UVARM subroutine

User subroutine to generate element output

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UVARM subroutine

From the ABAQUS documentation:

UVARM: User subroutine to generate element output.

Overview

User subroutine **UVARM**:

- will be called at all material calculation points of elements for which the material definition includes the specification of user-defined output variables;
- may be called multiple times for each material point in an increment, as Abaqus/Standard iterates to a converged solution;
- will be called for each increment in a step;
- allows you to define output quantities that are functions of any of the available integration point quantities listed in the Output Variable Identifiers table ("Abaqus/Standard output variable identifiers," Section 4.2.1 of the Abaqus Analysis User's Guide);
- allows you to define the material directions as output variables;
- can be used for gasket elements;
- can call utility routine **GETVRM** to access material point data;
- cannot be used with linear perturbation procedures; and
- cannot be updated in the zero increment.

UVARM subroutine

Description of the arguments for UVARM:

Material orientations

Variable(s) to be defined

Time and timestep

Material and orientations names

```
SUBROUTINE UVARM(UVAR,DIRECT,T,TIME,DTIME,CMNAME,ORNAME,
+ NUVARM,NOEL,NPT,LAYER,KSPT,KSTEP,KINC,NDI,NSHR,COORD,
+ JMAC,JMATYP,MATLAYO,LACCFLA)
```

Utility variables

Composite layer

Step number

Stress components

Element number

```
NUVARM,NOEL,NPT,LAYER,KSPT,KSTEP,KINC,NDI,NSHR,COORD,
```

Number of variables

Integration point

Section point

Increment number

Coordinates

UVARM subroutine

UVARM is useful to compute variables not always provided by ABAQUS

In this example, we want to compute the stress triaxiality σ^* and the Lode parameter μ:

$$\sigma^* = \frac{\sigma_h}{\sigma_{eq}} \qquad \text{and} \qquad \mu = \frac{2\sigma_2 - \sigma_1 - \sigma_3}{\sigma_1 - \sigma_3}$$

where σ_h is the hydrostatic stress, σ_{eq} is the von Mises equivalent stress and $\sigma_1, \sigma_2, \sigma_3$ are the ordered principal stresses

UVARM subroutine

Overview of the subroutine:

```fortran
      SUBROUTINE UVARM(UVAR,DIRECT,T,TIME,DTIME,CMNAME,ORNAME,
     + NUVARM,NOEL,NPT,LAYER,KSPT,KSTEP,KINC,NDI,NSHR,COORD,
     + JMAC,JMATYP,MATLAYO,LACCFLA)
      INCLUDE 'ABA_PARAM.INC'
!-----------------------------------------------------------------------
!-----Declaration ABAQUS variables
!-----------------------------------------------------------------------
      CHARACTER*80 CMNAME,ORNAME
      DIMENSION UVAR(NUVARM),DIRECT(3,3),T(3,3),TIME(2)
      DIMENSION JMAC(*),JMATYP(*),COORD(*)
!-----Data from ABAQUS
      CHARACTER*3 FLGRAY(15)
      DIMENSION ARRAY(15),JARRAY(15)
!-----------------------------------------------------------------------
!-----Declaration internal variables
!-----------------------------------------------------------------------
      real*8 SIGH,SMISES
      real*8 SP1,SP2,SP3
      real*8 TRIAX,LODE
!-----------------------------------------------------------------------
!     Access stress invariants
!-----------------------------------------------------------------------
      CALL GETVRM('SINV',ARRAY,JARRAY,FLGRAY,JRCD,
     +            JMAC,JMATYP,MATLAYO,LACCFLA)
c
      SIGH   = ARRAY(3)
      SMISES = ARRAY(1)
!-----------------------------------------------------------------------
!     Compute the stress triaxiality
!-----------------------------------------------------------------------
      TRIAX = -SIGH/SMISES
!-----------------------------------------------------------------------
!     Access principal stresses
!-----------------------------------------------------------------------
      CALL GETVRM('SP',ARRAY,JARRAY,FLGRAY,JRCD,
     +            JMAC,JMATYP,MATLAYO,LACCFLA)
c
      SP1 = ARRAY(3)
      SP2 = ARRAY(2)
      SP3 = ARRAY(1)
!-----------------------------------------------------------------------
!     Compute the Lode parameter
!-----------------------------------------------------------------------
      if(abs(SP1-SP3).gt.0.0)then
         LODE = (2.0*SP2-SP1-SP3)/(SP1-SP3)
      else
         LODE = 0.0
      endif
!-----------------------------------------------------------------------
!     Update user-defined variables
!-----------------------------------------------------------------------
      UVAR(1) = TRIAX
      UVAR(2) = LODE
!-----------------------------------------------------------------------
!     End of subroutine
!-----------------------------------------------------------------------
      RETURN
      END
```

$$\sigma^* = \frac{\boldsymbol{\sigma} : \mathbf{I}}{3\sqrt{3J_2}}$$

User-variables

$$\mu = \frac{2\sigma_2 - \sigma_1 - \sigma_3}{\sigma_1 - \sigma_3}$$

UVARM subroutine

Access to ABAQUS variables

```fortran
      SUBROUTINE UVARM(UVAR,DIRECT,T,TIME,DTIME,CMNAME,ORNAME,
     + NUVARM,NOEL,NPT,LAYER,KSPT,KSTEP,KINC,NDI,NSHR,COORD,
     + JMAC,JMATYP,MATLAYO,LACCFLA)
      INCLUDE 'ABA_PARAM.INC'
!-----------------------------------------------------------------------
!-----Declaration ABAQUS variables
!-----------------------------------------------------------------------
      CHARACTER*80 CMNAME,ORNAME
      DIMENSION UVAR(NUVARM),DIRECT(3,3),T(3,3),TIME(2)
      DIMENSION JMAC(*),JMATYP(*),COORD(*)
!-----Data from ABAQUS
      CHARACTER*3 FLGRAY(15)
      DIMENSION ARRAY(15),JARRAY(15)
!-----------------------------------------------------------------------
!-----Declaration internal variables
!-----------------------------------------------------------------------
      real*8 SIGH,SMISES
      real*8 SP1,SP2,SP3
      real*8 TRIAX,LODE
!-----------------------------------------------------------------------
!     Access stress invariants
!-----------------------------------------------------------------------
      CALL GETVRM('SINV',ARRAY,JARRAY,FLGRAY,JRCD,
     +            JMAC,JMATYP,MATLAYO,LACCFLA)
c
      SIGH   = ARRAY(3)
      SMISES = ARRAY(1)
!-----------------------------------------------------------------------
!     Compute the stress triaxiality
!-----------------------------------------------------------------------
      TRIAX = -SIGH/SMISES
!-----------------------------------------------------------------------
!     Access principal stresses
!-----------------------------------------------------------------------
      CALL GETVRM('SP',ARRAY,JARRAY,FLGRAY,JRCD,
     +            JMAC,JMATYP,MATLAYO,LACCFLA)
c
      SP1 = ARRAY(3)
      SP2 = ARRAY(2)
      SP3 = ARRAY(1)
!-----------------------------------------------------------------------
!     Compute the Lode parameter
!-----------------------------------------------------------------------
      if(abs(SP1-SP3).gt.0.0)then
        LODE = (2.0*SP2-SP1-SP3)/(SP1-SP3)
      else
        LODE = 0.0
      endif
!-----------------------------------------------------------------------
!     Update user-defined variables
!-----------------------------------------------------------------------
      UVAR(1) = TRIAX
      UVAR(2) = LODE
!-----------------------------------------------------------------------
!     End of subroutine
!-----------------------------------------------------------------------
      RETURN
      END
```

To get the variables we need, the GETVRM subroutine is used

Accessing ABAQUS variables

Utility routine GETVRM:

Output variable key

Array with variables

Integer array with components

Array with flags

Error code

```
CALL GETVRM('VAR',ARRAY,JARRAY,FLGRAY,JRCD,
+            JMAC,JMATYP,MATLAYO,LACCFLA)
```

Utility variables

```
      SUBROUTINE UVARM(UVAR,DIRECT,T,TIME,DTIME,CMNAME,ORNAME,
     + NUVARM,NOEL,NPT,LAYER,KSPT,KSTEP,KINC,NDI,NSHR,COORD,
     + JMAC,JMATYP,MATLAYO,LACCFLA)
      INCLUDE 'ABA_PARAM.INC'
!-----------------------------------------------------------------
!-----Declaration ABAQUS variables
!-----------------------------------------------------------------
      CHARACTER*80 CMNAME,ORNAME
      CHARACTER*3 FLGRAY(15)
      DIMENSION UVAR(NUVARM),DIRECT(3,3),T(3,3),TIME(2)
      DIMENSION ARRAY(15),JARRAY(15),JMAC(*),JMATYP(*),COORD(*)
```

By default ABAQUS expects an array with 15 or more lines

Accessing ABAQUS variables

Output variable key:

You can only access the variables available in the .fil file !

Element integration point variables

You can request element integration point variable output to the data, results, or output database file (see "Element output" in "Output to the data and results files," Section 4.1.2, and "Element output" in "Output to the output database," Section 4.1.3).

Tensors and associated principal values and invariants

Identifier	.dat	.fil	.odb Field	.odb History	Description
S	•	•	•	•	All stress components.
S*ij*	•			•	ij-component of stress ($i \leq j \leq 3$).
SP	•	•	•	•	All principal stresses.
SP*n*	•			•	Minimum, intermediate, and maximum principal stresses (SP1 $\leq$ SP2 $\leq$ SP3).
SINV	•	•	•	•	All stress invariant components (MISES, TRESC, PRESS, INV3). For field output SINV is converted to a request for the generic variable S.
MISES	•			•	Mises equivalent stress, defined as $q = \sqrt{\frac{3}{2}\mathbf{S}:\mathbf{S}}$, where $\mathbf{S}$ is the deviatoric stress tensor, defined as $\mathbf{S} = \boldsymbol{\sigma} + p\,\mathbf{I}$, where $\boldsymbol{\sigma}$ is the stress, p is the equivalent pressure stress (defined below), and $\mathbf{I}$ is a unit matrix. In index notation $q = \sqrt{\frac{3}{2}S_{ij}S_{ij}}$, where $S_{ij} = \sigma_{ij} + p\,\delta_{ij}$, $p = -\frac{1}{3}\sigma_{ii}$, and δ_{ij} is the Kronecker delta.

UVARM subroutine

Input file structure:

```
**------------------------------------------------------------------
** MATERIALS
**------------------------------------------------------------------
*material,name=EXAMPLE_UVARM
*elastic
210000.0, 0.3
*plastic
250.0, 0.0
350.0, 1.0
*User Output Variables
2
**------------------------------------------------------------------
```

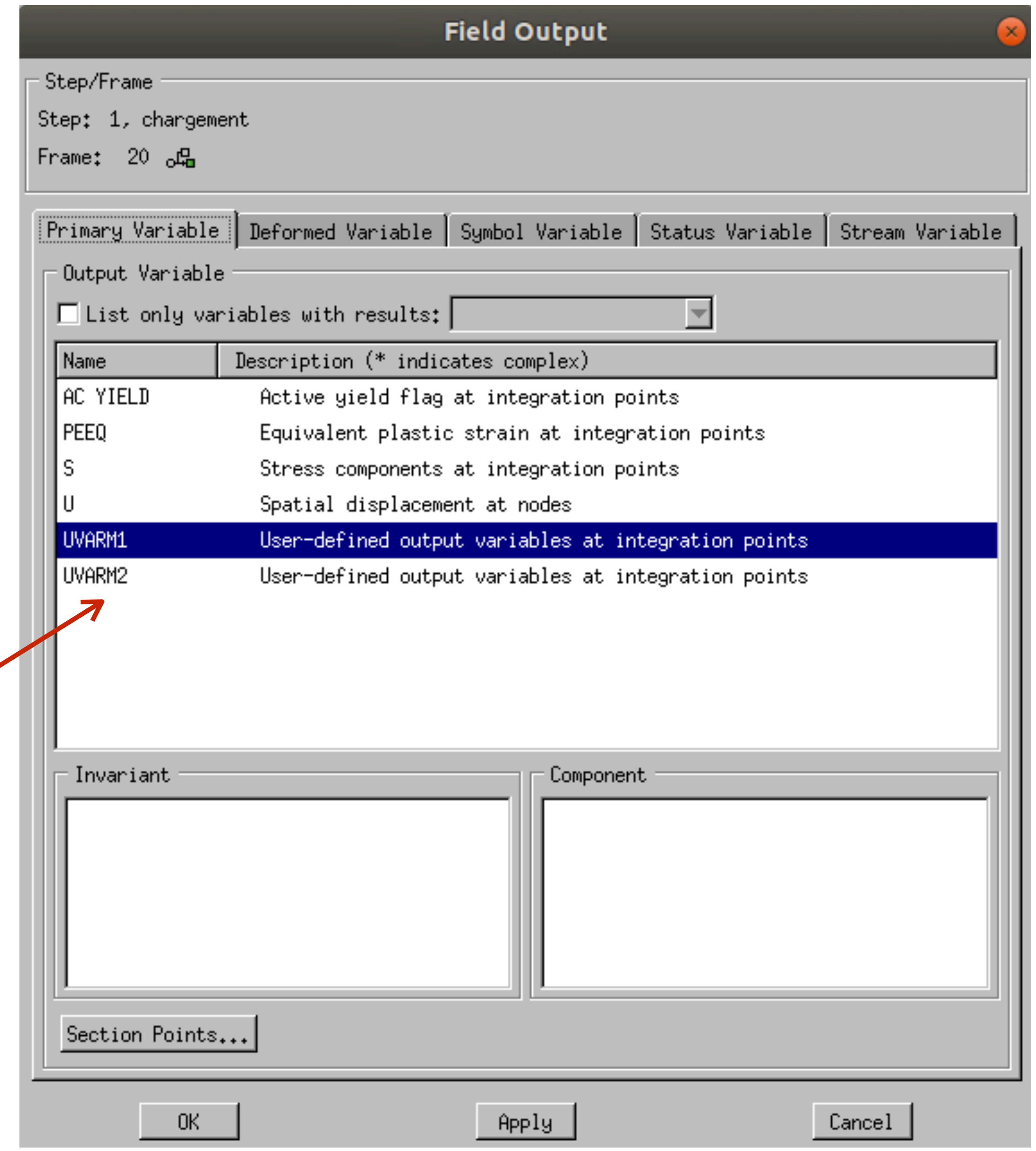
Call to the UVARM subroutine

Number of user-variables

```
**------------------------------------------------------------------
** FIELD OUTPUT
**------------------------------------------------------------------
*OUTPUT,FIELD
*ELEMENT OUTPUT
PEEQ,S,UVARM
*NODE OUTPUT
U
**------------------------------------------------------------------
```

User-variables as field outputs in odb file

Odb file structure:



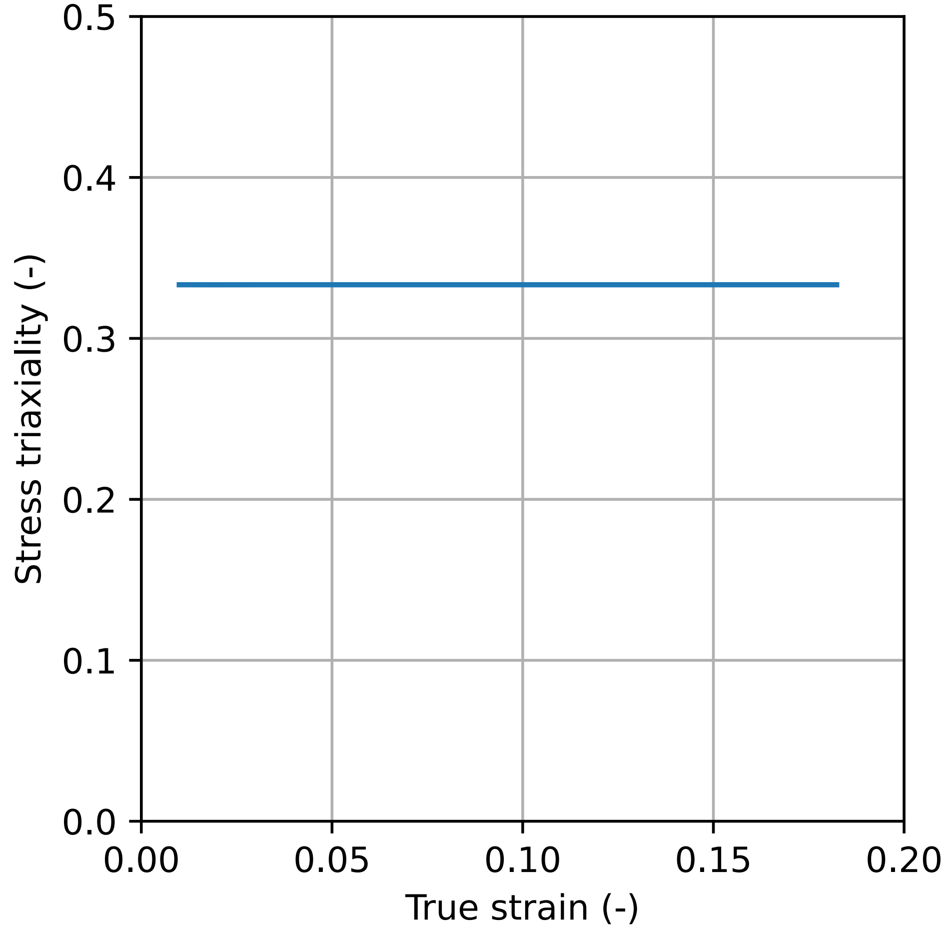
! UVARM subroutine limited to ABAQUS/Standard and is not available in ABAQUS/explicit

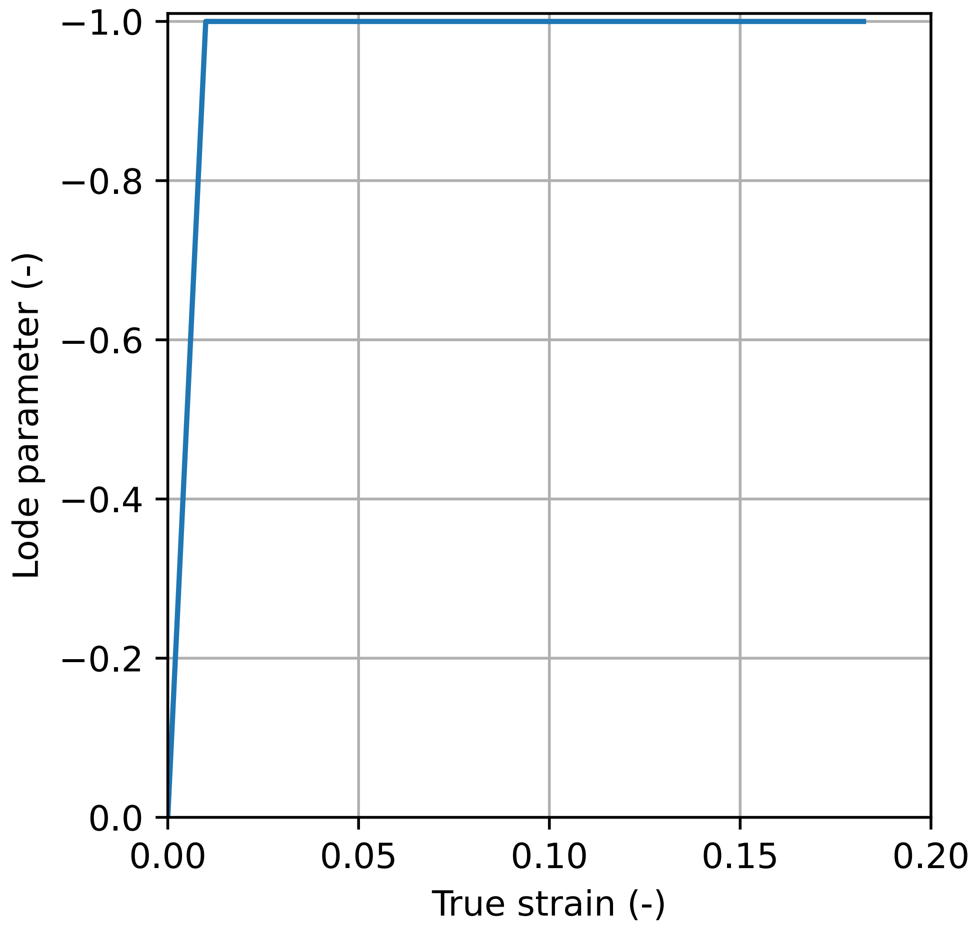
UVARM subroutine

Results from the UVARM example

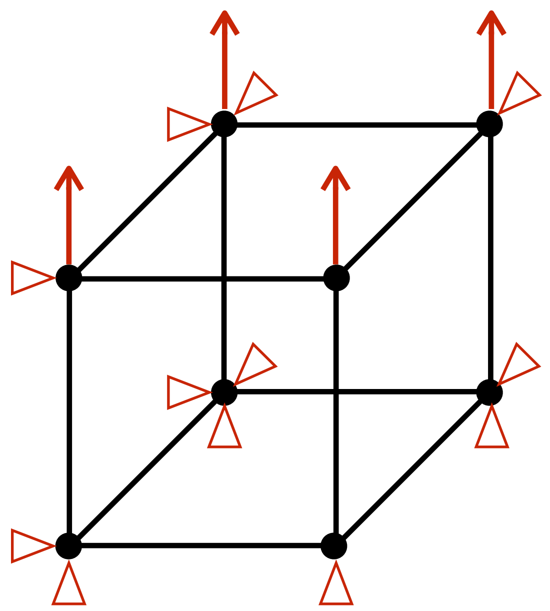
$$\sigma^* = \frac{\boldsymbol{\sigma} : \mathbf{I}}{3\sqrt{3J_2}}$$

$$\mu = \frac{2\sigma_2 - \sigma_1 - \sigma_3}{\sigma_1 - \sigma_3}$$





Single solid element in uniaxial tension



In uniaxial tension: $\sigma^* = \frac{1}{3}$ and $\mu = -1$

UVARM subroutine

- UVARM is useful to compute variables not always provided by ABAQUS but is only available in ABAQUS/Standard.
- A work-around in ABAQUS/Explicit is to use a VUSDFLD subroutine.