as well as their size (i.e., the number of random numbers in each increment).

The following limits have been preset:
mean : maximum 1000
number of increments (cuts) : 2 to 30
increment size : 10 to 200 numbers in each.

2.13.3 Sample Run

```
          ***** URANDT *****
            SAMPLING SIMULATION
       POPULATION MEAN (MAX=1000): 100
       POPULATION STD DEV: 10
       NUMBER OF INCREMENTS (MAX=30): 10
       SIZE OF INCREMENTS (MAX=200): 200



            SAMPLING SIMULATION
       POPULATION MEAN (MAX=1000): 100.0
       POPULATION STD DEV: 10.00
       NUMBER OF INCREMENTS (MAX=30):   10
       SIZE OF INCREMENTS (MAX=200):  200

    INCREMENT     MEAN       STD DEV
        1        99.83        10.01
        2        100.2        10.59
        3        101.5        10.19
        4        100.9        9.389
        5        99.25        9.592
        6        100.9        9.800
        7        99.79        9.819
        8        99.07        10.38
        9        98.50        11.29
       10        99.47        10.00
    ---------------------------------
COMPOSITE SAMPLE 99.94        .9433


ANOTHER SAMPLE?(Y/N): N

     STOP
     046000 MAXIMUM EXECUTION FL.
      0.894 CP SECONDS EXECUTION TIME.
```

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