APPENDIX D

COMPUTER PROGRAMS FOR LOWERING CALCULATIONS

APPENOIX D

PROGRAM PLIFT

The computer program PLIFT calculates the lift-off length and force required to lift the pipeline at a single point. The program *is* based on the equations for lifting the pipeline described in Appendix B. The input for the program consists *of:*

1. Outside diameter of the pipe, 00 (inches)
2. Wall thickness of the pipe, t (inches)
3. Elastic modulus of the pipe material, E (psi)
4. Specific weight *of* the pipe material, γ (lb/in^3)
5. Soil stiffness parameter, k (psi)
6. Specific gravity of the fluid in the pipe, SG (dimensionless)
7. Lifting height at center of pipeline, h (inches).

The PLIFT program calculates the lift-off lengths, maximum stress, and force required to lift the center of the pipeline to the specified height. These calculations are performed for existing axial stresses from -10 ksi to 30 ksi in 1 ksi increments. The axial stress induced by the lengthening of the pipeline is taken into account in the program and is added *to* the existing stress to determine the total axial stress. The program iterates on the solution until the lengthening stress from two successive iterations is equal.

The program was designed to be run interactively. The output form the program is displayed on the terminal screen. An additional copy of the output may be written *to* file FOR001.DAT, if desired. The output consists of:

1. An echo of the input parameters
2. Lift-off length, lifting force, and maximum stress for existing axial stresses from -10 to 30 ksi.

A computer listing of the program (VAX-11/780 version) is given below.

```
0001            PROGRAM PLIFT
0002            IMPLICIT REAL*8 (A-Z)
0003            INTEGER*4 IADD,SIGN,IERR,I
0004            CHARACTER*1 FILE
0005            PARAMETER (PI=3.141592654)
0006            DIMENSION LINC(5)
0007            COMMON /PARA/N,EI,L1,K,QN,QK,LM,LM2,EM,OD,QEI,Q,SIGMA
0008            COMMON /CONST/W0,P0,C1,C2,C3,C4,C5,C6,C7
0009            DATA LINC/50.,-10.,1.,-0.1,0.01/
0010      C
0011      C
0012            WRITE(6,1)
0013            WRITE(6,2)
0014            WRITE(6,3)
0015            READ(5,*)OD
0016            WRITE(6,4)
0017            READ(5,*)T
0018            WRITE(6,5)
0019            READ(5,*)EM
0020            WRITE(6,6)
0021            READ(5,*)GAMMA
0022            WRITE(6,7)
0023            READ(5,*)SG
0024            WRITE(6,8)
0025            READ(5,*)K
0026            WRITE(6,9)
0027            READ(5,*)H
0028      C
0029            WRITE(6,10)
0030            WRITE(6,11)
0031            READ(5,12)FILE
0032            IERR= STR$UPCASE(FILE,FILE)
0033            ID= OD - 2.*T
0034      C
0035            I= PI*(OD**4-ID**4)/64.
0036            EI= EM*I
0037            AREA= PI*(OD*OD-ID*ID)/4.
0038            AREAI  PI*ID*ID*9.013310185D-03
0039            Q= GAMMA*AREA + SG*AREAI
0040            QEI=Q/EI
0041            QK=Q/K
0042      C
0043            IF(FILE.EQ.'Y')THEN
0044              WRITE(1,1)
0045              WRITE(1,3)OD
0046              WRITE(1,4)T
0047              WRITE(1,5)EM
0048              WRITE(1,6)GAMMA
0049              WRITE(1,7)SG
0050              WRITE(1,8)K
```

```
051           WRITE(1,9)H
0052          WRITE(1,13)
053         ENDIF
054           WRITE(6,3)OD
0055          WRITE(6,4)T
056           WRITE(6,5)EM
357           WRITE(6,6)GAMMA
0058          WRITE(6,7)SG
359           WRITE(6,8)K
060           WRITE(6,9)H
0061          WRITE(6,13)
062     C
063         STL=0.0
0064        STOLD=0.0
365         L= 150.0
366         DO 400 I= -10000,30000,1000
0067        SIGINT= FLOAT(I)
068       100 STLX= 0.75*STL + 0.25*STOLD
069         STOLD=STL
0070        SIGMA=SIGINT+STLX
071         N= ABS(SIGMA*AREA)
072         IF(N.NE.0.0)QN= Q/N
0073        IADD= 1
074         SIGN= 1
075         LOLD= L
0076      200 L1= L*6.
077         CALL HEIGHT
078         IF(SIGN.EQ.1)THEN
0079          IF(WO.LT.H)GOTO 300
080           IADD= IADD + 1
081           SIGN = -1
0082        ELSE
383           IF(WO.GT.H)GOTO 300
084           IADD= IADD + 1
0085          SIGN =  1
086         ENDIF
087       300 IF(IADD.LT.6)THEN
0088          L= L + LINC(IADD)
089           GOTO 200
090         ENDIF
0091        CALL STRESS(SMAX,STL)
092         DSTL=ABS(STL-STOLD)
0093        DLL=ABS(L-LOLD)
0094        IF((DSTL.GT.0.5).OR.(DLL.GT.0.01))GOTO 100
095         IF(FILE.EQ.'Y')WRITE(1,14)I,L,SMAX,PO
0096      400 WRITE(6,14)I,L,SMAX,PO
0097        STOP
098       1 FORMAT(//'0This program calculates the lift-off length, maximum'
0099       &,' stress, and force'/' required to lift a pipeline to a'
0100       &,' specified height at the center.')
```

```
0101        2 FORMAT(///'0ENTER THE FOLLOWING DATA::')
0102        3 FORMAT(/'$ Outside diameter of pipe                    (inches): '
0103         &,:,F13.3)
0104        4 FORMAT('$ Wall thickness of pipe                       (inches): '
0105         &,:,F13.3)
0106        5 FORMAT('$ Elastic modulus of pipe material                (psi): '
0107         &,:,F13.3)
0108        6 FORMAT('$ Specific weight of pipe material             (lb/in**3): '
0109         &, :,F13.3)
0110        7 FORMAT('$ Specify gravity of fluid in pipeline                : '
0111         &,:,F13.3)
0112        8 FORMAT('$ Soil stiffness parameter                        (psi): '
0113         &,:,F13.3)
0114        9 FORMAT('$ Lifting height at center of pipeline         (inches): '
0115         &, :,F13.3)
0116       10 FORMAT('0 Output will be displayed on the terminal screen.')
0117       11 FORMAT('$ Do you want an additional copy on file FOR001? (Y/N): ')
0118       12 FORMAT(A1)
0119       13 FORMAT('0    Initial     Lift-off    Maximum     Lifting'/
0120         &       '     Stress      Length      Stress      Force '/
0121         &       '      (psi)      (feet)       (psi)       (lb) '/)
0122       14 FORMAT(6X,I6,3X,F9.1,3X,F10.0,2X,F10.0)
0123          END
```

```
      SUBROUTINE HEIGHT
      IMPLICIT REAL*8 (A-Z)
C
      PARAMETER (PI=3.141592654)
      COMMON /PARA/N,EI,L,K,QN,QK,LM,LM2,EM,OD,QEI,Q,SIGMA
      COMMON /CONST/WO,PO,C1,C2,C3,C4,C5,C6,C7
      COMMON /GREEK/AG,AG2,BG,BG2
C
      IF (SIGMA) 1000,2000,3000
C
 1000 CONTINUE
C
      LM2= N/EI
      LM= SQRT(LM2)
      LM3= LM*LM2
      CLL= COS(LM*L)
      SLL= SIN(LM*L)
C
      LC=SQRT(K/4./EI)
      DC= N/4./EI
      AG=SQRT(LC+DC)
      BG=SQRT(LC-DC)
C
      AG2=AG*AG
      BG2=BG*BG
      AO= SLL*(AG2-BG2)-CLL*LM*BG
      BO= 2.*AG*BG*SLL+AG*LM*CLL
      EO= BG*(LM2-3.*AG2+BG2)
      FO= AG*(AG2-3.*BG2-LM2)
      L2= L*L
C
      C5= QN/2.
      C6= -QK
      C7= (2.*LM*(L*LM-SLL)*C5-((CLL-1.)*EO+AO*LM)*C6)
     &    /(BO*LM+FO*(CLL-1.))
      C4= (2.*L*LM2*C5+EO*C6+FO*C7)/LM3
      C3= (AG*C7-BG*C6+(1.-CLL)*LM*C4-2.*L*C5)/(-LM*SLL)
      C2= -LM*C4
      C1= -QK-L2*C5+(LM*L-SLL)*C4-CLL*C3
      PO= -2.*LM3*EI*C4
      PO= ABS(PO)
      WO= ABS(C1 + C3)
      RETURN
 2000 CONTINUE
      LC=SQRT(K/4./EI)
      AG=SQRT(LC)
C
      AL= AG*L
      AL2= AL*AL
      AL3= AL*AL2
```