# USER DOCUMENTATION

# FOR

# NEW FEATURES OF PIPESTRESS

**October 2016**

# 1 What's New

Please find below a brief description of the new features implemented in PIPESTRESS and related utility programs. More detailed explanations follow.

## 1.1 PIPESTRESS

- ✓ Latest code editions.
- ✓ Up to 70 different combination methods for Response Spectrum analysis (RCAS).
- ✓ Implementation of CQC method for Complex Response Spectrum analysis (DCAS).
- ✓ Time History with applied moments.
- ✓ Time History with applied displacements.
- ✓ Numerous enhancements to the corrosion feature.
- ✓ Calculation of the penalty factor $Ke_{therm}$ for thermal gradient stresses (RCC-M Class 1 only).
- ✓ New fields to control Heat Transfer analysis output.
- ✓ Hot allowable option SH in the TITL card
- ✓ Much faster Modal Extraction, Time History and Response Spectrum analysis.
- ✓ Various improvements and correction of all errors reported since the release of version 3.8.0.

## 1.2 POSTR

- ✓ Detailed flange verification with calculation of bolt tightening torque.
- ✓ New option to output the range of shear forces and bending moments for elements
- ✓ Merged GROU and FXGR cards.
- ✓ New option ‘Excel’ in POSTR command file to generate Excel compatibles text files.

## 1.3 FHFILE

- ✓ Option to generate THF files with applied moments.
- ✓ Definition of groups of force and moment components
- ✓ Option to specify the maximum time span between consecutive times

## 1.4 THIST

- ✓ Support of Time History with applied moments.

## 1.5 COMPPS

- ✓ New options ‘SKIP’ and ‘INCLUDE’ to specify which reports are compared.
- ✓ New option ‘NOROUNDOFF’. By default, numeric values that only differ by 1 in the last digit are considered as equal (numerical round-off). The option ‘NOROUNDOFF’ may be specified to enforce strict equality.

# 2 Changes in PIPESTRESS

## 2.1 Latest code editions

| Code edition | IDEN card | TITL card |
|---|---|---|
| B31.1 Ed. 2014 | CD=0 | CV=16 |
| ASME NB-3600 Ed. 2015 | CD=1 | CV=23 |
| ASME NC-3600 Ed. 2015 | CD=2 | CV=24 |
| ASME ND-3600 Ed. 2015 | CD=3 | CV=24 |
| B31.3 Ed. 2014 | CD=4 | CV=13 |
| CODETI Ed. 2013 | CD=5 | CV=5 |
| N-755-2 | CD=P | CV=2 |

## 2.2 New fields MO, LV and OR for Response Spectrum analysis (RCAS)

The new fields allow much more control on how the response spectrum analysis is carried out. More than 70 combination methods are now available instead of 15 with the previous version. All methods in RG 1.92 Rev. 1 to 3 are implemented, in particular Der Kiureghian and Rosenblueth. Groups of levels can also be defined in phase.

**MO: Intermodal Superposition Option**

| MO | Intermodal Superposition | RG 1.92 | Formula |
|---|---|---|---|
| 1 | Grouping | Rev.1 §1.2.1 | $R_{\text{mod}} = \sqrt{\sum_{k=1}^{N} R_k^{\,2} + 2\sum_{i<j} \varepsilon_{ij} \left\| R_i R_j \right\|}$ |
| 2 | Ten Percent | Rev.1 §1.2.2 | |
| 3 | Double Sum | Rev.1 §1.2.3 | |
| 4 | SRSS - No coupling($\varepsilon_{ij} = 0$) | Rev.1 §1.1<br>Rev.2 and 3 §1.1.1 | |
| 5 | All coupling ($\varepsilon_{ij} = 1$) | - | |
| 6 | Rosenblueth | Rev.2 and 3 §1.1.2 | $R_{\text{mod}} = \sqrt{\sum_{k=1}^{N} R_k^{\,2} + 2\sum_{i<j} \varepsilon_{ij} R_i R_j}$ |
| 7 | Der Kiureghian | Rev.2 and 3 §1.1.3 | |

**LV: Interlevel Superposition Option**

| LV | Interlevel Superposition |
|---|---|
| 0 | Absolute without phase (default) |
| 1 | SRSS without phase |
| 2 | Algebraic |
| 3 | Absolute with phase |
| 4 | SRSS with phase |

**OR: Order Option**

| OR | Order of Superposition |
|---|---|
| 0 | Interlevel / Intermodal / Interspatial (default) |
| 1 | Interlevel / Interspatial / Intermodal |
| 2 | Intermodal / Interlevel / Interspatial |

The old field SU may still be used for compatibility reasons. Here is the correspondence between SU and MO/LV/OR:

| SU | Levels | Modal coupling | Directions | Order | Equivalent MO/LV/OR |
|---|---|---|---|---|---|
| 0 | Absolute | Grouping | SRSS | L / M / S | 1/0/0 |
| 1 | SRSS | Grouping | SRSS | L / M / S | 1/1/0 |
| 2 | Envelope | Grouping | SRSS | L / M / S | - |
| 3 | SRSS | None | SRSS | L / M / S | 4/1/0 |
| 4 | Absolute | All | Absolute | L / M / S | - |
| 5 | Absolute | Grouping | SRSS | L / S / M | 1/0/1 |
| 6 | SRSS | Grouping | SRSS | L / S / M | 1/1/1 |
| 8 | Absolute | Double Sum | SRSS | L / M / S | 3/0/0 |
| 9 | SRSS | Double Sum | SRSS | L / M / S | 3/1/0 |
| C | Algebraic | Der Kiureghian | SRSS | L / M / S | 7/2/0 |
| D | Absolute | Der Kiureghian | SRSS | L / M / S | - |
| E | SRSS | Der Kiureghian | SRSS | M / L / S | 7/1/2 |
| F | Absolute | Der Kiureghian | SRSS | M / L / S | 7/0/2 |

## 2.3 Time History with applied moments

The dynamic moments are defined directly in the THAFF file (see FHFILE). There is no change in the GCAS card.

## 2.4 Time History with applied displacements

The support dynamic displacements can be defined directly in the THACC file to calculate the secondary response in addition to the primary response due to support accelerations:

- If only displacements are defined in the THACC file, the calculated solution corresponds to the secondary response.
- If only accelerations are defined, the calculated solution corresponds to the primary (inertial) response.
- If both displacements and accelerations are defined, the calculated solution corresponds to the total response.

## 2.5 Corrosion

Corrosion allowances may be specified in the CROS card, either as a percentage (fields M1, M2) or as an absolute value (fields CO and CI). Fields M3 and M4 are now obsolete.

Additional stress reports are produced where stresses are calculated in the corroded geometry. The piping codes are not very explicit whether the stress indices and stress intensification factors shall be recalculated using the corroded geometry. Two options are therefore available in the TITL card:

- CO=0 : use the same stress indices and stress intensification factors as those based on the nominal geometry (default option)

- CO=1: use the stress indices and stress intensification factors based on the corroded geometry

## 2.6 Calculation of the penaly factor $Ke_{therm}$

The penalty factor $K_e$ may be split into two parts in the RCC-M code: $K_{e.méca}$ and $K_{e.therm}$.

If KE=0 (default) in the TITL card, no distinction is made: $K_{e.therm} = K_{e.méca}$.

If KE=1, $K_{e.therm}$ is calculated with the following formula for stainless austenitic and Ni-Cr-Fe steels:

$$K_{e.ther} = 1.86\left[1 - \frac{1}{1.66 + (S_n / S_m)}\right] \geq 1$$

## 2.7 New fields XT and DT in TRAN and FLUD cards

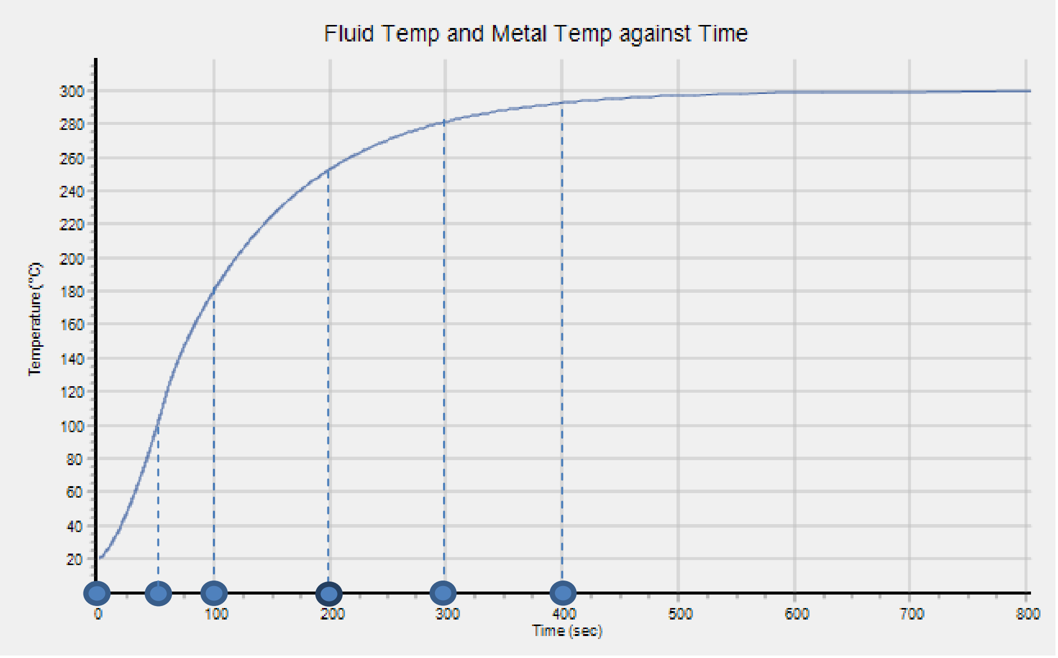
The new fields XT and DT allow to control more precisely the output of the heat transfer analysis.

If field XT is specified, the times in the report F-5 will be chosen such that the highest temperature variation ΔT through the wall thickness between two consecutive times is approximately equal to XT ($\approx 0.67\ XT \leq \Delta T \leq 1.33\ XT$).

If field DT is used, the heat transfer analysis results are printed at regular intervals: t, t + DT, t + 2×DT, etc. whatever the value of field XT.

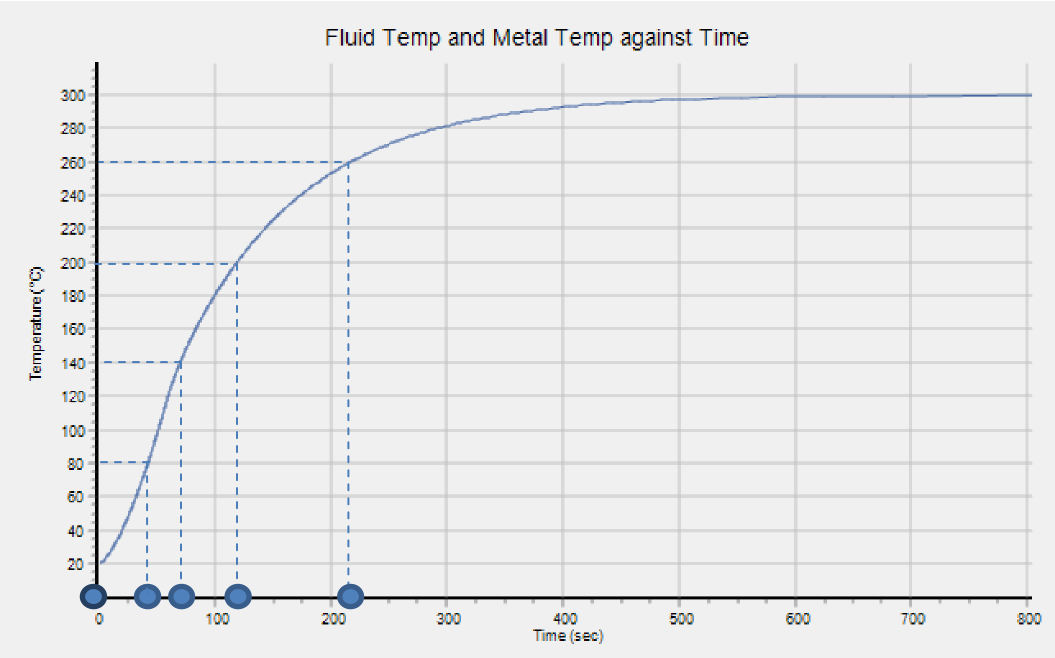
**Example 1: output times using option DT (only with method HT=1 in TITL card)**

```
TRAN CA=81 AL=/Heat up transient/
     TM=0   TE=20  PR=0.1  FL=100000. ST=1 DT=50
     TM=100 TE=300 PR=15.2 FL=100000. ST=1 DT=100
```




**Example 2: output times using option XT**

```
TRAN CA=81 XT=60 AL=/Heat up transient/
     TM=0  TE=20  PR=0.1  FL=100000. ST=1
     TM=75 TE=300 PR=15.2 FL=100000. ST=1
```



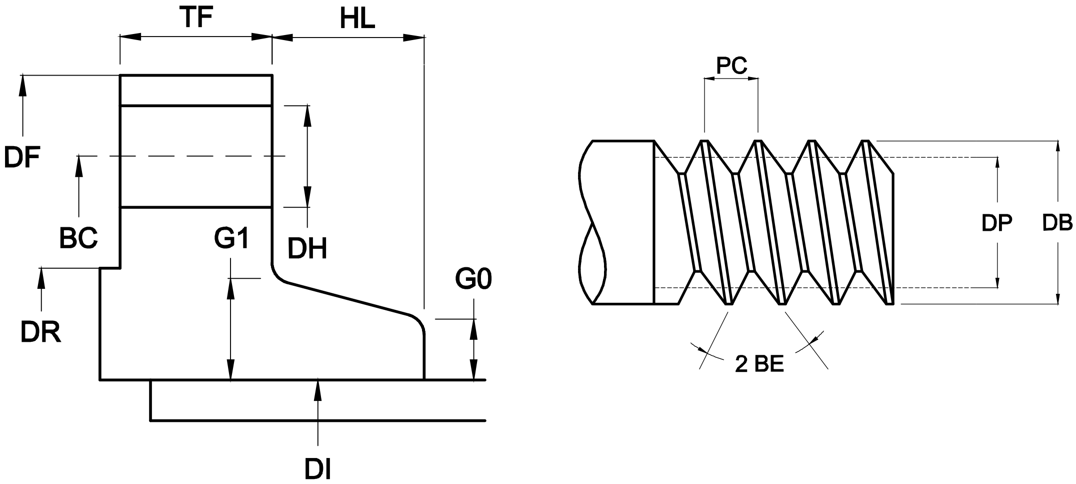

## 2.8 Hot allowable option SH in the TITL card

This option only applies to codes ASME Classes 2&3, RCC-M Class 2, KTA Class 2, ANSI B31.1 and ANSI B31.3.
When the SH field is set to 1, the allowable stress is taken at operating temperature instead of design temperature if the calculations are performed with the hot modulus option (MD=1 in the TITL card).

# 3 Changes in POSTR

## 3.1 Flange verification

The complete flange data (geometry, material, bolting and gasket) can be entered by means of the new cards RATC (rating curve), MATE (material) and FLNG (flange).



Four types of flange can be defined:

| | Integral | Loose | Lap | Optional |
|---|---|---|---|---|
| **Field TY** | 1 | 2 | 3 | 4 |

The following calculation methods can be selected in the new card OPTN:

| | | ME=1 (equivalent pressure) | ME=2 | ME=3 | ME=4 (Taylor Forge) |
|---|---|---|---|---|---|
| **ASME** | **CD=A** | NC-3658.1 | NC-3658.2 | NC-3658.3 | Appendix XI |
| **RCC-M** | **CD=R** | Z V 223.2 | C 3659.3 a) | C 3659.3 b) | Appendix ZV |
| **EN-13480** | **CD=F** | §6.6.3 | N/A | N/A | Appendix D |

The method ME=4 (Taylor Forge) is the most accurate but requires the flange geometry and gasket properties to be precisely defined.

In addition to the stress verification, POSTR evaluates the acceptable range of the tightening torque based on the friction coefficients entered by the user (ME=4 only).

## Example 1: simple verification using the equivalent pressure criteria

Welding neck flange 4" Class 300, material A 350 Gr. LF3

Two data are needed:

- average gasket diameter: DG=140 (mm)
- rating curve: given in ASME B16.5 Table 2-1.2 for material group 1.2

| Temperature (°C) | Rated pressure (MPa) |
|---|---|
| 20. | 5.175 |
| 93. | 5.175 |
| 204. | 4.86 |

The loading is described in the following table. The base cases CA=100 (dead weight), CA=101 (thermal expansion) and CA=200 (seism) are read from PIPESTRESS restart file.

| Load combination | Group | Ref. case | Level | C1 | C2 |
|---|---|---|---|---|---|
| Dead weight | 5000 | 101 | A | 100 | |
| Dead weight + Thermal | 5100 | 101 | A | 100 | 101 |
| Dead weight + Thermal + Seism | 5200 | 101 | B | 5100 | 200 |

The reference case (new field RF) is important: it provides the working pressure and temperature to be used for the loading under consideration. The level (new field LV) is purely informative here. It is only used for calculation methods ME=3 and RCC-M ME=4.
The POSTR input file is finally shown below:

```
IDN1 New features of POSTR
IDN2 Flange verification using the equivalent pressure criteria
IDN3 ASME Code

OPTN IU=0 ME=1 RP=0 CD=A

RATC TI=/rating #300 - material group 1.2/
     TE=20  PR=5.175
     TE=93  PR=5.175
     TE=204 PR=4.86

FLNG PI=220 PJ=225 DG=140 TI=/FL-01/

GROU CA=5000 ME=0 LV=A RF=101 C1=100         TI=/D.W./
GROU CA=5100 ME=0 LV=A RF=101 C1=100  C2=101 TI=/D.W.+TH./
GROU CA=5200 ME=0 LV=B RF=101 C1=5100 C2=200 TI=/D.W.+TH.+SEISM/
```

## Example 2: detailed verification using the Taylor Forge method

Same flange (WN 4” Class 300) and same loading as in example 1.
Additional data are needed:

### Flange geometry

- flange type: TY=1
- outside/inside diameter: DF=254 (mm), DI=116 (mm)
- flange thickness: TF=31.8 (mm)
- bolting circle diameter: BC=200. (mm)
- hub geometry: G0=5 (mm), G1=21 (mm), HL=54 (mm)
- number of bolts: NB=8

### Bolt

- bolt diameter and pitch: DB=20 (mm), PC=2.5 (mm)

**Gasket** (see ASME Appendix XI Tables XI-3221.1-1 and XI-3221.1-2)

- Load reaction diameter: DG=140 (mm)
- Effective gasket width: BG=4 (mm)
- Factors m and y: MG=2.25, YG=15 (MPa)

### Data for tightening torque calculation

- Hole diameter: DH=22.2 (mm)
- Nut diameter: DN=30 (mm)
- Minimum friction : B1=0.08 T1=0.08
- Maximum friction: B2=0.15 T2=0.15

The flange and bolt material mechanical properties need also to be entered (values in MPa):

| Temperature (°C) | A 350 Gr. LF3 Flange | | A 193 Gr. B7 Bolting | |
|---|---|---|---|---|
| | Sh | Sy | Sh | Sy |
| 20. | 138 | 259 | 172 | 517 |
| 100 | 138 | 235 | 172 | 479 |
| 200 | 138 | 221 | 172 | 451 |

The POSTR input file is finally shown below:

```
IDN1 New features of POSTR
IDN2 Flange verification using the Taylor Forge method
IDN3 ASME Code

OPTN IU=0 ME=4 RP=0 CD=A

MATE FO=F TI=/A350 Gr. LF3/
     TE=20  SH=138 SY=259
     TE=100SH=138 SY=235
     TE=200 SH=138 SY=221

MATE FO=B TI=/A19 Gr. B7/
     TE=20  SH=172 SY=517
     TE=100SH=172 SY=479
     TE=200 SH=172 SY=451

FLNG PI=220 PJ=225 TI=/FL-01/
     TY=1 DF=254 DI=116 TF=31.8 BC=200 G0=5 G1=21 HL=54 NB=8
     DB=20 PC=2.5 DG=140 BG=4 MG=2.25 YG=15
     DH=22.2 DN=30 B1=0.08 T1=0.08 B2=0.15 T2=0.15


GROU CA=5000 ME=0 LV=A RF=101 C1=100  TI=/D.W./
GROU CA=5100 ME=0 LV=A RF=101 C1=100  C2=101 TI=/D.W.+TH./
GROU CA=5200 ME=0 LV=B RF=101 C1=5100C2=200 TI=/D.W.+TH.+SEISM/
```

## 3.2 New combination method ME=1 in GROU combinations

The new combination method ME=1 outputs the resultant envelope of shear forces and bending moments for elements (ELEM).

# 4 Changes in FHFILE

## 4.1 Applied moments

Applied moments can now be entered in the THAFF file for Time History analysis (GCAS card).

The version identifier must be set to '$THAF5' in the component file. The moment components are identified by the flag 'M' :

```
$THAF5   0001      NEWTONS      0      1000.  0.  2.  0.001
Time history with applied moments

* NODE    DX     DY     DZ   FUNCTION  DELAY  FACTOR  TYPE
* ====    ==     ==     ==   ========  =====  ======  ====

N100      0      1      0    FORCE1    0.     1.      F
N200      0      1      0    MOMEN1    0.     1.      M
```

There are no changes in the load file.

## 4.2 Groups of components

Force and moment components using the same forcing function are grouped into a meta-component. This allows to reduce the analysis time and the memory requirements for GCAS cases with a large number of components (e.g. explosion loads).