Relative Flow Control (RFC)

Plant-based heat networks with multiple headers and demand nodes (e.g. domestic central heating, district heating) requires a method to ensure the proportion of the flow supplied to each header and node are accurate based on the relative capacity and control action at each node. The existing diverter valve component has no visibility on the capacity or current status of any downstream nodes relative to its demand, leading to unstable and unrealistic results. An alternative approach has been developed that allows the flow to each node to be determined based on the node control action relative to all node control actions.

This is achieved by assigning each demand node a maximum Relative Flow Factor (RFF) which reflects the flow capacity of this node relative to all other nodes. The most realistic basis for the RFF would be the node pipe cross-sectional area, which would be linked to the size of the control valve or pump in a real circuit. Alternatively, the maximum demand (e.g. radiator or Heat Interface Unit sizing) can be used as a proxy. The baseline value for the RFF is unimportant as long as the relative value for each node is consistent. The RFF is set via a control loop as the maximum control output linked to the outlet flow temperature from the node. RFC mimics actual pressure-driven operation of inlet control valves to demands by determining effectively how far the valves are open and allocating total system flow proportionally.

An example control loop for a diverter valve is shown below. The RFF for this junction is 3.0 (the second digit in the bottom row of data items).

```
* Control loops    6
# senses var in compt. 24:pipeL22 @ node no.  3
   -1   24    3    0    0  # sensor
# plant component  21:DivV2 @ node no.  1
   -1   21    1    0  # actuator
    1  # all daytypes
    1  365  # valid Sat-01-Jan - Sun-31-Dec
     1  # No. of periods in day: weekday
   18    5   0.000  # ctl type, law (Prop`l damper ctl.), start @
      6.  # No. of data items
  0.00000 3.00000 85.00000 65.00000 0.00000 0.00000
```

The RFC process requires that plant section before and after a flow split is given a node number (see red numbering on DH1.gif). These node numbers are referenced in the plant configuration file as outlined below. The number ordering is not important as long as it is consistent with the model structure.

Two types of RFC component is currently available, a diverter valve, where the flow is controlled for one of the two outlet nodes, this is typically a node feeding a demand, and a flow splitter, which splits the flow based on the relative demands from each downstream branch. Specific examples are shown below:

- *Diverter valve with further downstream demand nodes (i.e DV2 in 3BR_highres_plant exemplar):*
  Inlet (component node 1) and 2nd outlet node (component node 3) identified and bypass RFF nominally set to zero as it is ignored in this case:

```
 #->  xx, 3-node Diverter Valve - Relative Flow
  DivVx            123
    1        # Component has   1 control variable(s).
   0.00000000
    3
```

```
        4.0000     #   1 Outlet 2 RFF Node
        2.0000     #   2 Inlet RFF Node
        0.0000     #   3 Bypass RFF
```

- *Diverter valve with no further downstream demand nodes and supply-return bypass piping (i.e DivV2 in DH1 exemplar):*
  Inlet node identified, outlet node set to 99 to identify bypass, and fixed RFF of bypass pipework set to determine proportion of flow to bypass:

```
#->  xx, 3-node Diverter Valve - Relative Flow
  DivVx            123
    1        # Component has   1 control variable(s).
   1.00000000
    3
       99.000     #   1 Outlet 2 RFF Node
       4.0000     #   2 Inlet RFF Node
     0.50000E-02 #   3 Bypass RFF
```

- *Diverter valve with no further downstream demand nodes or bypass (i.e. a 2-port control valve) (i.e DV4 in 3BR_highres_plant exemplar):*
  Inlet node identified, outlet node set to 99 to identify no further downstream nodes, and a zero RFF set to indicate no further downstream flow. ESPr will give a warning that the third node of this diverter has no exit connection but this can be ignored :

```
#->  xx, 3-node Water 3-port Diverter Valve - Relative Flow
  DivVx            123
    1        # Component has   1 control variable(s).
   1.00000000
    3
       99.000     #   1 Outlet 2 RFF Node
       4.0000     #   2 Inlet RFF Node
       0.0000     #   3 Bypass RFF
```

- *Flow splitter to two main branches (i.e. SPM in 3BR_highres_plant exemplar):*
  Inlet and both outlet RFF node numbers identifed. RFF factor nominally set to zero as it is ignored.

```
#->  xx, 3-node Diverter Junction - Relative Flow
  SPx              122
    0        # Component has   0 control variable(s).
    4
       2.0000     #   1 Outlet 1 RFF Node
       3.0000     #   2 Outlet 2 RFF Node
       1.0000     #   3 Inlet RFF Node
       0.0000     #   4 Relative Flow Factor (RFF)
```

- *Flow splitter to a demand node (i.e. 'always-on' node with no flow control) (i.e. SP1 in 3BR_highres_plant exemplar):*
  Inlet and 2nd outlet RFF node number (component node 3) identified. Demand node (component node 2) RFF node number set to 999 to identify this as a demand node. RFF factor for this demand node set (ignored unless Outlet 1 is set to 999).

```
#->  xx, 3-node Diverter Junction - Relative Flow
  SPx              122
    0        # Component has   0 control variable(s).
    4
       999.00     #   1 Outlet 1 RFF Node
       4.0000     #   2 Outlet 2 RFF Node
       2.0000     #   3 Inlet RFF Node
       1.0000     #   4 Relative Flow Factor (RFF)
```

The RFC method requires that the call to the CMP_XXXC file in pmatrx.f is done in a particular order to ensure that each RFC connection has visibility of the total relative flow value for all downstream connections. This is done via a new subroutine (SRFCSEQ) in pltcfg.f, that identifies all flow splitters and diverter valves, and their inlet and outlet node values, and orders them appropriately. No other elements of the plant matrix calculation process is impacted by this order change. This also ensures that the order of the components in the plant configuration file is not important.