PIPESTRESS DESIGN REPORT

PIPING SYSTEM : CANTILEVER

Date: Di 01-Okt-1996
Time: 19:51:34

Project: MINI CLUSTER NAM BOTLEK

Jobnr: CBA29336

ABSTRACT:

P10 berekening van een ingeklemde balk.
Aan het uiteinde worden krachten en momenten aangebracht die in de WE, PR en TE case tot uiting horen te komen.

Bepaald kan worden in hoeverre de combinaties correct worden verwerkt.

REFERENCES:

P10 Manual
Stoomwezen D1101
Stoomwezen D0201

REV	BY	DATE	DESCRIPTION	CHECKED	PROJECT APPROVAL	THIRD PARTY APPROVAL
0	PVo	Do 26-Sep-1996	First Issue			

STATUS CODE	DOCUMENT NUMBER	REVISION	STATUS
A Preliminary for information only B For review C Authorized for construction	**SP96011**	**0**	**A**

GENERAL INFORMATION

Identification

Piping system : CANTILEVER

Process unit : NOPPES

Line numbers that form part of process unit : LEIDING

Connecting equipment : VASTE HAND

Piping specification : GEEN

Line list : GEEN

Drawing list : ABC-1234567

Installation temperature : 20 °C

Acceleration of gravity : 9.80665 m/sec^2

Direction of gravity : -Y

Stoomwezen registration No. : 2008702

Number of runs : 1

Total Number of loading cases : 1

Total Number of outputs : 5

STATIC ANALYSIS

Allowable stresses
The allowable stresses of Stoomwezen D1101 are determined as follows:

- $\sigma 1 \leq f$
- $\sigma 2 \leq f \times 1.2$
- $\sigma e \leq fe$

where:

- $\sigma 1$ = the equilibrium stress in the pipe due to pressure, weight and other equilibrium loads (exclusive occasional loadings and temperature).
- $\sigma 2$ = the equilibrium stress in the pipe due to the above mentioned loads plus occasional loadings.
- f = the design stress for primary stresses is the lesser of:
  - 0.67 x Re(ϑm)
  - 0.44 x Rm
  - Rrg(1%; 100 000h; ϑm)
  - 0.67 x Rmg(100 000h; ϑm)
  - 0.83 x Rm min(100 000h; ϑm)
- Re(ϑm) = yield stress at temperature ϑm.
- Rm = tensile strength.
- Rrg(1%; 100 000h; ϑm) = average creep tensile stress to produce 1% permanent set after 100 000 hours at temperature ϑm.
- Rmg(100 000h; ϑm) = average creep tensile stress to produce rupture after 100 000 hours at temperature ϑm.
- Rm min(100 000h; ϑm) = minimum creep stress to produce rupture after 100 000 hours at temperature ϑm.
- σe = allowable stress range due to thermal loading. (secondary type)
- fe = cf x { 0.8 x Re + 0.13 x Re(ϑm) } design stress due to thermal loading. (secondary type)
- cf = fatigue factor (see below).
- Re = yield stress at 20 °C.

The values "$\sigma 1$","$\sigma 2$" and "σe" are taken as the maximum allowable stresses for the static calculation.

Allowable stress range

According chapter 3.3 of Stoomwezen D1101:
The stress range is determined on the basis of modulus of elasticity at ambient temperature (20 °C); any cold pull applied is not taken into account.
The equilibrium stresses are determined on the basis of modulus of elasticity at metal temperature ϑm, with cold pull taken into account.

Allowances and tolerances in accordance with Stoomwezen D0101 are not deducted when determining the elastic properties of the piping system, but are deducted when calculating the stresses from the forces and moments.

The allowable stress range is described in Stoomwezen D1101 chapter 6.4.
The stress range is limited in such a way that cyclic plastic deformation outside peak stress areas is prevented.

Deformation is non-recurrent when the stress range is not greater than the sum of the hot and cold (relaxation) limits. A usable approximation of these limits is composed by the yield stress and approximately 1.5 times the creep stress respectively. With respect to this "relaxation range" a margin for unknown effects has been reserved, expressed in a reduction factor of 0.8.

The limiting value of: cf x { 0.8 x (Re + Re(ϑm) } thus obtained may not be exceeded by the total stress range, i.e. including the stresses due to pressure, weight loads, occasional loadings and temperature.

For the stresses due to pressure, dead weight, wind, occasional loadings etc. cf x { 0.67 x Re(ϑm) } is reserved, so for thermal expansion stresses is still cf x { 0.8 x Re + 0.13 x Re(ϑm) } available.

Fatigue factor

Number of complete temperature cycles during service lifetime (land installations)	cf
≤ 7 000	1
≤ 14 000	0.9
≤ 22 000	0.8
≤ 45 000	0.7
≤ 100 000	0.6
> 100 000	0.5

Settlement

Forces acting on nozzles and supporting due to settlement displacements are indicative only. Yielding due to settlement is allowed. This yielding will create lower actual forces than calculated. Therefore, when occurring stresses due to the displacements are higher than the allowable stresses, the pipe will deform and the stresses will be relaxed. This occurring stress range is allowed up to 1.5 times the allowable stress range (attributed to weight, pressure and occasional loading).

Summary of allowable stresses

The allowable stresses indicated in the previous sections can be summarized as follows:

Load combination	Stoomwezen equivalent stress (N/mm^2)
1. Weight + pressure (primary type loads)	σ1
2. Weight + pressure + occasional loadings (primary type loads)	σ2
3. Weight + pressure + temperature + occasional loadings (functional loads)	σe + σ2 (stress range)
4. Temperature only (secondary type loads)	σe (stress range)
5. Weight + pressure + temperature (functional loads)	σe + σ1 (stress range)
6. 2 + settlement	≤ 1.5 x σ2
7. 3 + settlement	σe + σ2 (stress range)

CASE DESCRIPTION

Computer Run Number : 1

Loading Case : 1

Rerounding included? : No

Bourdon effect included? : No

Young's Modulus : E-Cold

Where :
- E-hot = Young's modulus at working temperature.
- E-cold = Young's modulus at ambient temperature.

Rerounding is taking into account the increased stiffness of a curved member due to internal pressure. This is established by a rerounding correction of K- and I-factors. (flexibility and stress intensification factor).

The Bourdon-effect describes the rotation at the end of a curved member due to internal pressure. Although not mentioned in the Rules for Pressure Vessels, Stoomwezen is not averse to take into account the Bourdon effect when a significant influence on the results is to be expected.

Nodal movements

These nodal movements represent the rotations and displacements of nozzles of equipment or supports.

Where :
- Comp = Loading Component at which movement is acting. (for explanation see output description).
- Rx = Prescribed nodal rotation about X - axis.
- Ry = Prescribed nodal rotation about Y - axis.
- Rz = Prescribed nodal rotation about Z - axis.

- Dx = Prescribed nodal displacement in X - direction.
- Dy = Prescribed nodal displacement in Y - direction.
- Dz = Prescribed nodal displacement in Z - direction.

Nodal loadings

These nodal loadings represent the moments and forces acting on nozzles of equipment or supports.

Where :
- Comp = Loading Component at which movement is acting. (for explanation see output description).
- Mx = Nodal moment about X - axis.
- My = Nodal moment about Y - axis.
- Mz = Nodal moment about Z - axis.

- Fx = Nodal force in X - direction.
- Fy = Nodal force in Y - direction.
- Fz = Nodal force in Z - direction.

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OUTPUT DESCRIPTION
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Computer Run Number           :  1

Output Number of this run     :  1

Loading Case of this output   :  1

Loading Components            :  TE

Rerounding included?          :  No

Bourdon effect included?      :  No

Young's Modulus               :  E-Cold

Where :
      - WE     = Weight component.
      - CS     = Cold spring component, in the stress calculation
                 cold spring is considered to be a separate term.
      - CW     = Cold spring component, in the stress calculation
                 cold spring is combined with weight
                 (primary stresses).
      - CT     = Cold spring component, in the stress calculation
                 cold spring is combined with temperature
                 (secondary stresses).
      - PR     = Pressure component.
      - TE     = Temperature component.
      - WI     = Wind or occasional loading component.
      - DY     = dynamic loading component.
      - WD     = Wind + dynamic loading component (WI + DY).

Component DY is not comprized in the Stoomwezen approval of P10.

Explanation of the abbreviations used in the member output:

      - FR-TO  = Node-numbers at both ends of the branch.
      - NR     = Member-number within the branch.
                 ( T = Tee at one or both ends of the member )
                 ( B = Member is a bend )
      - MT-X   = Torsional-moment about the local X-Axis.
      - MB-Y   = Bending-moment about the local Y-Axis.
      - MB-Z   = Bending-moment about the local Z-Axis.

      - FN-X   = Normal-force in the local X-Axis direction.
      - FS-Y   = Shear-force in the local Y-Axis direction.
      - FS-Z   = Shear-force in the local Z-Axis direction.

      - RX     = Rotation about the global X-Axis.
      - RY     = Rotation about the global Y-Axis.
      - RZ     = Rotation about the global Z-Axis.

      - TX     = Translation along the global X-Axis.
      - TY     = Translation along the global Y-Axis.
      - TZ     = Translation along the global Z-Axis.

      - S-RAT  = Stress ratio of occurring stress and allowable stress.
      - S-CODE = Occurring stress according to the code.
```

OUTPUT DESCRIPTION (CONT'D)

Computer Run Number	:	1
Output Number of this run	:	1
Loading Case of this output	:	1
Loading Components	:	TE
Material	:	API-5L Gr.X52 NEN3650 <=35mm
Design temperature	:	200.0 °C
Design pressure	:	120.00 bar

MATERIAL PROPERTIES

Rm tensile strength	:	455.00 N/mm^2
Re yield stress at 20 °C	:	358.00 N/mm^2
Re(ϑm)	:	255.00 N/mm^2
Rrg(1%; 100 000h; ϑm)	:	.00 N/mm^2
Rmg(100 000h; ϑm)	:	.00 N/mm^2
Rm min(100 000h; ϑm)	:	.00 N/mm^2
cf fatigue factor	:	1.00

CALCULATION OF ALLOWABLE EQUILIBRIUM STRESS σ1

σ1 is the smallest value of

0.67 x Re(ϑm)	:	170.85 N/mm^2
0.44 x Rm	:	200.20 N/mm^2
Rrg(1%; 100 000h; ϑm)	:	0.00 N/mm^2
0.67 x Rmg(100 000h; ϑm)	:	0.00 N/mm^2
0.83 x Rm min(100 000h; ϑm)	:	0.00 N/mm^2

(in output) σ1 = 170.9 N/mm^2
σ1 x 1.2 = (in output) σ2 = N/mm^2

CALCULATION OF ALLOWABLE STRESS RANGE σe

cf x { 0.8 x Re + 0.13 x Re(ϑm) } : 319.55 N/mm^2

(in output) σe = 319.5 N/mm^2

OUTPUT DESCRIPTION (CONT'D)

Computer Run Number : 1

Output Number of this run : 1

Loading Case of this output : 1

Loading Components : TE

Material : API-5L Gr.X52 NEN3650 <=35mm

Design temperature : 200.0 °C

Design pressure : 120.00 bar

Summary of allowable stresses

The allowable stresses indicated in the previous section can be summarized as follows:

Load combination	Stoomwezen equivalent stress (N/mm^2)
4. Temperature only (secondary type loads)	319.5 N/mm^2 (stress range)

OUTPUT DESCRIPTION

Computer Run Number : 1

Output Number of this run : 2

Loading Case of this output : 1

Loading Components : WE

Rerounding included? : No

Bourdon effect included? : No

Young's Modulus : E-Cold

Where :

- WE = Weight component.
- CS = Cold spring component, in the stress calculation cold spring is considered to be a separate term.
- CW = Cold spring component, in the stress calculation cold spring is combined with weight (primary stresses).
- CT = Cold spring component, in the stress calculation cold spring is combined with temperature (secondary stresses).
- PR = Pressure component.
- TE = Temperature component.
- WI = Wind or occasional loading component.
- DY = dynamic loading component.
- WD = Wind + dynamic loading component (WI + DY).

Component DY is not comprized in the Stoomwezen approval of P10.

Explanation of the abbreviations used in the member output:

- FR-TO = Node-numbers at both ends of the branch.
- NR = Member-number within the branch.
  (T = Tee at one or both ends of the member)
  (B = Member is a bend)
- MT-X = Torsional-moment about the local X-Axis.
- MB-Y = Bending-moment about the local Y-Axis.
- MB-Z = Bending-moment about the local Z-Axis.

- FN-X = Normal-force in the local X-Axis direction.
- FS-Y = Shear-force in the local Y-Axis direction.
- FS-Z = Shear-force in the local Z-Axis direction.

- RX = Rotation about the global X-Axis.
- RY = Rotation about the global Y-Axis.
- RZ = Rotation about the global Z-Axis.

- TX = Translation along the global X-Axis.
- TY = Translation along the global Y-Axis.
- TZ = Translation along the global Z-Axis.

- S-RAT = Stress ratio of occurring stress and allowable stress.
- S-CODE = Occurring stress according to the code.

OUTPUT DESCRIPTION (CONT'D)

Computer Run Number	:	1
Output Number of this run	:	2
Loading Case of this output	:	1
Loading Components	:	WE
Material	:	API-5L Gr.X52 NEN3650 <=35mm
Design temperature	:	200.0 °C
Design pressure	:	120.00 bar

MATERIAL PROPERTIES

Rm tensile strength	:	455.00 N/mm^2
Re yield stress at 20 °C	:	358.00 N/mm^2
Re(ϑm)	:	255.00 N/mm^2
Rrg(1%; 100 000h; ϑm)	:	.00 N/mm^2
Rmg(100 000h; ϑm)	:	.00 N/mm^2
Rm min(100 000h; ϑm)	:	.00 N/mm^2
cf fatigue factor	:	1.00

CALCULATION OF ALLOWABLE EQUILIBRIUM STRESS σ1

σ1 is the smallest value of

0.67 x Re(ϑm)	:	170.85 N/mm^2
0.44 x Rm	:	200.20 N/mm^2
Rrg(1%; 100 000h; ϑm)	:	0.00 N/mm^2
0.67 x Rmg(100 000h; ϑm)	:	0.00 N/mm^2
0.83 x Rm min(100 000h; ϑm)	:	0.00 N/mm^2

(in output) σ1 = 170.9 N/mm^2
σ1 x 1.2 = (in output) σ2 = N/mm^2

CALCULATION OF ALLOWABLE STRESS RANGE σe

cf x { 0.8 x Re + 0.13 x Re(ϑm) } : 319.55 N/mm^2

(in output) σe = 319.5 N/mm^2

OUTPUT DESCRIPTION (CONT'D)

Computer Run Number : 1

Output Number of this run : 2

Loading Case of this output : 1

Loading Components : WE

Material : API-5L Gr.X52 NEN3650 <=35mm

Design temperature : 200.0 °C

Design pressure : 120.00 bar

Summary of allowable stresses

The allowable stresses indicated in the previous section can be summarized as follows:

Load combination	Stoomwezen equivalent stress (N/mm^2)
1. Weight + pressure (primary type loads)	170.9 N/mm^2

OUTPUT DESCRIPTION

Computer Run Number : 1

Output Number of this run : 3

Loading Case of this output : 1

Loading Components : PR

Rerounding included? : No

Bourdon effect included? : No

Young's Modulus : E-Cold

Where :

- WE = Weight component.
- CS = Cold spring component, in the stress calculation cold spring is considered to be a separate term.
- CW = Cold spring component, in the stress calculation cold spring is combined with weight (primary stresses).
- CT = Cold spring component, in the stress calculation cold spring is combined with temperature (secondary stresses).
- PR = Pressure component.
- TE = Temperature component.
- WI = Wind or occasional loading component.
- DY = dynamic loading component.
- WD = Wind + dynamic loading component (WI + DY).

Component DY is not comprized in the Stoomwezen approval of P10.

Explanation of the abbreviations used in the member output:

- FR-TO = Node-numbers at both ends of the branch.
- NR = Member-number within the branch.
  (T = Tee at one or both ends of the member)
  (B = Member is a bend)
- MT-X = Torsional-moment about the local X-Axis.
- MB-Y = Bending-moment about the local Y-Axis.
- MB-Z = Bending-moment about the local Z-Axis.

- FN-X = Normal-force in the local X-Axis direction.
- FS-Y = Shear-force in the local Y-Axis direction.
- FS-Z = Shear-force in the local Z-Axis direction.

- RX = Rotation about the global X-Axis.
- RY = Rotation about the global Y-Axis.
- RZ = Rotation about the global Z-Axis.

- TX = Translation along the global X-Axis.
- TY = Translation along the global Y-Axis.
- TZ = Translation along the global Z-Axis.

- S-RAT = Stress ratio of occurring stress and allowable stress.
- S-CODE = Occurring stress according to the code.

OUTPUT DESCRIPTION (CONT'D)

Computer Run Number	:	1
Output Number of this run	:	3
Loading Case of this output	:	1
Loading Components	:	PR
Material	:	API-5L Gr.X52 NEN3650 <=35mm
Design temperature	:	200.0 °C
Design pressure	:	120.00 bar

MATERIAL PROPERTIES

Rm tensile strength	:	455.00 N/mm^2
Re yield stress at 20 °C	:	358.00 N/mm^2
Re(ϑm)	:	255.00 N/mm^2
Rrg(1%; 100 000h; ϑm)	:	.00 N/mm^2
Rmg(100 000h; ϑm)	:	.00 N/mm^2
Rm min(100 000h; ϑm)	:	.00 N/mm^2
cf fatigue factor	:	1.00

CALCULATION OF ALLOWABLE EQUILIBRIUM STRESS σ1

σ1 is the smallest value of

0.67 x Re(ϑm)	:	170.85 N/mm^2
0.44 x Rm	:	200.20 N/mm^2
Rrg(1%; 100 000h; ϑm)	:	0.00 N/mm^2
0.67 x Rmg(100 000h; ϑm)	:	0.00 N/mm^2
0.83 x Rm min(100 000h; ϑm)	:	0.00 N/mm^2

(in output) σ1 = 170.9 N/mm^2
σ1 x 1.2 = (in output) σ2 = N/mm^2

CALCULATION OF ALLOWABLE STRESS RANGE σe

cf x { 0.8 x Re + 0.13 x Re(ϑm) } : 319.55 N/mm^2

(in output) σe = 319.5 N/mm^2

OUTPUT DESCRIPTION (CONT'D)

Computer Run Number : 1

Output Number of this run : 3

Loading Case of this output : 1

Loading Components : PR

Material : API-5L Gr.X52 NEN3650 <=35mm

Design temperature : 200.0 °C

Design pressure : 120.00 bar

Summary of allowable stresses

The allowable stresses indicated in the previous section can be summarized as follows:

Load combination	Stoomwezen equivalent stress (N/mm^2)
1. Weight + pressure (primary type loads)	170.9 N/mm^2

```
OUTPUT DESCRIPTION
------------------

Computer Run Number           :  1

Output Number of this run     :  4

Loading Case of this output   :  1

Loading Components            :  WE + PR

Rerounding included?          :  No

Bourdon effect included?      :  No

Young's Modulus               :  E-Cold

Where :
      - WE     = Weight component.
      - CS     = Cold spring component, in the stress calculation
                 cold spring is considered to be a separate term.
      - CW     = Cold spring component, in the stress calculation
                 cold spring is combined with weight
                 (primary stresses).
      - CT     = Cold spring component, in the stress calculation
                 cold spring is combined with temperature
                 (secondary stresses).
      - PR     = Pressure component.
      - TE     = Temperature component.
      - WI     = Wind or occasional loading component.
      - DY     = dynamic loading component.
      - WD     = Wind + dynamic loading component (WI + DY).

Component DY is not comprized in the Stoomwezen approval of P10.

Explanation of the abbreviations used in the member output:

      - FR-TO  = Node-numbers at both ends of the branch.
      - NR     = Member-number within the branch.
                 ( T = Tee at one or both ends of the member )
                 ( B = Member is a bend )
      - MT-X   = Torsional-moment about the local X-Axis.
      - MB-Y   = Bending-moment about the local Y-Axis.
      - MB-Z   = Bending-moment about the local Z-Axis.

      - FN-X   = Normal-force in the local X-Axis direction.
      - FS-Y   = Shear-force in the local Y-Axis direction.
      - FS-Z   = Shear-force in the local Z-Axis direction.

      - RX     = Rotation about the global X-Axis.
      - RY     = Rotation about the global Y-Axis.
      - RZ     = Rotation about the global Z-Axis.

      - TX     = Translation along the global X-Axis.
      - TY     = Translation along the global Y-Axis.
      - TZ     = Translation along the global Z-Axis.

      - S-RAT  = Stress ratio of occurring stress and allowable stress.
      - S-CODE = Occurring stress according to the code.
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OUTPUT DESCRIPTION (CONT'D)

Computer Run Number	:	1
Output Number of this run	:	4
Loading Case of this output	:	1
Loading Components	:	WE + PR
Material	:	API-5L Gr.X52 NEN3650 <=35mm
Design temperature	:	200.0 °C
Design pressure	:	120.00 bar

MATERIAL PROPERTIES

Rm tensile strength	:	455.00 N/mm^2
Re yield stress at 20 °C	:	358.00 N/mm^2
Re(ϑm)	:	255.00 N/mm^2
Rrg(1%; 100 000h; ϑm)	:	.00 N/mm^2
Rmg(100 000h; ϑm)	:	.00 N/mm^2
Rm min(100 000h; ϑm)	:	.00 N/mm^2
cf fatigue factor	:	1.00

CALCULATION OF ALLOWABLE EQUILIBRIUM STRESS σ1

σ1 is the smallest value of

0.67 x Re(ϑm)	:	170.85 N/mm^2
0.44 x Rm	:	200.20 N/mm^2
Rrg(1%; 100 000h; ϑm)	:	0.00 N/mm^2
0.67 x Rmg(100 000h; ϑm)	:	0.00 N/mm^2
0.83 x Rm min(100 000h; ϑm)	:	0.00 N/mm^2

(in output) σ1 = 170.9 N/mm^2
σ1 x 1.2 = (in output) σ2 = N/mm^2

CALCULATION OF ALLOWABLE STRESS RANGE σe

cf x { 0.8 x Re + 0.13 x Re(ϑm) } : 319.55 N/mm^2

(in output) σe = 319.5 N/mm^2

OUTPUT DESCRIPTION (CONT'D)

Computer Run Number : 1

Output Number of this run : 4

Loading Case of this output : 1

Loading Components : WE + PR

Material : API-5L Gr.X52 NEN3650 <=35mm

Design temperature : 200.0 °C

Design pressure : 120.00 bar

Summary of allowable stresses

The allowable stresses indicated in the previous section can be summarized as follows:

Load combination	Stoomwezen equivalent stress (N/mm^2)
1. Weight + pressure (primary type loads)	170.9 N/mm^2

OUTPUT DESCRIPTION

Computer Run Number : 1

Output Number of this run : 5

Loading Case of this output : 1

Loading Components : WE + PR + TE

Rerounding included? : No

Bourdon effect included? : No

Young's Modulus : E-Cold

Where :

- WE = Weight component.
- CS = Cold spring component, in the stress calculation cold spring is considered to be a separate term.
- CW = Cold spring component, in the stress calculation cold spring is combined with weight (primary stresses).
- CT = Cold spring component, in the stress calculation cold spring is combined with temperature (secondary stresses).
- PR = Pressure component.
- TE = Temperature component.
- WI = Wind or occasional loading component.
- DY = dynamic loading component.
- WD = Wind + dynamic loading component (WI + DY).

Component DY is not comprized in the Stoomwezen approval of P10.

Explanation of the abbreviations used in the member output:

- FR-TO = Node-numbers at both ends of the branch.
- NR = Member-number within the branch.
  (T = Tee at one or both ends of the member)
  (B = Member is a bend)
- MT-X = Torsional-moment about the local X-Axis.
- MB-Y = Bending-moment about the local Y-Axis.
- MB-Z = Bending-moment about the local Z-Axis.

- FN-X = Normal-force in the local X-Axis direction.
- FS-Y = Shear-force in the local Y-Axis direction.
- FS-Z = Shear-force in the local Z-Axis direction.

- RX = Rotation about the global X-Axis.
- RY = Rotation about the global Y-Axis.
- RZ = Rotation about the global Z-Axis.

- TX = Translation along the global X-Axis.
- TY = Translation along the global Y-Axis.
- TZ = Translation along the global Z-Axis.

- S-RAT = Stress ratio of occurring stress and allowable stress.
- S-CODE = Occurring stress according to the code.

OUTPUT DESCRIPTION (CONT'D)

Computer Run Number	:	1
Output Number of this run	:	5
Loading Case of this output	:	1
Loading Components	:	WE + PR + TE
Material	:	API-5L Gr.X52 NEN3650 <=35mm
Design temperature	:	200.0 °C
Design pressure	:	120.00 bar

MATERIAL PROPERTIES

Rm tensile strength	:	455.00 N/mm^2
Re yield stress at 20 °C	:	358.00 N/mm^2
Re(ϑm)	:	255.00 N/mm^2
Rrg(1%; 100 000h; ϑm)	:	.00 N/mm^2
Rmg(100 000h; ϑm)	:	.00 N/mm^2
Rm min(100 000h; ϑm)	:	.00 N/mm^2
cf fatigue factor	:	1.00

CALCULATION OF ALLOWABLE EQUILIBRIUM STRESS σ1

σ1 is the smallest value of

0.67 x Re(ϑm)	:	170.85 N/mm^2
0.44 x Rm	:	200.20 N/mm^2
Rrg(1%; 100 000h; ϑm)	:	0.00 N/mm^2
0.67 x Rmg(100 000h; ϑm)	:	0.00 N/mm^2
0.83 x Rm min(100 000h; ϑm)	:	0.00 N/mm^2

(in output) σ1 = 170.9 N/mm^2
σ1 x 1.2 = (in output) σ2 = N/mm^2

CALCULATION OF ALLOWABLE STRESS RANGE σe

cf x { 0.8 x Re + 0.13 x Re(ϑm) } : 319.55 N/mm^2

(in output) σe = 319.5 N/mm^2

OUTPUT DESCRIPTION (CONT'D)

Computer Run Number : 1

Output Number of this run : 5

Loading Case of this output : 1

Loading Components : WE + PR + TE

Material : API-5L Gr.X52 NEN3650 <=35mm

Design temperature : 200.0 °C

Design pressure : 120.00 bar

Summary of allowable stresses

The allowable stresses indicated in the previous section can be summarized as follows:

Load combination	Stoomwezen equivalent stress (N/mm^2)
5. Weight + pressure + temperature (functional loads)	490.4 N/mm^2 (stress range)

ALLOWANCES

Allowances of Stoomwezen D0101 are determined as follows:

Symbols and units

- d mm = formula wallthickness (required minimum wallthickness)
- dd mm = wallthickness in accordance with construction drawing or dimension table.
- Δdf mm = fabrication allowance
- Δdc mm = corrosion allowance
- Δdt mm = tolerance allowance

In the strength assessment the minimum wall thickness (formula wallthickness) d shall always be used. The actual wall thickness may never be less than this minimum.
The wall thickness therefore have to be greater than d for three reasons:

- fabrication can lead to a reduction of wall thickness.
- wear and corrosion will cause a reduction of wall thickness sufficient to endanger the required lifetime.
- the basic material shows deviations in dimensions.

Minimum wallthickness:

$d = dd - \Delta df - \Delta dc - \Delta dt$ for assessment
$dd \leq d + \Delta df + \Delta dc + \Delta dt$ for design

Tolerance allowance Δdt

For the tolerance allowance either the guaranteed value out of the dimensional standard or specification of the tolerance guaranteed by the manufacturer shall be adhered to.
If such data are not available, an allowance in accordance in accordance with the following table shall be taken into account.

Material	Wall-thickness	Δdt for assessment	Δdt for design
rolled or forged	d ≤ 25 mm	0.5 mm	
	d > 25 mm	0.02 dd	0.02(d + Δdt + Δdc)
seamless pipe		0.13 dd	0.15(d + Δdt + Δdc)
cast iron	d ≤ 20 mm	2 mm + 0.045(dd-2mm)	0.05(d+Δdt+Δdc)+2mm
	d > 20 mm	0.13 dd	0.15(d + Δdt + Δdc)
other cast materials	d ≤ 10 mm	1 mm	
	d > 10 mm	0.09 dd	0.1(d + Δdt + Δdc)
sight glasses	d ≤ 20 mm	0.7 mm	
	d > 20 mm	1 mm	

PRESSURE TEST

The test pressure of Stoomwezen T0240 is determined as follows:

Symbols and units:

- pd MPa = design pressure
- pdl MPa = adjusted design pressure
- pt bar = test pressure
- ptmax bar = allowable test pressure

The following requirements, applicable to all pressure vessels are, apart from the symbols and units used, in concordance with Section 13 of the Steam Decree.
In accordance with sheet G0201 the test pressure is expressed in bar and the design pressure in MPa.
Consequently the expressions in this Section contain a conversion factor of 10.

The influence of wind load during the test of vertical pressure vessels has been introduced in sheet D1201; it is made under the provision that the pressure test will not be made in a heavy gale.

Required test pressure:

Initial test	
pd	pt
pd ≤ 0.25 MPa	10 pd + 1 bar
0.25 MPa < pd ≤ 2 MPa	14 pd
pd > 2 MPa	13 pd + 2 bar

Allowable test pressure

The allowable test pressure for dished walls with pressure on the convex side is:

ptmax = 13 x pdl

in all other cases:

ptmax = 14 x pdl

Here 'pdl' is the lowest value of the 'adjusted design pressure' calculated for each wall of the space.

The adjusted design pressure is established as follows:
- determine the formula wall thickness 'd' in accordance with sheet D0101, however without deduction of the corrosion allowance.
- determine the design pressure corresponding to this 'd' for a metal temperature equal to the temperature of the test liquid, in accordance with the applicable design sheets.

The resulting ptmax shall satisfy:

ptmax ≥ pt

This requirement may be determining for the construction of the pressure vessel or parts of it; for each wall 'pd' must be so chosen that this condition is satisfied.

P10 PROGRAMME DESCRIPTION

P10 is a computer programme to calculate the deformations, forces and stresses, which will occur in piping systems, due to internal and external loadings.
A range of loading conditions can be described. The programme can be used to solve very simple piping systems as well as rather complex systems with nonlinear boundary conditions (friction, limit stops, linear and non-linear springs etc.).

The P10 programme is based upon the "General analytical method" as described in "Design of Piping Systems" by M.W. Kellogg Company, 2nd edition, 1965.
This method is also known as the "Force method", the opposite of the "Displacement method", which is usually used by FEM-programmes.

For piping systems with only a relative low number of supports and internal connections (closed loops) the "Force method" is advantageous with respect to the "Displacement method". Especially for non-linear boundary conditions these advantages are exploited intensively.

For the calculation of the stresses the formulae according to the appropriate design code are used. This counts also for the default values of K- and I- factors (flexibility and stress intensification factors).
There are a number of design codes available within the programme.

For special features like spring design or the iteration process to distinguish the behaviour of non-linear boundary conditions, the algorithms are included in the programme.

P10 can handle all types of piping systems. Closed loops are handled automatically. Partially tied connections between parts of the system are also covered.

The piping system can be supported in the following ways:
-rigid
-by spring with known spring rate and preset loading
-by a spring to be chosen from included spring tables
-by displacement limits (gap, lift-off, etc.)
-by reaction limits
-by friction forces
-by particular combinations of these elements

Several load cases can be defined to represent different loading variants. Each case comprises all data for one actual loading condition.

The first case of a calculation is called the base case. This case is used for spring design, so it should contain the conditions which are relevant for the spring design.

The other cases are called variant cases. These cases define variants of the base case.

The loading per case can be separated into components:
-weight
-cold spring (cold pull)
-internal pressure
-thermal expansion
-wind loading

For each component nodal pre-displacements, pre-rotations, forces and moments can be defined.
These components are used to select the output. The output of any loading component and of any combination of loading components is possible for each case.

Furthermore the loading components are used to define the loading situations, in which the behaviour of the non-linear boundary conditions are determined. The order, in which the loading is applied, is called the iteration sequence.

P10 is a widely accepted programme, holding "Stoomwezen" approval.

STRESS CALCULATION AND PRINCIPLES IN P10

The stresses are calculated in 11 equidistant cross-sections of the tubular members. The stress intensification factors are applied to the forces and moments of the single components in these points.
From these intensified values the stresses are calculated:

- S-NORM = The normal stress
- S-BEND = The bending stress
- SHEAR = The shear stress
- S-HOOP = The hoop stress
- S-HUBE = The equivalent stress (ideal stress) according to Huber-Hencky or
- S-COUL = The equivalent stress (ideal stress) according to Coulomb.
- S-CODE = The stress value according to the code.

As the S-CODE does not include the normal stresses (except for the normal stresses due to pressure), the equivalent stress S-HUBE or S-COUL should be taken into account in case of large normal forces, for example due to thermal stresses in jacketed lines.

The equivalent stress is the maximum value of 24 points over the circumference (every 15°). The corresponding angle α is printed also (ALPHA).
At the first and the last cross-section an additional calculation is made with the stress intensification factors of attached T-connections if any.

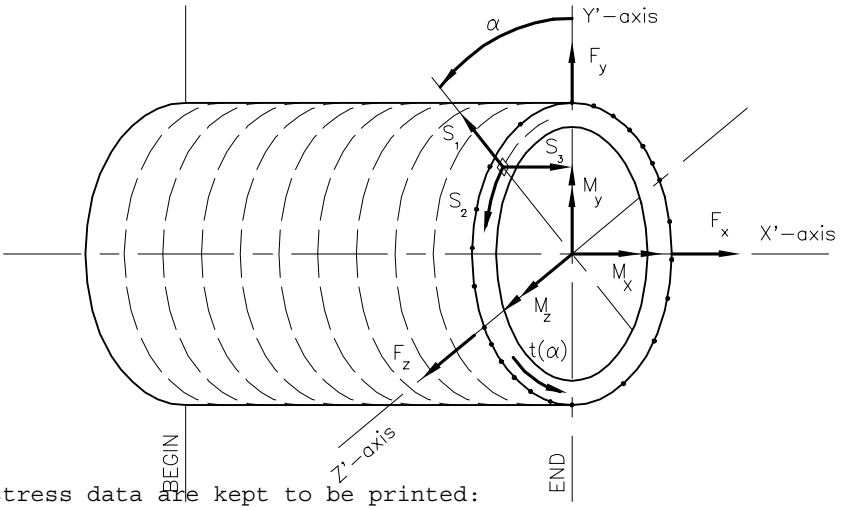
EQUIVALENT STRESS

S_1 : radial

S_2 : tangential

S_3 : axial

$t(\alpha)$: shear stress axial/tangential



Three sets of stress data are kept to be printed:

1. The set of stresses at the first cross-section, including the maximum equivalent stress at this point. (BEGIN, including T-connections if any).
2. The set of stresses at the location of the maximum equivalent stress from the 11 cross-sections. (MAXIMUM, without T-connections taken into account).
3. The set of stresses at the last cross-section, including the maximum equivalent stress at this point. (END, including T-connections if any).

```
STRESS 1    REV 1.0                                          PAGE     0
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK
```

```
 ****     ******    ******      *******     ****      ****        **
**  **    * ** *     **  **      **   *    **  **    **  **      ***
***         **       **  **      ** *      ***       ***        ****
 ***        **       *****       ****       ***       ***         **
  ***       **       **  **      ** *        ***       ***        **
**  **      **       **   **     **   *    **  **    **  **       **
 ****      ****     ***   **    *******     ****      ****       ****
```

Stress 1 is a programme based on the "General analytical method",
fully described in "Design of piping systems" by
M.W. Kellog Company.
This method is also called the "Force method".

PLACE - OUDEWATER DATE - Zo 29-Sep-1996

COMPANY- CBA Stoomwezen BV

NAME - P.W.H. VOORHAAR SIGNATURE- P.W.H. Voorhaar

```
STRESS 1    REV 1.0                    INPUT DATA            PAGE     1
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K- AND I- FACTORS ACCORDING TO                          = STOOMWEZEN D1101
INPUT UNITS                                             =              S.I.
PIPE DIMENSION UNITS                                    =                MM
FORCE UNITS                                             =                 N
OUTPUT UNITS                                            =              S.I.
INSTALLATION TEMPERATURE                                =       20 CELSIUS
ALLOWED NUMBER OF ITERATIONS PER LOAD-COMPONENT         =               40
EQUIVALENT STRESSES CALCULATED ACCORDING TO             =     HUBER HENCKY
DIRECTION OF GRAVITY                                    =               -Y
ACCELERATION OF GRAVITY                                 =     9.80665 M/S2
MULTIPLICATION FACTOR FOR PRIMARY STRESSES              =            0.750
BASE CASE (SPRING DESIGN)                               =                1
FATIGUE FACTOR                                          =            1.000

*************************************************************************
*                . = NOT RESTRAINED                                     *
*                A = RESTRAINED                                         *
*                F = RESTRAINED BY FRICTION FORCE                       *
* RESTRAINT-CODE N = ONLY NEGATIVE REACTION POSSIBLE                    *
*  DESCRIPTION   P = ONLY POSITIVE REACTION POSSIBLE                    *
*                S = CONVENTIONAL SPRING TO BE DESIGNED                 *
*                C = CONSTANT-LOAD-HANGER TO BE DESIGNED                *
*                I = INVERSE SPRING TO BE DESIGNED                      *
*************************************************************************

NOD ====GLOBAL COORDINATES==== ====RESTRAINTS=== PAIR PENDULUM ==TEXT=
 NR         X         Y         Z RX RY RZ TX TY TZ NODE   LENGTH
           MM        MM        MM                          MM

 10         0         0         0  A  A  A  A  A  A                    10
 20      1000         0         0  .  .  .  .  .  .                    20



============================TUBULAR PIPE DATA=========================
PN      TEXT     ODIAM SCHEDULE DIAMETER  WALLTH     TOL     CORR EFACTOR
                   MM                MM       MM PERCENT      MM

 1  100* 10   100.00            100.00   10.00   10.00    1.00    1.00

========CONTINUATION TUBULAR PIPE DATA========
PN      TEXT      MASS   INSUL.    WIDTH SHAPE-M
                    KG     KG/M       MM

 1  100* 10                     100.00    0.67
```

```
STRESS 1    REV 1.0                  INPUT DATA            PAGE     2
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============================PIPE DATA SUMMARY==========================
PN     TEXT TYPE NR    LENGTH  SURFACE  MEDIUM MASS OF   INSU- MASS OF
                                                MEDIUM  LATION    PIPE
                           MM       M2       M3      KG      KG      KG

 1  100* 10 STR.   1     1000     0.31     0.01                     22
                +--- +------- +------- +------ +------ +------ +------
                   1     1000     0.31     0.01                     22
```

```
STRESS 1    REV 1.0                  INPUT DATA            PAGE     3
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==MEMBER== ===PIPE=== ===LOAD=== =====CENTERLINE===== ===BEND=== JACK.
 FR  TO NR PN    TEXT LN    TEXT       X       Y       Z  RAD.FL MI PI LO
                                      MM      MM      MM     MM

 10  20  1  1 100* 10  1 200C120   1000

==MEMBER== ==K AND I FACTOR= ==COLD==
 FR  TO NR                   =SPRING=
                  K         I       MM

 10  20  1            10.000
```

```
STRESS 1    REV 1.0                    INPUT DATA CASE   1   PAGE     4
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CASE

==============================GENERAL DATA==============================
   NEW    REROUN-    BOUR-     YOUNGS     COLD    ===ITERATED SITUATIONS===
MATRIX       DING      DON    MODULUS   SPRING    CO CO CO CO CO   FRICTION

   YES         NO       NO     E-COLD     100%



NOD COMP =====================NODAL LOADS====================== ==TEXT=
 NR             MX        MY        MZ        FX        FY        FZ
                NM        NM        NM         N         N         N

 20   WE                                              2000              20
 20   PR      2000                        -2000              1000      20
 20   TE                                                     1000      20



==============================MATERIAL DATA=============================
LN    TEXT  NR =========DESCRIPTION========  E-MOD L.E.C. D-PIPE POISS
                                            N/MM2  E-6/C  KG/M3

 1 200C120  35 API-5L Gr.X52 NEN3650 <=35mm 192000 12.300 7849.0 0.303



==============================MATERIAL DATA=============================
LN    TEXT  NR =========DESCRIPTION========      FE      F1      F2     CM
                                            N/MM2  N/MM2  N/MM2

 1 200C120  35 API-5L Gr.X52 NEN3650 <=35mm  319.5  170.9         1.000



===LOAD=== ==========MEDIUM DATA==========
LN    TEXT    TEMP    PRESS    LEVEL     MASS
                 C      BAR       MM    KG/M3

 1 200C120   200.0  120.00        0      0.0
```

```
STRESS 1    REV 1.0                    INPUT DATA            PAGE     5
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=========================OUTPUT SELECTION DATA=========================

CASE   1 COMPONENTS                 : TE
         TEXT FOR PAGE HEADING      : COMP TE
         SELECTED CASE OUTPUT       : SUPPORT REACTIONS
                                      NODAL MOVEMENTS
                                      MEMBER OUTPUT VERTICAL
                                      DISPLACEMENT PLOT
         STRESSES IN STRESS SUMMARY: YES

CASE   1 COMPONENTS                 : WE
         TEXT FOR PAGE HEADING      : COMP WE
         SELECTED CASE OUTPUT       : SUPPORT REACTIONS
                                      NODAL MOVEMENTS
                                      MEMBER OUTPUT VERTICAL
         STRESSES IN STRESS SUMMARY: YES

CASE   1 COMPONENTS                 : PR
         TEXT FOR PAGE HEADING      : COMP PR
         SELECTED CASE OUTPUT       : SUPPORT REACTIONS
                                      NODAL MOVEMENTS
                                      MEMBER OUTPUT VERTICAL
         STRESSES IN STRESS SUMMARY: YES

CASE   1 COMPONENTS                 : WE + PR
         TEXT FOR PAGE HEADING      : COMP WE+PR
         SELECTED CASE OUTPUT       : SUPPORT REACTIONS
                                      NODAL MOVEMENTS
                                      MEMBER OUTPUT VERTICAL
                                      DISPLACEMENT PLOT
         STRESSES IN STRESS SUMMARY: YES

CASE   1 COMPONENTS                 : WE + PR + TE
         TEXT FOR PAGE HEADING      : COMP WE+PR+TE
         SELECTED CASE OUTPUT       : SUPPORT REACTIONS
                                      NODAL MOVEMENTS
                                      MEMBER OUTPUT VERTICAL
                                      DISPLACEMENT PLOT
         STRESSES IN STRESS SUMMARY: YES
```

```
STRESS 1    REV 1.0                   COMP TE               PAGE     6
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE

*************************************************************************
*                  = NOT RESTRAINED                                     *
*                A = RESTRAINED                                         *
*                F = RESTRAINED BY FRICTION FORCE                       *
* RESTRAINT-CODE N = ONLY NEGATIVE REACTION POSSIBLE                    *
*  DESCRIPTION   P = ONLY POSITIVE REACTION POSSIBLE                    *
*                S = DESIGNED CONVENTIONAL SPRING                       *
*                C = DESIGNED CONSTANT-LOAD-HANGER                      *
*                I = DESIGNED INVERSE SPRING                            *
*                                                                       *
*                * = ADDITIONAL SUPPORT DATA                            *
*                    (SPRING RATE, LIMIT OR PENDULUM)                   *
*************************************************************************

==FORCES BY THE SUPPORTS ON THE SYSTEM IN GLOBAL OR LOCAL DIRECTIONS==
==================LOCAL DIRECTIONS ARE MARKED BY LOC==================
NOD LOC      MX       MY       MZ       FX       FY       FZ    ==TEXT=
 NR         N.M      N.M      N.M       N        N        N

 10             A   1000 A        A        A        A  -1000 A      10
 20                                                                   20
```

```
STRESS 1    REV 1.0                  COMP TE              PAGE     7
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE

=============NODAL MOVEMENTS IN GLOBAL OR LOCAL DIRECTIONS============
==================LOCAL DIRECTIONS ARE MARKED BY LOC==================
NOD LOC      RX        RY        RZ        TX        TY        TZ    ==TEXT=
 NR         MRAD      MRAD      MRAD       MM        MM        MM

 10        0.00 A    0.00 A    0.00 A    0.00 A    0.00 A    0.00 A      10
 20        0.00     -0.90      0.00      2.21      0.00      0.61        20
```

```
STRESS 1    REV 1.0                    COMP TE              PAGE     8
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE

*************************************************************************
*  ABBREVIATION    *  EXPLANATION OF THE ABBREVIATIONS                  *
*  ============    *  ================================                  *
*                  *                                                    *
*  FR-TO           *  NODE-NUMBERS AT BOTH ENDS OF THE BRANCH           *
*  NR              *  MEMBER-NUMBER WITHIN THE BRANCH                   *
*                  *  ( T = TEE AT ONE OR BOTH ENDS OF THE MEMBER )     *
*                  *  ( B = MEMBER IS A BEND )                          *
*                  *                                                    *
*  BEGIN           *  THE RESULTS APPLY AT THE MEMBER-BEGINNING         *
*  MAXIMUM         *  THE MAXIMUM EQUIVALENT STRESS OF THE WHOLE        *
*                  *  MEMBER IS CALCULATED, INCLUDING MOMENTS AND       *
*                  *  FORCES BELONGING TO IT, BUT WITHOUT TAKING        *
*                  *  INTO ACCOUNT THE I-FACTORS AT BEGIN AND END       *
*  PART            *  POINT WHERE THE MAXIMUM EQUIVALENT STRESS         *
*                  *  OCCURS, EXPRESSED IN A PERCENTAGE OF THE          *
*                  *  MEMBER-LENGTH FROM THE BEGINNING                  *
*  END             *  THE RESULTS APPLY AT THE MEMBER-END               *
*                  *                                                    *
*                  *  ********************************************      *
*                  *  *   THE MOMENTS, FORCES AND STRESSES EX-    *     *
*                  *  *   PRESS THE ACTION BY THE FARTHER END     *     *
*                  *  *   OF THE MEMBER ON THE NEARER END         *     *
*                  *  ********************************************      *
*                  *                                                    *
*  MX    (   N.M)  *  MOMENT ABOUT THE X-AXIS,        MT-X IS LOCAL     *
*  MY    (   N.M)  *  MOMENT ABOUT THE Y-AXIS,        MB-Y IS LOCAL     *
*  MZ    (   N.M)  *  MOMENT ABOUT THE Z-AXIS,        MB-Z IS LOCAL     *
*  FX    (     N)  *  FORCE IN THE X-AXIS DIRECTION,  FN-X IS LOCAL     *
*  FY    (     N)  *  FORCE IN THE Y-AXIS DIRECTION,  FS-Y IS LOCAL     *
*  FZ    (     N)  *  FORCE IN THE Z-AXIS DIRECTION,  FS-Z IS LOCAL     *
*  ALPHA (DEGREE)  *  ANGLE WHERE THE MAXIMUM EQUIVALENT STRESS         *
*                  *  OCCURS, POSITIVE LOCAL Y-AXIS =  0,               *
*                  *  POSITIVE LOCAL Z-AXIS = 90 DEGREES                *
*  I               *  STRESS-INTENSIFICATION FACTOR OF MEMBER OR T      *
*  I-RER           *  SAME, REROUNDING TAKEN INTO ACCOUNT               *
*  S-NORM( N/MM2)  *  NORMAL  STRESS ( DUE TO FN-X                 )    *
*  S-BEND( N/MM2)  *  BENDING STRESS ( DUE TO MB-Y, MB-Z           )    *
*  SHEAR ( N/MM2)  *  SHEAR   STRESS ( DUE TO MT-X, FS-Y, FS-Z     )    *
*  S-HOOP( N/MM2)  *  HOOP    STRESS ( DUE TO PRESSURE             )    *
*  S-HUBE( N/MM2)  *  EQUIVALENT STRESS, MAXIMUM OF THE WHOLE           *
*                  *  CROSS-SECTION, OCCURRING AT ANGLE ALPHA           *
*  S-CODE( N/MM2)  *  STRESS ACCORDING TO THE CODE                     *
*  S-MAX ( N/MM2)  *  THE MAXIMUM S-CODE OF THE WHOLE MEMBER           *
*                  *                                                    *
*  RX    (  MRAD)  *  ROTATION    ABOUT THE GLOBAL X-AXIS               *
*  RY    (  MRAD)  *  ROTATION    ABOUT THE GLOBAL Y-AXIS               *
*  RZ    (  MRAD)  *  ROTATION    ABOUT THE GLOBAL Z-AXIS               *
*  TX    (    MM)  *  TRANSLATION ALONG THE GLOBAL X-AXIS               *
*  TY    (    MM)  *  TRANSLATION ALONG THE GLOBAL Y-AXIS               *
*  TZ    (    MM)  *  TRANSLATION ALONG THE GLOBAL Z-AXIS               *
*                  *                                                    *
*************************************************************************
```

```
STRESS 1    REV 1.0                    COMP TE              PAGE     9
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE
FR-TO    10-20
NR           1
P-TEXT 100* 10
L-TEXT 200C120
S-RAT     0.59
=====BEGIN=====
MX           0
MY       -1000
MZ           0
FX           0
FY           0
FZ        1000
ALPHA       90
I        10.00
S-NORM
S-BEND  188.04
SHEAR     0.85
S-HOOP
S-HUBE  188.04
S-CODE  188.04
====MAXIMUM====
MT-X         0
MB-Y     -1000
MB-Z         0
FN-X         0
FS-Y         0
FS-Z      1000
PART         0
ALPHA       90
I        10.00
S-NORM
S-BEND  188.04
SHEAR     0.85
S-HOOP
S-HUBE  188.04
S-CODE  188.04
======END======
MX           0
MY           0
MZ           0
FX           0
FY           0
FZ        1000
ALPHA        0
I        10.00
S-NORM
S-BEND
SHEAR     0.85
S-HOOP
S-HUBE    1.48
S-CODE
======END======
RX        0.00
RY       -0.90
RZ        0.00
TX        2.21
TY        0.00
TZ        0.61
```

```
STRESS 1    REV 1.0                    COMP TE                PAGE    10
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE

==================MAXIMUM STRESSES IN THIS OUTPUT====================
 FR  TO NR PAGE S-CODE*  FR  TO NR PAGE S-HUBE*  FR  TO NR PAGE S-HOOP
                 N/MM2*                  N/MM2*                   N/MM2
                       *                       *
 10  20  1    9  188.0*  10  20  1    9  188.0*
                       *                       *
                       *                       *
                       *                       *
                       *                       *

 MAXIMUM STRESS-RATIO IN THIS OUTPUT
 FR  TO NR PAGE S-ALL. S-RATIO
                 N/MM2

 10  20  1    9  319.5    0.59


==================MAXIMUM MOVEMENTS IN THIS OUTPUT===================
 FR  TO NR PAGE     TX*  FR  TO NR PAGE     TY*  FR  TO NR PAGE     TZ
                    MM*                     MM*                     MM
                       *                       *
 10  20  1    9   2.21*                       *  10  20  1    9   0.61
                       *                       *
                       *                       *
                       *                       *
                       *                       *
```

```
STRESS 1    REV 1.0                    COMP WE               PAGE    11
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE

*************************************************************************
*                   = NOT RESTRAINED                                    *
*                 A = RESTRAINED                                        *
*                 F = RESTRAINED BY FRICTION FORCE                      *
* RESTRAINT-CODE N = ONLY NEGATIVE REACTION POSSIBLE                    *
*  DESCRIPTION   P = ONLY POSITIVE REACTION POSSIBLE                    *
*                 S = DESIGNED CONVENTIONAL SPRING                      *
*                 C = DESIGNED CONSTANT-LOAD-HANGER                     *
*                 I = DESIGNED INVERSE SPRING                           *
*                                                                       *
*                 * = ADDITIONAL SUPPORT DATA                           *
*                     (SPRING RATE, LIMIT OR PENDULUM)                  *
*************************************************************************

==FORCES BY THE SUPPORTS ON THE SYSTEM IN GLOBAL OR LOCAL DIRECTIONS==
==================LOCAL DIRECTIONS ARE MARKED BY LOC==================
NOD LOC      MX       MY       MZ       FX       FY       FZ    ==TEXT=
 NR         N.M      N.M      N.M       N        N        N

 10             A        A  -1891 A        A  -1782 A        A      10
 20                                                                  20
```

```
STRESS 1    REV 1.0                  COMP WE              PAGE    12
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE

=============NODAL MOVEMENTS IN GLOBAL OR LOCAL DIRECTIONS============
==================LOCAL DIRECTIONS ARE MARKED BY LOC==================
NOD LOC      RX        RY        RZ        TX        TY        TZ    ==TEXT=
 NR         MRAD      MRAD      MRAD       MM        MM        MM

 10         0.00 A    0.00 A    0.00 A    0.00 A    0.00 A    0.00 A      10
 20         0.00      0.00      1.73      0.00      1.17      0.00        20
```

```
STRESS 1    REV 1.0                  COMP WE              PAGE    13
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE

*************************************************************************
*  ABBREVIATION    *  EXPLANATION OF THE ABBREVIATIONS                  *
*  ============    *  ================================                  *
*                  *                                                    *
*  FR-TO           *  NODE-NUMBERS AT BOTH ENDS OF THE BRANCH           *
*  NR              *  MEMBER-NUMBER WITHIN THE BRANCH                   *
*                  *  ( T = TEE AT ONE OR BOTH ENDS OF THE MEMBER )     *
*                  *  ( B = MEMBER IS A BEND )                          *
*                  *                                                    *
*  BEGIN           *  THE RESULTS APPLY AT THE MEMBER-BEGINNING         *
*  MAXIMUM         *  THE MAXIMUM EQUIVALENT STRESS OF THE WHOLE        *
*                  *  MEMBER IS CALCULATED, INCLUDING MOMENTS AND       *
*                  *  FORCES BELONGING TO IT, BUT WITHOUT TAKING        *
*                  *  INTO ACCOUNT THE I-FACTORS AT BEGIN AND END       *
*  PART            *  POINT WHERE THE MAXIMUM EQUIVALENT STRESS         *
*                  *  OCCURS, EXPRESSED IN A PERCENTAGE OF THE          *
*                  *  MEMBER-LENGTH FROM THE BEGINNING                  *
*  END             *  THE RESULTS APPLY AT THE MEMBER-END               *
*                  *                                                    *
*                  *  ********************************************      *
*                  *  *   THE MOMENTS, FORCES AND STRESSES EX-    *     *
*                  *  *   PRESS THE ACTION BY THE FARTHER END     *     *
*                  *  *   OF THE MEMBER ON THE NEARER END         *     *
*                  *  ********************************************      *
*                  *                                                    *
*  MX    (   N.M)  *  MOMENT ABOUT THE X-AXIS,        MT-X IS LOCAL     *
*  MY    (   N.M)  *  MOMENT ABOUT THE Y-AXIS,        MB-Y IS LOCAL     *
*  MZ    (   N.M)  *  MOMENT ABOUT THE Z-AXIS,        MB-Z IS LOCAL     *
*  FX    (     N)  *  FORCE IN THE X-AXIS DIRECTION,  FN-X IS LOCAL     *
*  FY    (     N)  *  FORCE IN THE Y-AXIS DIRECTION,  FS-Y IS LOCAL     *
*  FZ    (     N)  *  FORCE IN THE Z-AXIS DIRECTION,  FS-Z IS LOCAL     *
*  ALPHA (DEGREE)  *  ANGLE WHERE THE MAXIMUM EQUIVALENT STRESS         *
*                  *  OCCURS, POSITIVE LOCAL Y-AXIS =  0,               *
*                  *  POSITIVE LOCAL Z-AXIS = 90 DEGREES                *
*  I               *  STRESS-INTENSIFICATION FACTOR OF MEMBER OR T      *
*  I-RER           *  SAME, REROUNDING TAKEN INTO ACCOUNT               *
*  S-NORM( N/MM2)  *  NORMAL  STRESS ( DUE TO FN-X                 )    *
*  S-BEND( N/MM2)  *  BENDING STRESS ( DUE TO MB-Y, MB-Z           )    *
*  SHEAR ( N/MM2)  *  SHEAR   STRESS ( DUE TO MT-X, FS-Y, FS-Z     )    *
*  S-HOOP( N/MM2)  *  HOOP    STRESS ( DUE TO PRESSURE             )    *
*  S-HUBE( N/MM2)  *  EQUIVALENT STRESS, MAXIMUM OF THE WHOLE           *
*                  *  CROSS-SECTION, OCCURRING AT ANGLE ALPHA           *
*  S-CODE( N/MM2)  *  STRESS ACCORDING TO THE CODE                      *
*  S-MAX ( N/MM2)  *  THE MAXIMUM S-CODE OF THE WHOLE MEMBER           *
*                  *                                                    *
*  RX    (  MRAD)  *  ROTATION    ABOUT THE GLOBAL X-AXIS                *
*  RY    (  MRAD)  *  ROTATION    ABOUT THE GLOBAL Y-AXIS                *
*  RZ    (  MRAD)  *  ROTATION    ABOUT THE GLOBAL Z-AXIS                *
*  TX    (    MM)  *  TRANSLATION ALONG THE GLOBAL X-AXIS                *
*  TY    (    MM)  *  TRANSLATION ALONG THE GLOBAL Y-AXIS                *
*  TZ    (    MM)  *  TRANSLATION ALONG THE GLOBAL Z-AXIS                *
*                  *                                                    *
*************************************************************************
```

```
STRESS 1    REV 1.0                    COMP WE              PAGE    14
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE
FR-TO    10-20
NR           1
P-TEXT 100* 10
L-TEXT 200C120
S-RAT     1.56
=====BEGIN=====
MX           0
MY           0
MZ        1891
FX           0
FY        1782
FZ           0
ALPHA        0
I        10.00
S-NORM
S-BEND  266.71
SHEAR     1.52
S-HOOP
S-HUBE  266.71
S-CODE  266.71*
====MAXIMUM====
MT-X         0
MB-Y         0
MB-Z      1891
FN-X         0
FS-Y      1782
FS-Z         0
PART         0
ALPHA        0
I        10.00
S-NORM
S-BEND  266.71
SHEAR     1.52
S-HOOP
S-HUBE  266.71
S-CODE  266.71*
======END======
MX           0
MY           0
MZ           0
FX           0
FY        2000
FZ           0
ALPHA       90
I        10.00
S-NORM
S-BEND    0.00
SHEAR     1.71
S-HOOP
S-HUBE    2.96
S-CODE    0.00
======END======
RX        0.00
RY        0.00
RZ        1.73
TX        0.00
TY        1.17
TZ        0.00
```

```
 STRESS 1    REV 1.0                   COMP WE               PAGE    15
 ORDER CBA29336    Zo 29-Sep-1996    16:57:06
 PROJ  MINI CLUSTER NAM BOTLEK

 CASE

 ==================MAXIMUM STRESSES IN THIS OUTPUT====================
  FR  TO NR PAGE S-CODE*  FR  TO NR PAGE S-HUBE*  FR  TO NR PAGE S-HOOP
                 N/MM2*                  N/MM2*                  N/MM2
                       *                       *
  10  20  1   14  266.7*  10  20  1   14  266.7*
                       *                       *
                       *                       *
                       *                       *
                       *                       *

  MAXIMUM STRESS-RATIO IN THIS OUTPUT
  FR  TO NR PAGE S-ALL. S-RATIO
                 N/MM2

  10  20  1   14  170.9    1.56


 ==================MAXIMUM MOVEMENTS IN THIS OUTPUT===================
  FR  TO NR PAGE     TX*  FR  TO NR PAGE     TY*  FR  TO NR PAGE     TZ
                     MM*                     MM*                     MM
                       *                       *
                       *  10  20  1   14   1.17*
                       *                       *
                       *                       *
                       *                       *
                       *                       *
```

```
STRESS 1    REV 1.0                    COMP PR               PAGE    16
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE

*************************************************************************
*                   = NOT RESTRAINED                                    *
*                 A = RESTRAINED                                        *
*                 F = RESTRAINED BY FRICTION FORCE                      *
* RESTRAINT-CODE  N = ONLY NEGATIVE REACTION POSSIBLE                   *
*  DESCRIPTION    P = ONLY POSITIVE REACTION POSSIBLE                   *
*                 S = DESIGNED CONVENTIONAL SPRING                      *
*                 C = DESIGNED CONSTANT-LOAD-HANGER                     *
*                 I = DESIGNED INVERSE SPRING                           *
*                                                                       *
*                 * = ADDITIONAL SUPPORT DATA                           *
*                     (SPRING RATE, LIMIT OR PENDULUM)                  *
*************************************************************************

==FORCES BY THE SUPPORTS ON THE SYSTEM IN GLOBAL OR LOCAL DIRECTIONS==
==================LOCAL DIRECTIONS ARE MARKED BY LOC==================
NOD LOC      MX       MY       MZ       FX       FY       FZ    ==TEXT=
 NR         N.M      N.M      N.M        N        N        N

 10       -2000 A   1000 A        A   2000 A        A  -1000 A      10
 20                                                                  20
```

```
STRESS 1    REV 1.0                  COMP PR              PAGE    17
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE

=============NODAL MOVEMENTS IN GLOBAL OR LOCAL DIRECTIONS============
==================LOCAL DIRECTIONS ARE MARKED BY LOC==================
NOD LOC      RX        RY        RZ        TX        TY        TZ    ==TEXT=
 NR         MRAD      MRAD      MRAD       MM        MM        MM

 10        0.00 A    0.00 A    0.00 A    0.00 A    0.00 A    0.00 A      10
 20        4.68     -0.90      0.00      0.08      0.00      0.61        20
```

```
STRESS 1    REV 1.0                  COMP PR              PAGE    18
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE

*************************************************************************
*  ABBREVIATION    *  EXPLANATION OF THE ABBREVIATIONS                   *
*  ============    *  ================================                   *
*                  *                                                     *
*  FR-TO           *  NODE-NUMBERS AT BOTH ENDS OF THE BRANCH            *
*  NR              *  MEMBER-NUMBER WITHIN THE BRANCH                    *
*                  *  ( T = TEE AT ONE OR BOTH ENDS OF THE MEMBER )      *
*                  *  ( B = MEMBER IS A BEND )                           *
*                  *                                                     *
*  BEGIN           *  THE RESULTS APPLY AT THE MEMBER-BEGINNING          *
*  MAXIMUM         *  THE MAXIMUM EQUIVALENT STRESS OF THE WHOLE         *
*                  *  MEMBER IS CALCULATED, INCLUDING MOMENTS AND        *
*                  *  FORCES BELONGING TO IT, BUT WITHOUT TAKING         *
*                  *  INTO ACCOUNT THE I-FACTORS AT BEGIN AND END        *
*  PART            *  POINT WHERE THE MAXIMUM EQUIVALENT STRESS          *
*                  *  OCCURS, EXPRESSED IN A PERCENTAGE OF THE           *
*                  *  MEMBER-LENGTH FROM THE BEGINNING                   *
*  END             *  THE RESULTS APPLY AT THE MEMBER-END                *
*                  *                                                     *
*                  *  *********************************************      *
*                  *  *   THE MOMENTS, FORCES AND STRESSES EX-    *      *
*                  *  *   PRESS THE ACTION BY THE FARTHER END     *      *
*                  *  *   OF THE MEMBER ON THE NEARER END         *      *
*                  *  *********************************************      *
*                  *                                                     *
*  MX    (   N.M)  *  MOMENT ABOUT THE X-AXIS,        MT-X IS LOCAL      *
*  MY    (   N.M)  *  MOMENT ABOUT THE Y-AXIS,        MB-Y IS LOCAL      *
*  MZ    (   N.M)  *  MOMENT ABOUT THE Z-AXIS,        MB-Z IS LOCAL      *
*  FX    (     N)  *  FORCE IN THE X-AXIS DIRECTION,  FN-X IS LOCAL      *
*  FY    (     N)  *  FORCE IN THE Y-AXIS DIRECTION,  FS-Y IS LOCAL      *
*  FZ    (     N)  *  FORCE IN THE Z-AXIS DIRECTION,  FS-Z IS LOCAL      *
*  ALPHA (DEGREE)  *  ANGLE WHERE THE MAXIMUM EQUIVALENT STRESS          *
*                  *  OCCURS, POSITIVE LOCAL Y-AXIS =  0,                *
*                  *  POSITIVE LOCAL Z-AXIS = 90 DEGREES                 *
*  I               *  STRESS-INTENSIFICATION FACTOR OF MEMBER OR T       *
*  I-RER           *  SAME, REROUNDING TAKEN INTO ACCOUNT                *
*  S-NORM( N/MM2)  *  NORMAL  STRESS ( DUE TO FN-X                 )     *
*  S-BEND( N/MM2)  *  BENDING STRESS ( DUE TO MB-Y, MB-Z           )     *
*  SHEAR ( N/MM2)  *  SHEAR   STRESS ( DUE TO MT-X, FS-Y, FS-Z     )     *
*  S-HOOP( N/MM2)  *  HOOP    STRESS ( DUE TO PRESSURE             )     *
*  S-HUBE( N/MM2)  *  EQUIVALENT STRESS, MAXIMUM OF THE WHOLE            *
*                  *  CROSS-SECTION, OCCURRING AT ANGLE ALPHA            *
*  S-CODE( N/MM2)  *  STRESS ACCORDING TO THE CODE                       *
*  S-MAX ( N/MM2)  *  THE MAXIMUM S-CODE OF THE WHOLE MEMBER            *
*                  *                                                     *
*  RX    (  MRAD)  *  ROTATION    ABOUT THE GLOBAL X-AXIS                 *
*  RY    (  MRAD)  *  ROTATION    ABOUT THE GLOBAL Y-AXIS                 *
*  RZ    (  MRAD)  *  ROTATION    ABOUT THE GLOBAL Z-AXIS                 *
*  TX    (    MM)  *  TRANSLATION ALONG THE GLOBAL X-AXIS                 *
*  TY    (    MM)  *  TRANSLATION ALONG THE GLOBAL Y-AXIS                 *
*  TZ    (    MM)  *  TRANSLATION ALONG THE GLOBAL Z-AXIS                 *
*                  *                                                     *
*************************************************************************
```

```
STRESS 1    REV 1.0                    COMP PR              PAGE    19
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE
FR-TO    10-20
NR           1
P-TEXT 100* 10
L-TEXT 200C120
S-RAT
=====BEGIN=====
MX        2000
MY       -1000
MZ           0
FX       74341
FY           0
FZ        1000
ALPHA      270
I        10.00
S-NORM   32.15
S-BEND  141.03
SHEAR   141.88
S-HOOP   69.00
S-HUBE  289.76
S-CODE  349.85
====MAXIMUM====
MT-X      2000
MB-Y     -1000
MB-Z         0
FN-X     74341
FS-Y         0
FS-Z      1000
PART         0
ALPHA      270
I        10.00
S-NORM   32.15
S-BEND  141.03
SHEAR   141.88
S-HOOP   69.00
S-HUBE  289.76
S-CODE  349.85
======END======
MX        2000
MY           0
MZ           0
FX       74341
FY           0
FZ        1000
ALPHA        0
I        10.00
S-NORM   32.15
S-BEND
SHEAR   141.88
S-HOOP   69.00
S-HUBE  254.19
S-CODE  316.56
======END======
RX        4.68
RY       -0.90
RZ        0.00
TX        0.08
TY        0.00
TZ        0.61
```

```
STRESS 1    REV 1.0                  COMP PR              PAGE    20
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE

==================MAXIMUM STRESSES IN THIS OUTPUT====================
 FR  TO NR PAGE S-CODE*  FR  TO NR PAGE S-HUBE*  FR  TO NR PAGE S-HOOP
                 N/MM2*                  N/MM2*                  N/MM2
                       *                       *
 10  20  1   19  349.8*  10  20  1   19  289.8*  10  20  1   19   69.0
                       *                       *
                       *                       *
                       *                       *
                       *                       *


==================MAXIMUM MOVEMENTS IN THIS OUTPUT==================
 FR  TO NR PAGE     TX*  FR  TO NR PAGE     TY*  FR  TO NR PAGE     TZ
                    MM*                     MM*                     MM
                       *                       *
 10  20  1   19   0.08*                       *  10  20  1   19   0.61
                       *                       *
                       *                       *
                       *                       *
                       *                       *
```

```
STRESS 1    REV 1.0                    COMP WE+PR            PAGE    21
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE

*************************************************************************
*                   = NOT RESTRAINED                                    *
*                 A = RESTRAINED                                        *
*                 F = RESTRAINED BY FRICTION FORCE                      *
* RESTRAINT-CODE N = ONLY NEGATIVE REACTION POSSIBLE                    *
*  DESCRIPTION   P = ONLY POSITIVE REACTION POSSIBLE                    *
*                 S = DESIGNED CONVENTIONAL SPRING                      *
*                 C = DESIGNED CONSTANT-LOAD-HANGER                     *
*                 I = DESIGNED INVERSE SPRING                           *
*                                                                       *
*                 * = ADDITIONAL SUPPORT DATA                           *
*                     (SPRING RATE, LIMIT OR PENDULUM)                  *
*************************************************************************

==FORCES BY THE SUPPORTS ON THE SYSTEM IN GLOBAL OR LOCAL DIRECTIONS==
==================LOCAL DIRECTIONS ARE MARKED BY LOC==================
NOD LOC      MX        MY        MZ        FX        FY        FZ    ==TEXT=
 NR         N.M       N.M       N.M        N         N         N

 10       -2000 A   1000 A  -1891 A   2000 A  -1782 A  -1000 A      10
 20                                                                   20
```

```
STRESS 1    REV 1.0                  COMP WE+PR            PAGE    22
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE

=============NODAL MOVEMENTS IN GLOBAL OR LOCAL DIRECTIONS============
==================LOCAL DIRECTIONS ARE MARKED BY LOC==================
NOD LOC      RX        RY        RZ        TX        TY        TZ    ==TEXT=
 NR         MRAD      MRAD      MRAD       MM        MM        MM

 10        0.00 A    0.00 A    0.00 A    0.00 A    0.00 A    0.00 A      10
 20        4.68     -0.90      1.73      0.08      1.17      0.61        20
```

```
STRESS 1    REV 1.0                  COMP WE+PR           PAGE    23
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE

*************************************************************************
*  ABBREVIATION    *  EXPLANATION OF THE ABBREVIATIONS                  *
*  ============    *  ================================                  *
*                  *                                                    *
*  FR-TO           *  NODE-NUMBERS AT BOTH ENDS OF THE BRANCH           *
*  NR              *  MEMBER-NUMBER WITHIN THE BRANCH                   *
*                  *  ( T = TEE AT ONE OR BOTH ENDS OF THE MEMBER )     *
*                  *  ( B = MEMBER IS A BEND )                          *
*                  *                                                    *
*  BEGIN           *  THE RESULTS APPLY AT THE MEMBER-BEGINNING         *
*  MAXIMUM         *  THE MAXIMUM EQUIVALENT STRESS OF THE WHOLE        *
*                  *  MEMBER IS CALCULATED, INCLUDING MOMENTS AND       *
*                  *  FORCES BELONGING TO IT, BUT WITHOUT TAKING        *
*                  *  INTO ACCOUNT THE I-FACTORS AT BEGIN AND END       *
*  PART            *  POINT WHERE THE MAXIMUM EQUIVALENT STRESS         *
*                  *  OCCURS, EXPRESSED IN A PERCENTAGE OF THE          *
*                  *  MEMBER-LENGTH FROM THE BEGINNING                  *
*  END             *  THE RESULTS APPLY AT THE MEMBER-END               *
*                  *                                                    *
*                  *  ********************************************      *
*                  *  *   THE MOMENTS, FORCES AND STRESSES EX-    *     *
*                  *  *   PRESS THE ACTION BY THE FARTHER END     *     *
*                  *  *   OF THE MEMBER ON THE NEARER END         *     *
*                  *  ********************************************      *
*                  *                                                    *
*  MX    (   N.M)  *  MOMENT ABOUT THE X-AXIS,        MT-X IS LOCAL     *
*  MY    (   N.M)  *  MOMENT ABOUT THE Y-AXIS,        MB-Y IS LOCAL     *
*  MZ    (   N.M)  *  MOMENT ABOUT THE Z-AXIS,        MB-Z IS LOCAL     *
*  FX    (     N)  *  FORCE IN THE X-AXIS DIRECTION,  FN-X IS LOCAL     *
*  FY    (     N)  *  FORCE IN THE Y-AXIS DIRECTION,  FS-Y IS LOCAL     *
*  FZ    (     N)  *  FORCE IN THE Z-AXIS DIRECTION,  FS-Z IS LOCAL     *
*  ALPHA (DEGREE)  *  ANGLE WHERE THE MAXIMUM EQUIVALENT STRESS         *
*                  *  OCCURS, POSITIVE LOCAL Y-AXIS =  0,               *
*                  *  POSITIVE LOCAL Z-AXIS = 90 DEGREES                *
*  I               *  STRESS-INTENSIFICATION FACTOR OF MEMBER OR T      *
*  I-RER           *  SAME, REROUNDING TAKEN INTO ACCOUNT               *
*  S-NORM( N/MM2)  *  NORMAL  STRESS ( DUE TO FN-X                 )    *
*  S-BEND( N/MM2)  *  BENDING STRESS ( DUE TO MB-Y, MB-Z           )    *
*  SHEAR ( N/MM2)  *  SHEAR   STRESS ( DUE TO MT-X, FS-Y, FS-Z     )    *
*  S-HOOP( N/MM2)  *  HOOP    STRESS ( DUE TO PRESSURE             )    *
*  S-HUBE( N/MM2)  *  EQUIVALENT STRESS, MAXIMUM OF THE WHOLE           *
*                  *  CROSS-SECTION, OCCURRING AT ANGLE ALPHA           *
*  S-CODE( N/MM2)  *  STRESS ACCORDING TO THE CODE                      *
*  S-MAX ( N/MM2)  *  THE MAXIMUM S-CODE OF THE WHOLE MEMBER           *
*                  *                                                    *
*  RX    (  MRAD)  *  ROTATION    ABOUT THE GLOBAL X-AXIS                *
*  RY    (  MRAD)  *  ROTATION    ABOUT THE GLOBAL Y-AXIS                *
*  RZ    (  MRAD)  *  ROTATION    ABOUT THE GLOBAL Z-AXIS                *
*  TX    (    MM)  *  TRANSLATION ALONG THE GLOBAL X-AXIS                *
*  TY    (    MM)  *  TRANSLATION ALONG THE GLOBAL Y-AXIS                *
*  TZ    (    MM)  *  TRANSLATION ALONG THE GLOBAL Z-AXIS                *
*                  *                                                    *
*************************************************************************
```

```
STRESS 1    REV 1.0                    COMP WE+PR            PAGE    24
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE
FR-TO    10-20
NR           1
P-TEXT 100* 10
L-TEXT 200C120
S-RAT     4.21
=====BEGIN=====
MX        2000
MY       -1000
MZ        1891
FX       74341
FY        1782
FZ        1000
ALPHA      210
I        10.00
S-NORM   32.15
S-BEND  301.70
SHEAR   142.77
S-HOOP   69.00
S-HUBE  393.95
S-CODE  719.27*
====MAXIMUM====
MT-X      2000
MB-Y     -1000
MB-Z      1891
FN-X     74341
FS-Y      1782
FS-Z      1000
PART         0
ALPHA      210
I        10.00
S-NORM   32.15
S-BEND  301.70
SHEAR   142.77
S-HOOP   69.00
S-HUBE  393.95
S-CODE  719.27*
======END======
MX        2000
MY           0
MZ           0
FX       74341
FY        2000
FZ        1000
ALPHA      300
I        10.00
S-NORM   32.15
S-BEND    0.00
SHEAR   142.94
S-HOOP   69.00
S-HUBE  255.95
S-CODE  598.61*
======END======
RX        4.68
RY       -0.90
RZ        1.73
TX        0.08
TY        1.17
TZ        0.61
```

```
STRESS 1    REV 1.0                  COMP WE+PR            PAGE    25
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE

==================MAXIMUM STRESSES IN THIS OUTPUT====================
 FR  TO NR PAGE S-CODE*  FR  TO NR PAGE S-HUBE*  FR  TO NR PAGE S-HOOP
                N/MM2*                  N/MM2*                   N/MM2
                      *                       *
 10  20  1   24  719.3*  10  20  1   24  393.9*  10  20  1   24   69.0
                      *                       *
                      *                       *
                      *                       *
                      *                       *

 MAXIMUM STRESS-RATIO IN THIS OUTPUT
 FR  TO NR PAGE S-ALL. S-RATIO
                N/MM2

 10  20  1   24  170.9    4.21


==================MAXIMUM MOVEMENTS IN THIS OUTPUT==================
 FR  TO NR PAGE     TX*  FR  TO NR PAGE     TY*  FR  TO NR PAGE     TZ
                    MM*                     MM*                     MM
                      *                       *
 10  20  1   24   0.08*  10  20  1   24   1.17*  10  20  1   24   0.61
                      *                       *
                      *                       *
                      *                       *
                      *                       *
```

```
STRESS 1    REV 1.0                    COMP WE+PR+TE         PAGE    26
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE

*************************************************************************
*                   = NOT RESTRAINED                                    *
*                A  = RESTRAINED                                        *
*                F  = RESTRAINED BY FRICTION FORCE                      *
* RESTRAINT-CODE N  = ONLY NEGATIVE REACTION POSSIBLE                   *
*  DESCRIPTION   P  = ONLY POSITIVE REACTION POSSIBLE                   *
*                S  = DESIGNED CONVENTIONAL SPRING                      *
*                C  = DESIGNED CONSTANT-LOAD-HANGER                     *
*                I  = DESIGNED INVERSE SPRING                           *
*                                                                       *
*                *  = ADDITIONAL SUPPORT DATA                           *
*                     (SPRING RATE, LIMIT OR PENDULUM)                  *
*************************************************************************

==FORCES BY THE SUPPORTS ON THE SYSTEM IN GLOBAL OR LOCAL DIRECTIONS==
==================LOCAL DIRECTIONS ARE MARKED BY LOC==================
NOD LOC      MX        MY        MZ        FX        FY        FZ    ==TEXT=
 NR         N.M       N.M       N.M        N         N         N

 10       -2000 A   2000 A  -1891 A   2000 A  -1782 A  -2000 A      10
 20                                                                   20
```

```
STRESS 1    REV 1.0                  COMP WE+PR+TE         PAGE    27
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE

=============NODAL MOVEMENTS IN GLOBAL OR LOCAL DIRECTIONS============
==================LOCAL DIRECTIONS ARE MARKED BY LOC==================
NOD LOC      RX        RY        RZ        TX        TY        TZ    ==TEXT=
 NR         MRAD      MRAD      MRAD       MM        MM        MM

 10        0.00 A    0.00 A    0.00 A    0.00 A    0.00 A    0.00 A      10
 20        4.68     -1.80      1.73      2.30      1.17      1.22        20
```

```
STRESS 1    REV 1.0                  COMP WE+PR+TE         PAGE    28
ORDER CBA29336    Zo 29-Sep-1996    16:57:06
PROJ  MINI CLUSTER NAM BOTLEK

CASE

*************************************************************************
*  ABBREVIATION    *  EXPLANATION OF THE ABBREVIATIONS                  *
*  ============    *  ================================                  *
*                  *                                                    *
*  FR-TO           *  NODE-NUMBERS AT BOTH ENDS OF THE BRANCH           *
*  NR              *  MEMBER-NUMBER WITHIN THE BRANCH                   *
*                  *  ( T = TEE AT ONE OR BOTH ENDS OF THE MEMBER )     *
*                  *  ( B = MEMBER IS A BEND )                          *
*                  *                                                    *
*  BEGIN           *  THE RESULTS APPLY AT THE MEMBER-BEGINNING         *
*  MAXIMUM         *  THE MAXIMUM EQUIVALENT STRESS OF THE WHOLE        *
*                  *  MEMBER IS CALCULATED, INCLUDING MOMENTS AND       *
*                  *  FORCES BELONGING TO IT, BUT WITHOUT TAKING        *
*                  *  INTO ACCOUNT THE I-FACTORS AT BEGIN AND END       *
*  PART            *  POINT WHERE THE MAXIMUM EQUIVALENT STRESS         *
*                  *  OCCURS, EXPRESSED IN A PERCENTAGE OF THE          *
*                  *  MEMBER-LENGTH FROM THE BEGINNING                  *
*  END             *  THE RESULTS APPLY AT THE MEMBER-END               *
*                  *                                                    *
*                  *  ********************************************      *
*                  *  *   THE MOMENTS, FORCES AND STRESSES EX-    *     *
*                  *  *   PRESS THE ACTION BY THE FARTHER END     *     *
*                  *  *   OF THE MEMBER ON THE NEARER END         *     *
*                  *  ********************************************      *
*                  *                                                    *
*  MX    (   N.M)  *  MOMENT ABOUT THE X-AXIS,        MT-X IS LOCAL     *
*  MY    (   N.M)  *  MOMENT ABOUT THE Y-AXIS,        MB-Y IS LOCAL     *
*  MZ    (   N.M)  *  MOMENT ABOUT THE Z-AXIS,        MB-Z IS LOCAL     *
*  FX    (     N)  *  FORCE IN THE X-AXIS DIRECTION,  FN-X IS LOCAL     *
*  FY    (     N)  *  FORCE IN THE Y-AXIS DIRECTION,  FS-Y IS LOCAL     *
*  FZ    (     N)  *  FORCE IN THE Z-AXIS DIRECTION,  FS-Z IS LOCAL     *
*  ALPHA (DEGREE)  *  ANGLE WHERE THE MAXIMUM EQUIVALENT STRESS         *
*                  *  OCCURS, POSITIVE LOCAL Y-AXIS =  0,               *
*                  *  POSITIVE LOCAL Z-AXIS = 90 DEGREES                *
*  I               *  STRESS-INTENSIFICATION FACTOR OF MEMBER OR T      *
*  I-RER           *  SAME, REROUNDING TAKEN INTO ACCOUNT               *
*  S-NORM( N/MM2)  *  NORMAL  STRESS ( DUE TO FN-X                 )    *
*  S-BEND( N/MM2)  *  BENDING STRESS ( DUE TO MB-Y, MB-Z           )    *
*  SHEAR ( N/MM2)  *  SHEAR   STRESS ( DUE TO MT-X, FS-Y, FS-Z     )    *
*  S-HOOP( N/MM2)  *  HOOP    STRESS ( DUE TO PRESSURE             )    *
*  S-HUBE( N/MM2)  *  EQUIVALENT STRESS, MAXIMUM OF THE WHOLE           *
*                  *  CROSS-SECTION, OCCURRING AT ANGLE ALPHA           *
*  S-CODE( N/MM2)  *  STRESS ACCORDING TO THE CODE                      *
*  S-MAX ( N/MM2)  *  THE MAXIMUM S-CODE OF THE WHOLE MEMBER           *
*                  *                                                    *
*  RX    (  MRAD)  *  ROTATION    ABOUT THE GLOBAL X-AXIS                *
*  RY    (  MRAD)  *  ROTATION    ABOUT THE GLOBAL Y-AXIS                *
*  RZ    (  MRAD)  *  ROTATION    ABOUT THE GLOBAL Z-AXIS                *
*  TX    (    MM)  *  TRANSLATION ALONG THE GLOBAL X-AXIS                *
*  TY    (    MM)  *  TRANSLATION ALONG THE GLOBAL Y-AXIS                *
*  TZ    (    MM)  *  TRANSLATION ALONG THE GLOBAL Z-AXIS                *
*                  *                                                    *
*************************************************************************
```

```
STRESS 1    REV 1.0                    COMP WE+PR+TE         PAGE    29
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PROJ  MINI CLUSTER NAM BOTLEK

CASE
FR-TO    10-20
NR           1
P-TEXT 100* 10
L-TEXT 200C120
S-RAT     1.85
=====BEGIN=====
MX        2000
MY       -2000
MZ        1891
FX       74341
FY        1782
FZ        2000
ALPHA      225
I        10.00
S-NORM   32.15
S-BEND  423.58
SHEAR   143.32
S-HOOP   69.00
S-HUBE  491.73
S-CODE  907.31*
====MAXIMUM====
MT-X      2000
MB-Y     -2000
MB-Z      1891
FN-X     74341
FS-Y      1782
FS-Z      2000
PART         0
ALPHA      225
I        10.00
S-NORM   32.15
S-BEND  423.58
SHEAR   143.32
S-HOOP   69.00
S-HUBE  491.73
S-CODE  907.31*
======END======
MX        2000
MY           0
MZ           0
FX       74341
FY        2000
FZ        2000
ALPHA      315
I        10.00
S-NORM   32.15
S-BEND    0.00
SHEAR   143.44
S-HOOP   69.00
S-HUBE  256.80
S-CODE  598.61*
======END======
RX        4.68
RY       -1.80
RZ        1.73
TX        2.30
TY        1.17
TZ        1.22
```

```
 STRESS 1    REV 1.0                   COMP WE+PR+TE         PAGE    30
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 CASE

 ==================MAXIMUM STRESSES IN THIS OUTPUT====================
  FR  TO NR PAGE S-CODE*  FR  TO NR PAGE S-HUBE*  FR  TO NR PAGE S-HOOP
                 N/MM2*                 N/MM2*                   N/MM2
                       *                      *
  10  20  1   29  907.3*  10  20  1   29  491.7*  10  20  1   29   69.0
                       *                      *
                       *                      *
                       *                      *
                       *                      *

  MAXIMUM STRESS-RATIO IN THIS OUTPUT
  FR  TO NR PAGE S-ALL. S-RATIO
                 N/MM2

  10  20  1   29  490.4    1.85


 ==================MAXIMUM MOVEMENTS IN THIS OUTPUT===================
  FR  TO NR PAGE     TX*  FR  TO NR PAGE     TY*  FR  TO NR PAGE     TZ
                     MM*                    MM*                      MM
                       *                      *
  10  20  1   29   2.30*  10  20  1   29   1.17*  10  20  1   29   1.22
                       *                      *
                       *                      *
                       *                      *
                       *                      *
```

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MAXIMUM STRESSES IN CASE: 1 OUTPUT: COMP TE

FR	TO	NR	PAGE	S-CODE* N/MM2	FR	TO	NR	PAGE	S-RAT.*	FR	TO	NR	PAGE	S-HUBE N/MM2
10	20	1	9	188.0*	10	20	1	9	0.59*	10	20	1	9	188.0

MAXIMUM STRESSES IN CASE: 1 OUTPUT: COMP WE

FR	TO	NR	PAGE	S-CODE* N/MM2	FR	TO	NR	PAGE	S-RAT.*	FR	TO	NR	PAGE	S-HUBE N/MM2
10	20	1	14	266.7*	10	20	1	14	1.56*	10	20	1	14	266.7

MAXIMUM STRESSES IN CASE: 1 OUTPUT: COMP PR

FR	TO	NR	PAGE	S-CODE* N/MM2	FR	TO	NR	PAGE	S-RAT.*	FR	TO	NR	PAGE	S-HUBE N/MM2
10	20	1	19	349.8*					*	10	20	1	19	289.8

MAXIMUM STRESSES IN CASE: 1 OUTPUT: COMP WE+PR

FR	TO	NR	PAGE	S-CODE* N/MM2	FR	TO	NR	PAGE	S-RAT.*	FR	TO	NR	PAGE	S-HUBE N/MM2
10	20	1	24	719.3*	10	20	1	24	4.21*	10	20	1	24	393.9

MAXIMUM STRESSES IN CASE: 1 OUTPUT: COMP WE+PR+TE

FR	TO	NR	PAGE	S-CODE* N/MM2	FR	TO	NR	PAGE	S-RAT.*	FR	TO	NR	PAGE	S-HUBE N/MM2
10	20	1	29	907.3*	10	20	1	29	1.85*	10	20	1	29	491.7

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STRESS 1    REV 1.0                    CONTENTS              PAGE    32
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CASE:

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