Procedure **MACR_ECREVISSE**

**Summary:**

The macro-order **MACR_ECREVISSE** is to calculate the flow of fluid (air/vapor/liquid) through one (or several) fissures (S) crossing (S) in a structure modelled in 2 dimensions. It realizes for that, with each step of time, the chaining of two codes:

- **Code_Aster** who allows to know the thermomechanical state of the structure
- **Crayfish** which carries out the thermohydraulic calculation of flow through the crack.

In practice, the macro-order is given the responsibility to carry out successively for all the steps of time:

- a linear thermal calculation
- a quasi-static mechanical calculation
- to call the macro-order **CALC_ECREVISSE**, which it will be in load:
  1. to recover the profile of the crack
  2. to call a third macro-order **MACR_ECRE_CALC** who will generate the command file and will launch **Crayfish**
  3. to extract and copy the results
  4. to check the imposed criteria are checked and if need be redécouper the step of time.

The principal concept of exit is the structure of data result of mechanical calculation (**evol_noli**). It is also possible to obtain the structure of data results of thermal calculation, like 2 tables, one containing the flows at every moment, the other recapitulating the data relating to the cracks. By creating a repertoire of exit in the profile of study, one will be able to recover all the exits there relating to **Crayfish**.
It is possible to carry out continuations of calculation.

**Notice**

It is necessary to specify the keyword **DEBUG=_F (HIST_ETAPE=' OUI')** in **BEGINNING** or **CONTINUATION** to use **MACR_ECREVISSE**.
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1 Goal

This order allows the chaining of Code_Aster with the software CRAYFISH. The principle rests for each step of time, with a successive call to:

- **THER_LINEAIRE** to obtain the thermal state of the structure
- **STAT_NON_LINE** to obtain the mechanical state of the structure
- with the code CRAYFISH to know the conditions of flow of the fluid.

Notice

*It is necessary to specify the keyword* DEBUG=_F (HIST_ETAPE=' OUI') *in BEGINNING or CONTINUATION to use MACR_ECREVISSE.*

2 Syntax

MACR_ECREVISSE ( 

# OUTGOING CONCEPTS
◊ TABLE = CO ('table') [CO]
◊ FLOW = CO ('flow') [CO]
◊ TEMPER = CO ('temp') [CO]

# ETAT_INITIAL
◊ ETAT_INIT = _F ( 
    ◊ EVOL_NOLI = evol_noli [evol_noli]
    ◊ EVOL_THER = evol_ther [evol_ther]
    ◊ NUME_ORDRE = nume_ordre [I]
 ),

# MODEL THERMOMECHANICAL
◊ MODELE_MECA = m_meca [modele_sdaster]
◊ MODELE_THER = m_ther [modele_sdaster]

# LISTS MOMENTS
◊ LIST_INST = list_inst [listr8]

# GIVEN FOR STAT_NON_LINE AND THER_LINEAIRE
◊ CHAM_MATER = chmat [cham_mater]
◊ CARA_ELEM = carac [cara_elem]
◊ EXCIT_MEC = _F ( 
    ◊ LOAD = chi [char_meca]
    ◊ FONC_MULT = fi [function]
    ◊ TYPE_CHARGE = / 'FIXE_CSTE' [DEFECT]
    / 'SUIV'
    / 'DIDI'
 ),
◊ CONTACT = char_contact [char_contact]
◊ EXCIT_THER = _F ( 
    ◊ LOAD = chi [char_ther]
    ◊ FONC_MULT = fi [function]
 ),

◊ BEHAVIOR = _F (see the document [U4.51.11])
◊ NENTON = _F (see the document [U4.51.03])
◊ CONVERGENCE = _F (see the document [U4.51.03])
◊ ENERGY = _F ()
◊ PARM_THETA = theta [DEFAULT=0.57] [R]

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# GIVEN GEOMETRICAL RELATING TO THE CRACK

◊ CRACK = _F (  
  ♦ GROUP_MA = gma  [grma]  
  ♦ GROUP_NO_ORIG = ogno  [grno]  
  ♦ GROUP_NO_EXTR = egno  [grno]  
  ♦ SECTION = / "ELLIPSE"  
     / "RIGHT-ANGLES"  
  ♦ LISTE_COTES_BL = / (0, max (abs_curv))  [DEFECT]  
     / lcb1  [lstr8]  
  ♦ LISTE_VAL_BL = lvbl  [lstr8]  
  ♦ ZETA = zeta  [R]  
  ♦ ROUGHNESS = eps  [R]  
  ♦ OUVERT_REMANENT = ouv_rem  [R]  
  ♦ TORTUOSITY = / 1  [DEFECT]  
     / wrong  [R]  
  ♦ PREFIXE_FICHIER = /'FISSURE1'  [DEFECT]  
     /'prefix'  [KN]  
)

#,  

# RELATIVE DATA WITH THE FLOW

◊ FLOW = _F (  
  ♦ / PRES_ENTREE = EP  [R]  
     / PRES_ENTREE_FO = fpe  / [function]  
     / PRES_SORTIE = PS  [R]  
     / PRES_SORTIE_FO = fps  / [function]  
  ♦ / FLUIDE_ENTREE = /1,  
     /2,  
     /3,  
     /4,  
     /5,  
     /6  
  # if FLUIDE_ENTREE = 1,3,4 or 6  
  ♦ / TEMP_ENTREE = you  [R]  
     / TEMP_ENTREE_FO = fte  / [function]  
  # if FLUIDE_ENTREE = 2 or 5  
  ♦ / TITR_MASS = Xe  [R]  
     / TITR_MASS_FO = fxe  / [function]  
  # if FLUIDE_ENTREE = 4 or 5  
  ♦ / PRES_PART = pae  [R]  
     / PRES_PART_FO = fpae  / [function]  
)

#,  

# CHOICE OF THE MODELS FOR CRAYFISH

◊ MODELE_ECRE = _F (  
  ♦ IVENAC = / 0,  [DEFECT]  
     / 1,  
  ♦ FLOW = / 'SATURATION',  
     / 'COLD',  
  # if FLOW = 'COLD'  
  ♦ PRESS_EBULLITION = peb,  [R]  
)

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♦ FRICTION = / -14,
/ -12,
/ -11,
/ -4,
/ -3,
/ -2,
/ -1,
/ 0,
/ 1,
/ 2,
/ 3,
/ 4,
/ 11,
/ 12,
/ 14,
# if negative FRICTION
♦ REYNOLDS_LIM = relim [R]
♦ FROTTEMENT_LIM = frtlim [R]
♦ TRANSFERT_CHAL = / -12,
/ -11,
/ -2,
/ -1,
/ 0,
/ 1,
/ 2,
/ 11,
/ 12,
# if negative TRANSFERT_CHAL
♦ XMINCH = xminch [R]
♦ XMAXCH = xmaxch [R]

# CONVERGENCE CRITERIA OF THE MACRO-COMMANDE
♦ CONV_CRITERE = _F (  
  ♦ TEMP_REF = tref [R]
  ♦ PRES_REF = pref [R]
  
  ♦ CRITERION = / 'TEMP_PRESS' [DEFECT]
  / 'TEMP'
  / 'CLOSE'
  / 'CLARIFIES'
# if CRITERION different from EXPLICIT
♦ NUME_ORDRE_MIN = N [I]
♦ PREC_CRIT = prec [R]
♦ SUBD_NIVEAU = Nb [I]
♦ SUBD_PAS_MINI = nbpas [R]
),

# CONVERGENCE DIGITAL OF CRAYFISH
♦ CONVERGENCE_ECREVISSE = _F (  
  ♦ KGTEST = / kgtest [R]
  / 0.5 [DEFECT]
  ♦ ITER_GLOB_MAX = / itnmax [I]
  / 400 [DEFECT]
  ♦ CRIT_CONV_DEBI = / precdb [I]
  / 1.E-5 [DEFECT]
 ),

# GENERAL
♦ CURVED = / 'NO' [DEFECT]
/ 'POSTSCRIPT' [KN]
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3 Operands

3.1 Operands TABLE/TEMPER/FLOW

◊ TEMPER  = CO ('temp')
◊ TABLE   = CO ('table')
◊ FLOW    = CO ('flow')

These keywords make it possible to give the name of the concepts leaving the macro-order, namely:

- **TABLE**: a table of 7 columns giving for each step of time: the dimension \(z\), flow, total pressure (\(Pa\)), the temperature of the fluid (\(°C\)), the coefficient of exchange by convection (\(W.m^{-2}.°C^{-1}\)), the name of the crack.

- **TEMPER**: the structure of data result of thermal calculation

- **FLOW**: the value of the flow (\(kg.s^{-1}\)) with each step of time and for each crack

**Note:**

1. *all the concepts of exit are optional; it nevertheless is highly advised to inform has minimum TEMPER, if not it is impossible to control the fields of temperature in the structure and to make a continuation*

2. *if the concept is réentrant, the keyword TEMPER does not have to be here well informed but under the keyword ETAT_INIT, operand EVOL_THER.*

3.2 Keyword ETAT_INIT

◊ ETAT_INIT  = _F (  
   ♦ EVOL_NOLI  = evol_noli  
   ♦ EVOL_THER  = evol_ther  
   ♦ NUME_ORDRE = nume_ordre  

Keyword allowing to define the initial state within the framework of a continuation of the macro-order.

3.2.1 Operand EVOL_NOLI

Name of the concept of the type evol_noli from where will be extracted the mechanical state.

3.2.2 Operand EVOL_THER

Name of the concept of the type evol_ther from where will be extracted the thermal state. This concept will be enriched during calculation.

3.2.3 Operand NUME_ORDRE

The initial state to continue calculation will be defined starting from the number of filing NUME_ORDRE for evol_noli and for evol_ther.

3.3 Operands MODELE_MECA/MODELE_THER

♦ MODELE_MECA= m_meca  
♦ MODELE_THER = m_ther

These keywords make it possible to inform the name of the model (\(m\_meca\)) whose elements are the object of mechanical calculation and the name of the model (\(m\_ther\)) whose elements are the object of thermal calculation.
3.4 **Operand LIST_INST**

♦ LIST_INST = list_inst

List of the steps of times which correspond to the imposed moments of calculation. In the event of recutting, the moments are inserted in this list.

3.5 **Operand CHAM_MATER**

♦ CHAM_MATER = chmat

Name of the affected material field to the grid. Attention, this field must understand the data associated with the mechanical behavior and the thermal behavior (keyword THER of DEFI_MATERIAU). It is also necessary to have defined the temperature of reference under AFFE_VARC.

3.6 **Operand CARA_ELEM**

◊ CARA_ELEM = carac

This keyword makes it possible to inform, the characteristics of the elements of beam, bars, hull, pipe, discrete element, when they are present in the model. Attention, this keyword is used only for mechanical calculation but is not transmitted for the operator of thermics (to avoid any problem with the bars).

3.7 **Keyword EXCIT_MECA**

♦ EXCIT_MECA = _F (  
  ♦ LOAD = chi  
  ♦ FONC_MULT = fi  
  ♦ TYPE_CHARGE = / “FIXE_CSTE”  
  ♦ “SUIV”  
  ♦ “DIDI”  
  )

It is a question here of informing the boundary conditions of the mechanical problem, as well as the possible mechanical loadings which apply to the structure. Syntax is identical to that of the keyword EXCIT of STAT_NON_LINE but it is not possible to control a loading. See the document [U4.51.03].

3.8 **Keyword CONTACT**

♦ CONTACT = char_contact

One informs here the conditions of contact between the lips of the crack, which can be closed during calculation. The goal of this keyword is that to avoid the interpenetration of the lips which can occur under the effect of the flow of the fluid.

3.9 **Keyword EXCIT_THER**

♦ EXCIT_THER = _F (  
  ♦ LOAD = chi  
  ♦ FONC_MULT = fi  
  )

It is a question here of informing the boundary conditions of the thermal problem as well as the possible thermal loadings. Syntax is identical to that of the keyword EXCIT of THER_LINEAIRE. See the document [U4.54.01].

3.10 **Keyword BEHAVIOR**

It is a question here of informing the law of behavior which will be used to solve the mechanical problem. See the document [U4.51.03].
3.11 **Keyword NEWTON**

It is a question here of informing the parameters of the algorithm of Newton to solve the mechanical problem. This keyword is identical to that of `STAT_NON_LINE`, it is thus advisable to refer to the document [U4.51.03].

3.12 **Keyword CONVERGENCE**

It is a question here of informing the convergence criteria for mechanical calculation. Syntax corresponds to that of `STAT_NON_LINE` (see the document [U4.51.03]).

**Note:**

> It can be necessary to use `RESI_GLOB_MAXI` rather than `RESI_GLOB_RELA`, when there is no mechanical loading (if not, null effort, therefore `RESI_GLOB_RELA` indefinite).

3.13 **Keyword ENERGY**

This keyword makes it possible to activate the calculation of the assessment of energy and its posting during mechanical calculation (see the document [R4.09.01]). This assessment is stored in the table of name `PARA_CALC` from where it can be extracted using the order `RECU_TABLE` [U4.71.02].

3.14 **Operand PARM_THETA**

It is a question here of informing the value of the parameter $\theta$ characteristic of the theta-diagram used to solve the thermal problem. See the document [U4.54.01].

3.15 **Keyword CRACK**

$\star$ **CRACK**

This keyword makes it possible to define all the parameters having milked in a crack. Several occurrences of this keyword are possible if there are several cracks.

3.15.1 **Operand GROUP_MA**

$\star$ **GROUP_MA** = `gma`

Groups of the meshes defining the lips of the crack. One gives the group of the lower lip and higher.

3.15.2 **operands GROUP_NO_ORIG and GROUP_NO_EXTR**

$\star$ **GROUP_NO_ORIG** = `ogno`

$\star$ **GROUP_NO_EXTR** = `egno`

Allows to define the two groups of nodes which define the two ends of the cracks in order to direct it.

3.15.3 **Operand SECTION**

$\star$ **SECTION** = `"ELLIPSE"` / `"RIGHT-ANGLED"`

It is a question here of defining the bypass section of the flow (plan perpendicular to the plan of modeling). This one can be elliptic or rectangular. One of dimensions of this section corresponds in keeping with the crack in the plan of modeling. This one is at every moment given by the macro-order. Other dimension corresponds in keeping with the crack out of plan of modeling. This one is fixed during all calculation and must be indicated thanks to the operands `LISTE_COTES_BL` and `LISTE_VAL_BL`.

3.15.4 **operands LISTE_COTES_BL/LISTE_VAL_BL**

$\star$ **LISTE_COTES_BL** = `lcbl`

$\star$ **LISTE_VAL_BL** = `lvbl`

---

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To characterize the size of the crack in the plan not modelled, it is necessary to provide the value of the “small” axis of the elliptic section or the width of the rectangular section at least in 2 points.

LISTE_COTES_BL allows to inform the curvilinear X-coordinates where the dimension of the crack is given and LISTE_VAL_BL allows to give dimension. If LISTE_COTES_BL is not informed, LISTE_VAL_BL must contain the width of the crack at the entry and the exit of the crack.

### 3.15.5 Operand ROUGHNESS

◊ ROUGHNESS = eps

Absolute roughness of the wall (in meters). This value influences the result only if friction is calculated by Crayfish (operand FRICTION > 0) and if the flow is not laminar any more.

### 3.15.6 Operand ZETA

◊ ZETA = zeta

Loss ratio of singular load at the entry (without dimension).

### 3.15.7 Operand OUVERT_REMANENTE

◊ OUVERT_REMANENTE = ouv_rem

Value of the remanent opening (in meters) for calculation Crayfish corresponding to the real hydraulic opening of the crack when the two lips are with the contact. This translated the fact that, even when the crack is closed, a small amount of fluid will forward, in particular because of roughness. This parameter depends on material: for example, it is about $10 \mu m$ for the concrete.

This keyword is thus taken into account thus during hydraulic calculation (Crayfish), but not by Code_Aster: I can thus arrive well that hydraulic calculation is carried out with the remanent opening, is that the contact is activated in mechanical calculation.

### 3.15.8 Operand TORTUOSITY

◊ TORTUOSITY = wrong

If the crack is tortuous, one can admit that, seen fluid, the length of the crack is higher than the thickness of the crossed wall. This coefficient, which by default is worth 1, makes it possible to take into account this phenomenon. The length of the crack will be thus equal to $\frac{L}{tort}$ with $tort \leq 1$.

### 3.15.9 Operand PREFIXE_FICHIER

◊ PREFIXE_FICHIER = prefix
3.16 **Keyword FLOW**

♦ FLOW
It is a question in this keyword of defining the nature of the fluid and its characteristics.

### 3.16.1 Operands PRES_ENTREE/PRES_ENTREE_FO

♦  
/ PRES_ENTREE = EP  
/ PRES_ENTREE_FO = fpe

This operand makes it possible to give the total pressure \(( Pa )\) or its evolution in the course of time, upstream of the crack. It must be understood enters 215.10^5 Pa and 10^5 Pa.

### 3.16.2 Operands PRES_SORTIE/PRES_SORTIE_FO

♦  
/ PRES_SORTIE = EP  
/ PRES_SORTIE_FO = fpe

This operand makes it possible to give the total pressure \(( Pa )\) or its evolution in the course of time, at exit of the crack. It must be understood enters 215.10^5 Pa and 10^5 Pa and being higher than the pressure of entry (if not, there is no flow and calculation stops).

### 3.16.3 Operand FLUIDE_ENTREE

♦ FLUIDE_ENTREE = 1,2,3,4,5 or 6

This operand makes it possible to define the state of the fluid at the entrance of the crack:
1: Supercooled or saturated water;  
2: Diphasic fluid;  
3: Saturated or overheated vapour;  
4: Air + overheated vapor;  
5: Air + saturated vapour;  
6: Air alone.

According to the situation of the fluid, only some of the following characteristics are to be informed.

### 3.16.4 Operands TEMP_ENTREE/TEMP_ENTREE_FO

♦  
/ TEMP_ENTREE = you  
/ TEMP_ENTREE_FO = fte

This operand makes it possible to inform the temperature \((°C)\) or its evolution in the course of time, upstream of the crack. It must be indicated if the fluid at the entry is “supercooled or saturated Water”, “saturated or overheated Vapour”, “Air + overheated vapor” or “Air alone”.  
(operand FLUIDE_ENTREE = 1,3,4, or 6).

### 3.16.5 Operands TITR_MASS/TITR_MASS_FO

♦  
/ TITR_MASS = Xe  
/ TITR_MASS_FO = fxe

This operand makes it possible to inform the mass vapor title, or its evolution in the course of time, upstream of the crack. It corresponds to the relationship between the vapor mass and the mass of water liquid and vapor. It must be indicated if the fluid at the entry is “Fluid diphasic” or “Air + saturated vapour” (operand FLUIDE_ENTREE = 2 or 5).

### 3.16.6 Operands PRES_PART/PRES_PART_FO

♦  
/ PRES_PART = pae

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This operand makes it possible to inform the pressure partial of air (\( Pa \)) or its evolution in the course of time, upstream of the crack. It must be indicated if the fluid at the entry is “Air + overheated vapor” or “Air + saturated vapour” (operand \texttt{FLUIDE_ENTREE}=4 or 5).

3.17 Keyword MODELE_ECRE

\begin{itemize}
\item \texttt{MODELE_ECRE}
\end{itemize}

This keyword makes it possible to inform the models which will be used by Crayfish to calculate the flow of the fluid.

3.17.1 Operand IVENAC

\begin{itemize}
\item \texttt{IVENAC} = 0 or 1,
\end{itemize}

When this operand is activated (IVENAC=1), calculation CRAYFISH is carried out with taking into account of the vena contracted (pressure loss as starter). If not (case by default), calculation will be carried out without this option of modeling.

3.17.2 Operand FLOW

\begin{itemize}
\item \texttt{FLOW} = / ‘SATURATION’,
\item / ‘COLD’
\end{itemize}

In the absence of air and in the presence of water (operand \texttt{FLUIDE_ENTREE}=1 or 2), this operand makes it possible to choose between the homogeneous model with balance and the model of flow “COLD” characterized by a nonworthless fraction of metastable liquid.

3.17.3 Operand PRESS_EBULLITION

Pressure of boiling (\( Pa \)) to provide only for the model of cold flow.

3.17.4 Operand FRICTION

It is a question here of defining how friction is calculated. The valid values are:

\begin{itemize}
\item \(-14, -12, -11, -4, -3, -2, -1, 0, 1, 2, 3, 4, 11, 12, 14\).
\end{itemize}

Value 0 corresponds to a calculation without friction.

For the negative values, the user fixes the value of the coefficient of friction for the turbulent flows. For the positive values, friction in turbulent flow is calculated starting from the coefficient of roughness. Moreover, for the values superiors to 10, the law used for the laminar flow is connected with that in turbulent flow. Otherwise, a discontinuity is present.

According to the value used, the calculation of dynamic viscosity is done differently (important for the diphasic flows), cf documentation Crayfish.

3.17.5 Operands REYNOLDS_LIM/FROTTEMENT_LIM

Coefficient of Reynolds limiting and coefficient of friction imposed for a Reynolds higher than the limiting Reynolds.

To provide only if \texttt{FRICTION} < 0.

3.17.6 Operand TRANSFERT_CHAL

This operand makes it possible to determine whether one wants or not to take into account the transfer of heat by convection between the fluid and the wall. The valid values are:

\begin{itemize}
\item \(-12, -11, -2, -1, 0, 1, 2, 11, 12\).
\end{itemize}

Value 0 corresponds to a calculation without transfer of heat (adiabatic).

The other values correspond to various options for the calculation of the convection coefficient (differences only for the laminar mode). To refer to documentation Crayfish.

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3.17.7 Operands XMINCH/XMAXCH

This operator has direction only in the diphasic cases, if $\text{TRANSFERT\_CHAL} < 0$. It makes it possible to inform the value of the mass gas titles delimiting the zone of transition between the models from calculation from the convection coefficient, cf documentation Crayfish.

3.18 Keyword CONV_CRITERE

The macro-order calculates three criteria at every moment making it possible to estimate the importance of the changes occurred between two steps of time and thus the validity of the chaining carried out. To calculate these criteria, the user must define values of reference for the pressure and the temperature, allowing to quantify the acceptable variation.

$$e_T = \frac{\max (T_t - T_{t-1})}{T_{\text{REF}}}$$
$$e_P = \frac{\max (P_t - P_{t-1})}{P_{\text{REF}}}$$
$$e_G = \sqrt{e_T^2 + e_P^2}$$

Then, it can activate if it wishes it the recutting of the step of time if the value of the criterion is lower than a given value.

The gained experience watch however that it is to better try to optimize the list of moment to count on the recutting of the step of time, because calculations Crayfish are relatively long.

3.18.1 Operand CRITERION

Allows to define the nature of the criterion used to manage the steps of time in the macro-order. The possible values are:

- **EXPLICIT**: no recutting some is the value of the indicators
- **TEMP**: there will be recutting according to the value of $e_T$
- **NEAR**: there will be recutting according to the value of $e_P$
- **TEMP\_PRES**: there will be recutting according to the value of $e_G$

3.18.2 Operand TEMP\_REF

Temperature of reference for the calculation of the criterion in temperature of the macro-order.

3.18.3 Operand PRES\_REF

Pressure of reference for the calculation of the criterion in pressure of the macro-order.

3.18.4 Operand PREC\_CRIT

Value with which one compares the error obtained to activate or not the recutting of the step of time (1 by default). For example for the temperature: $e_T < \text{PREC\_CRIT}$

3.18.5 Operand NUME\_ORDRE\_MIN

Sequence number from which the criterion of error is taken into account. Convergence is forced on the lower sequence numbers. One often uses this operand to start the activation of the criterion of error starting from the second step of time and to force convergence on the first step which is often delicate to treat, since one imposes brutal loadings on the initial moment.

3.18.6 Operand SUBD\_NIVEAU

Number of recutting of the step of authorized time. Beyond this value, one redécoupe more and one leave the macro-order.

3.18.7 Operand SUBD\_PAS\_MINI

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3.19 **Keyword CONVERGENCE_ECREVISSE**

3.19.1 **Operand KGTEST**

Parameter of the iterative Crayfish algorithm. Must be understood enters 0 and 1. Fixed by default at 0.5, one can have to so put a slightly lower value difficulties of convergence on the flow are observed.

3.19.2 **Operand ITER_GLOB_MAXI**

Maximum number of iterations authorized for the calculation of the flow (400 by defaults).

3.19.3 **Operand CRIT_CONV_DEBI**

Precision used for the convergence of the calculation of the flow. It is the value compared to which Crayfish tests the flow max and min in its process of calculation.

\[
\frac{G_{\text{max}} - G_{\text{min}}}{G} \leq \text{CRIT_CONV_DEBI}
\]

By default with $10^{-5}$, values until $10^{-2}$ improve the computing time without losing much precision.

3.20 **Operand CURVES**

\[\diamond \text{CURVED} = \begin{cases} \\ \\ \text{"NO"} & [\text{DEFECT}] \\ \text{"POSTSCRIPT"} \\ \text{"INTERACTIVE"} \end{cases} \]

Allows to generate or not the curves of Crayfish exit. If the curves are generated, they are stored in the file `REPE_OUT` with the format postscript (every moment is in the same file postscript). In interactive mode, the curves are displayed for each step of time.

3.21 **Operand SOFTWARE**

Allows to specify “into hard” the way to find achievable Crayfish. Now, only versions 3.2 and 3.2.1 are compatible with the MACR_ECREVISSE. It is necessary obligatorily to inform this operand or alternatively the operand VERSION.

3.22 **Operand VERSION**

Indicate the Crayfish version used in the coupling. It is necessary obligatorily to inform this operand or alternatively the operand SOFTWARE. Now, version 3.2.1 is used. It is the only one that one can inform under the operand VERSION. If one wishes to use version 3.2, this one must be indicated under the operand SOFTWARE.

3.23 **Operand HEADING**

Is used to give a title to calculation Crayfish.

3.24 **Operand IMPRESSION**

When the operand is worth ‘YES’, the macro one prints a summary table of the results of Crayfish along the curvilinear X-coordinate (temperature, pressure, flow, speed, convection coefficient,…).

3.25 **Operand INFORMATION**

INFO=1: almost no posting.
INFO=2: poster information concerning the convergence criteria.
4 Operation of the coupling

4.1 Principle

This macro-order was developed within a precise framework: to estimate the flows of a crack in a concrete block modelled in 2D, possibly containing the steels modelled in the form of bar (not taken into account in thermal calculation). The use in very other framework must thus be done with the greatest precaution. However, it in fact 3 macro-order imbricated there, which can make it possible to use only part of the features.

The algorithm is the following:

```
Beginning of macro
Buckle on the list of moments
MACR_ECREVISSE.py
Recovery loading thermal and mechanical
Execution of THER_LINEAIRE
Projection of the thermal loading and definition of the loadings coming from Crayfish
Exécution de STAT_NON_LINE
Entry in CALC_ECREVISSE.py
  Recovery of the opening of the crack (POST_RELEVE_T)
  Recovery of the temperature in edge of crack
Entry in MACR_ECRE_CALC.py
  CRAYFISH execution
  Recovery of the calculated flow and the tables of results
Extraction and copy of the outgoing data (CL, thermics, Crayfish result…)
Evaluation of the convergence criteria (error in temperature and/or pressure)
Possible Recutting of the step of time even stop following the conditions
Recovery of information and concepts (loading,…)
```

The detail of the intermediate macro-orders, CALC_ECREVISSE and MACR_ECRE_CALC, is given in appendix.

4.2 Units

One can usually do without the units in Code_Aster while remaining coherent. However, for the needs for Crayfish, it is important to respect the international system of units here (IF), in particular for the lengths (m), pressures (Pa), and temperatures (°C).

4.3 Some advices of use

grid must be in 2 dimensions, and the crack with a grid explicitly. So that calculation is of good quality, it is necessary to optimize the grid so that it is compatible with the phenomena which one wants to represent: mechanical loadings, thermal loadings but also the flow of the fluid. It is thus important sufficiently to refine the grid at the edges of the crack if one wants to see to warm up material. As starter of cracks, the thermal and hydraulic phenomena are fast, it is thus necessary there too to refine the grid sufficiently.

```
discretization in time is also very important and must be sufficiently fine, under penalty of having important variations in the answers. Better is worth to try to optimize this list of moments rather than to rest only on the criteria for redécouper because this strategy is much more expensive in time.
```

For calculations with condensation vapor on the way of cracking, the convection coefficient can increase up to two orders of magnitude on the way in the liquid state. As condensation takes place on a very small zone in space, the variation of the convection coefficient and thus of the heat flow transferred to the wall can be very fast (see Figure 4.3-1).

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That can generate space oscillations in the temperature of the solid mass.

The macro-order can be réentrante. The thermal and mechanical results will be well enriched, on the other hand new tables of exit will be created for the new list of step of time.

**Note:**
The loadings are destroyed with each step of time, as well as the material field, possible postprocessings are in fact limited (internal displacement, constraint and variables at the points of Gauss).

## 5 Example of use

See test zzzz218a, B and C.

## 6 Reference Crayfish

2. H-I81-2008-03647-FR, Modifications made to the software CRAYFISH version 3.1 to obtain CRAYFISH version 3.1.1, HERVOUET Chantal.
7 Appendices

7.1 Syntax of the procedure CALC_ECREVISSE

```
CALC_ECREVISSE =
{
    # OUTGOING CONCEPT
    ♦ CHARGE_MECA = CO ('char_meca') [CO]
    ♦ CHARGE_THER1 = CO ('char_ther') [CO]
    ♦ CHARGE_THER2 = CO ('char_ther') [CO]
    ♦ TABLE = CO ('table') [CO]
    ♦ FLOW = CO ('flow') [CO]

    # MODEL MECHANICAL
    ♦ MODELE_MECA = m_meca [model]
    ♦ MODELE_THER = m_ther [model]

    # GIVEN GEOMETRICAL RELATING TO THE RESULTS
    ♦ RESULT = _F (
        ♦ MECHANICAL = rmeca [result]
        ♦ THERMAL = rther [result]
        / ♦ NUME_ORDRE = nume_ordre [I]
        ♦ INST = urgent [R]
    ),

    # GIVEN GEOMETRICAL RELATING TO THE CRACK
    ♦ CRACK = _F (
        ♦ GROUP_MA = gma [grma]
        ♦ GROUP_NO_ORIG = ogno [grno]
        ♦ GROUP_NO_EXTR = egno [grno]
        ♦ ZETA = zeta [R]
        ♦ ROUGHNESS = rug [R]
        ♦ OUVERT_REMANENTE = ouv_rem [R]
        ♦ PREFIXE_FICHIER = / 'FISSURE1', [DEFECT] /prefix
        ♦ TORTUOSITY = wrong [R]
        ♦ SECTION = / "ELLIPSE"
        / "RIGHT-ANGLED"
        ♦ LISTE_COTES_BL = / (0, max (abs_curv)) [DEFECT]
        / lcbl [listr8]
        ♦ LISTE_VAL_BL = lvbl [listr8]
    ),

    # RELATIVE DATA WITH THE FLOW
    ♦ FLOW =...
        idem MACR_ECREVISSE/ECOULEMENT

    ♦ MODELE_ECRE =...
        idem MACR_ECREVISSE/MODELE_ECRE

    # RELATIVE DATA WITH DIGITAL CONVERGENCE
    ♦ CONVERGENCE_ECREVISSE =...
        idem MACR_ECREVISSE/CONVERGENCE_ECREVISSE

    # GENERAL
    CURVES, SOFTWARE, VERSION... = ...
        idem MACR_ECREVISSE/GENERAL
        ♦ INFORMATION = / 1 [DEFECT]
        / 2
```

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7.2 Operands specific to CALC_ECREVISSE

7.2.1 Operand CHARGE_MECA
Outgoing concept containing the mechanical loading provided by Crayfish.

7.2.2 Operands CHARG_THER1 and CHARG_THER2
Outgoing concepts containing the thermal loadings provided by Crayfish.

7.2.3 Keyword RESULT

7.2.3.1 Operand MECHANICS
The result contains of STAT_NON_LINE

7.2.3.2 Operand THERMICS
The result contains of THER_LINEAIRE

7.2.3.3 Operand NUME_ORDRE
Sequence number of the step of computing time in progress.

7.2.3.4 Operand INST
Value of the moment (in seconds) of the step of computing time in progress.
7.3 Syntax of the procedure MACR_ECRE_CALC

MACR_ECRE_CALC =

(  
# OUTGOING CONCEPT  
  ♦ TABLE = CO ('table')                           [CO]  
  ♦ FLOW = CO ('flow')                             [CO]  

# GIVEN GEOMETRICAL RELATING TO THE CRACK  
  ♦ CRACK = F (  
      ♦ LENGTH = long                              [R]  
      ♦ ROUGHNESS = rug                            [R]  
      ♦ ANGLE = alpha                              [R]  
      ♦ ZETA = zeta                                [R]  
      ♦ SECTION = / "ELLIPSE"                     / "RIGHT-ANGLED"  
          ♦ LISTE_COTES_BL = / (0, max (abs_curv)) [DEFECT]  
            / lcbl                                [listr8]  
          ♦ LISTE_VAL_BL = lvbl                       [listr8]  
  ),

# RELATIVE DATA WITH THE FLOW  
  ♦ FLOW = idem MACR_ECREVISSE/ECOULEMENT

# RELATIVE DATA WITH THE PROFILE OF TEMPERATURE THROUGH THE WALL  
  ♦ TEMPERATURE = _F (  
      / ♦ GRADIENT = "PROVIDED"  
           ♦ LISTE_COTES_TEMP = lct                [R]  
           ♦ LISTE_VAL_TEMP = lvt                 [R]  
      / ♦ GRADIENT = "IMPOSES"  
           ♦ TEMP1 = tm1                           [R]  
           ♦ TEMP2 = tm2                           [R]  
      / ♦ GRADIENT = "CALCULATES"  
           ♦ EPAISSEUR_PAROI = epp                  [R]  
           ♦ CONVECTION_AMONT = alphs              [R]  
           ♦ CONVECTION_AVAL = alphas              [R]  
           ♦ AVERAGE ♦                              = lambd [R]  
           ♦ TEMP_FLUIDE_AVAL = ts                  [R]  
  ),

# RELATIVE DATA WITH THE FLOW  
  ♦ FLOW = idem MACR_ECREVISSE/ECOULEMENT

  ♦ MODELE_ECRE = idem MACR_ECREVISSE/MODELE_ECRE

# RELATIVE DATA WITH DIGITAL CONVERGENCE  
  ♦ CONVERGENCE_ECREVISSE = idem MACR_ECREVISSE/CONVERGENCE_ECREVISSE

# GENERAL  
  CURVES, SOFTWARE, VERSION = idem MACR_ECREVISSE/GENERAL
)

7.4 Operands specific to MACR_ECRE_CALC

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7.4.1 **Keyword CRACK**

7.4.1.1 **Operand ANGLE**

Angle of the flow compared to the ascending vertical (degrees).

7.4.1.2 **Operand LENGTH**

The real length of the crack defines (taking account of its tortuosity).

7.4.1.3 **Operand LISTE_COTES_AH**

According to the value of the operand **SECTION**:

- **ELLIPSE** : List of dimensions of the points defining the main roads of the section;
- **RECTANGLE** : List of dimensions of the points defining the length of the section.

7.4.1.4 **Operand LISTE_VAL_AH**

According to the value of the operand **SECTION**:

- **ELLIPSE** : List of the values of the points defining the main roads of the section;
- **RECTANGLE** : List of the values of the points defining the length of the section.

7.4.2 **Keyword TEMPERATURE**

7.4.2.1 **Operand GRADIENT**

Model of the variation in temperature:

- **Provided** : Distribution of provided temperature;
- **Imposed** : Imposed distribution of temperature;
- **Calculated** : Profile of temperature calculated;

7.4.2.2 **Operand LISTE_COTES_TEMP**

List of the dimensions for the temperatures.

7.4.2.3 **Operand LISTE_VAL_TEMP**

List of the values of temperature.

7.4.2.4 **Operand TEMP1**

Variation in temperature of the wall along the flow.

7.4.2.5 **Operand TEMP2**

Temperature of the wall at the entry.

7.4.2.6 **Operand EPAISSEUR_PAROI**

Thickness of the wall (m).

7.4.2.7 **Operand CONVECTION_AMONT**

Convection coefficient on the surface of the wall with dimensions upstream.

7.4.2.8 **Operand CONVECTION_AVAL**

Convection coefficient on the surface of the wall with dimensions downstream.

7.4.2.9 **Operand LAMBDA**

Thermal conduction of the wall.
7.4.2.10 **Operand** TEMP\_FLUIDE\_AVAL

Temperature of the fluid with dimensions downstream.