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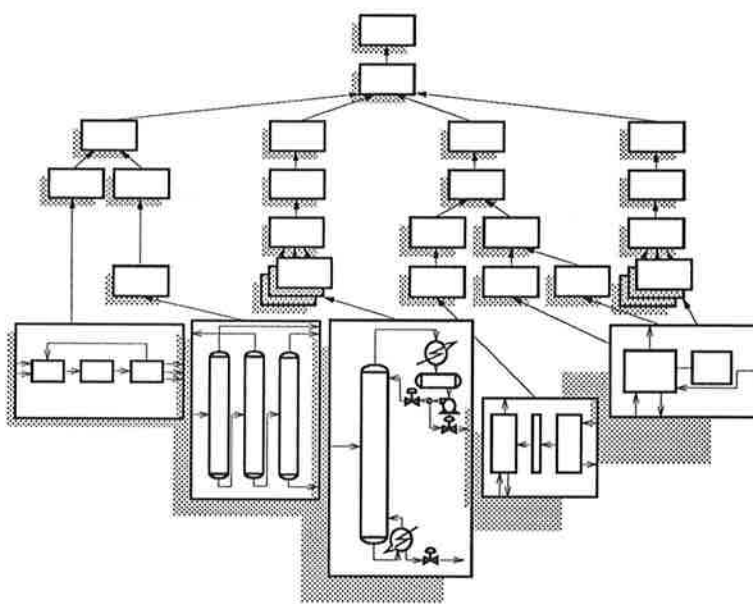
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A Chemical Plant Model in Omola — the code

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<i>Title and subtitle</i> A Chemical Plant Model in Omola			
<i>Abstract</i> This report is a documentation of a chemical plant modeled in Omola and simulated in OmSim. The plant model is discussed in "Object-Oriented Modeling of Chemical Processes" by Nilsson, 1993. The plant is composed of one pretreatment section, one tank reactor and one distillation unit. The process is controlled by nine PID controllers and four sequential controllers. It also contain Omola libraries for PID controllers and Grafcet primitives.			
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Introduction

This report is a documentation of a chemical plant model in Omola presented in Chapter 9 in [Nilsson, 1993]. The plant is modeled in the object-oriented modeling language, Omola, and simulated in the Omola simulation environment, OmSim. The plant is composed of one pretreatment section, one tank reactor and one distillation column unit. The plant is controlled by nine PID controllers and four sequential controllers.

The browser in Figure 1 shows all the libraries, 19 in all, and the libraries contain over 200 global Omola classes. The libraries are all printed on the following pages, page 2 to 70, in the order they are loaded into OmSim. The first two libraries, in the bottom in the library list, are predefined OmSim libraries.

An Omola description is found in [Andersson, 1993].

References

- ANDERSSON, M. (1993): "OmSim and Omola Tutorial and User's Manual." Technical Report TFRT-7504, Department of Automatic Control, Lund Institute of Technology, Lund, Sweden.
- NILSSON, B. (1993): *Object-Oriented Modeling in Process and Control Applications*. PhD thesis ISSN 0280-5316 ISRN LUTFD2/TFRT--LUTFD2/TFRT-1041-SE--SE, Dept. of Automatic Control, Lund Institute of Technology, Lund, Sweden.

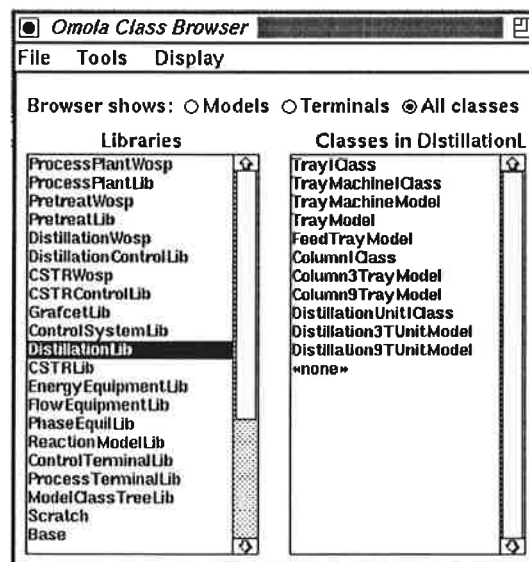


Figure 1. The Omola browser with the plant libraries.

```

LIBRARY ModelClassTreeLib;
%% This is the root library for the
%% classification of the model class tree.
%% It contain only empty classes
%% for the organization of the class hierarchy.
%%
%% Design: Bernt Nilsson, 13 jan 93.
%-----
% application class
ProcessClass ISA Model;
%--granularity classes
FlowsheetClass ISA ProcessClass;
UnitClass ISA ProcessClass;
SubUnitClass ISA ProcessClass;
MediumClass ISA ProcessClass;
%----unit type classes
PlantClass ISA FlowsheetClass;
PlantSectionClass ISA FlowsheetClass;
%
FlowEquipClass ISA UnitClass;
EnergyEquipClass ISA UnitClass;
ReactorClass ISA UnitClass;
SeparatorClass ISA UnitClass;
%
SubEnergyEquipClass ISA SubUnitClass;
SubReactorClass ISA SubUnitClass;
SubSeparatorClass ISA SubUnitClass;
%
ReactionClass ISA MediumClass;
PhaseEquilibriaClass ISA MediumClass;
%-----
%application class
ControlClass ISA Model;
%--new granularity classes
SubControllerClass ISA ControlClass;
ControllerClass ISA ControlClass;

ControlSystemClass ISA ControlClass;
%%---new controller type classes
AnalogBlockClass ISA SubControllerClass;
SubContControllerClass ISA SubControllerClass;
SubGrafcetClass ISA SubControllerClass;
%
SISOControllerClass ISA ControllerClass;
MISOControllerClass ISA ControllerClass;
GrafcetControllerClass ISA ControllerClass;
SensorClass ISA ControllerClass;
%
UnitController ISA ControlSystemClass WITH
icon:
    Graphic ISA Layout WITH
        bitmap TYPE String := "iconcontsyst";
    END;
END;

```

```

LIBRARY ProcessTerminalLib;
%% Contains the terminals describing proccess
%% flows in the Process Example.
%% The flows can be ordinary mass/mole flows of the
%% processing medium or flow of heat.
%% It also contain the medium and machine
%% communication terminals.
%%
%% Design: Bernt Nilsson, 12 jan 93, 4 may 93
%%
%%-----
%% flow terminals
%%-----

SimpleInFlow ISA ZeroSumTerminal WITH
direction := 'in;
END;

SimpleOutFlow ISA ZeroSumTerminal WITH
direction := 'out;
END;

FlowInTerminal ISA RecordTerminal WITH
components:
  Flow ISA SimpleInFlow;
  Pres ISA SimpleTerminal;
  Temp ISA SimpleTerminal;
END;

FlowOutTerminal ISA RecordTerminal WITH
components:
  Flow ISA SimpleOutFlow;
  Pres ISA SimpleTerminal;
  Temp ISA SimpleTerminal;
END;

%%-----
%% process flow terminals
%% (used in the nonmatrix based reactor model)
%%-----

PipeInTerminal ISA RecordTerminal WITH
components:
  Flow ISA SimpleInFlow;
  Pres ISA SimpleTerminal;
  Temp ISA SimpleTerminal;
  AConc ISA SimpleTerminal;
  BConc ISA SimpleTerminal;
END;

PipeOutTerminal ISA RecordTerminal WITH
components:
  Flow ISA SimpleOutFlow;
  Pres ISA SimpleTerminal;
  Temp ISA SimpleTerminal;
  AConc ISA SimpleTerminal;
  BConc ISA SimpleTerminal;
END;

%%-----
%% MATRIX based notation
%% parameters
%%-----
IntegerParameter ISA Parameter WITH

```

```

value TYPE Integer;
default TYPE Integer := 1;
END;

RowParameter ISA Parameter WITH
n TYPE Integer;
value TYPE row[n];
default TYPE row[n] := zeros(1,n);
END;

%%-----
%% Variables
%%-----

ColumnVectorClass ISA Variable WITH
n TYPE Integer;
value TYPE column[n];
initial TYPE column[n] := zeros(n,1);
END;

RowVectorClass ISA Variable WITH
n TYPE Integer;
value TYPE row[n];
initial TYPE row[n];
END;

%%-----
%% matrix based process flow terminals
%%-----

VectorTerminalClass ISA SimpleTerminal WITH
n TYPE Integer;
value TYPE column[n];
default TYPE column[n];
END;

LiquidInTerminal ISA RecordTerminal WITH
components:
  Phase ISA SimpleTerminal WITH
    value TYPE String := "Liquid";
  END;
  Flow ISA SimpleInFlow;
  Comp ISA VectorTerminalClass;
  Pressure ISA SimpleTerminal;
  MoleEnergy ISA SimpleTerminal;
END;

VaporInTerminal ISA LiquidInTerminal WITH
components:
  Phase ISA super::Phase WITH
    value TYPE String := "Vapor";
  END;
  END;

LiquidOutTerminal ISA LiquidInTerminal WITH
  Flow ISA SimpleOutFlow;
END;

VaporOutTerminal ISA VaporInTerminal WITH
  Flow ISA SimpleOutFlow;
END;

%%-----
%% heat flow terminals
%%-----

```

```

HeatTransferInTerminal ISA RecordTerminal WITH
  Temp ISA SimpleTerminal;
  Qtrans ISA SimpleInFlow;
END;

HeatTransferOutTerminal ISA RecordTerminal WITH
  Temp ISA SimpleTerminal;
  Qtrans ISA SimpleOutFlow;
END;

%%-----
%% reactionmodel/reactormachine-terminal
%% (nonmatrix based used in reactor model)
ReactionReactorTerminal ISA RecordTerminal WITH
  NoC TYPE Integer;
  Comp, Conc, ReactionRate ISA VectorTerminalClass WITH
    n := NoC;
  END;
  Pressure, Temp ISA SimpleTerminal;
  Density, MoleWeight ISA SimpleTerminal;
  Cp ISA SimpleTerminal;
  EnergyProd ISA SimpleTerminal;
END;

%%-----
%% phaseequilibriummodel/distillationmachine-terminal
MediumMachineTerminal ISA RecordTerminal WITH
  NoC TYPE Integer;
  LComp, VComp ISA VectorTerminalClass WITH
    n := NoC;
  END;
  Pressure, Temp ISA SimpleTerminal;
  Density, MoleWeight ISA SimpleTerminal;
  LiqMoleEn, VapMoleEn ISA SimpleTerminal;
END;

```

```

LIBRARY ControlTerminalLib;
%% Contains the terminals describing control
%% signals in the Process Example.
%% Signals can be continuous and discrete.
%%
%% Design: Bernt Nilsson, 12 Jan 93.

```

```

%%-----
%% general control terminals

```

```

ManualControlInTerminal ISA RecordTerminal WITH
components:
  Manual, UMan ISA SimpleInput;
END;

```

```

ManualControlOutTerminal ISA RecordTerminal WITH
components:
  Manual, UMan ISA SimpleOutput;
END;

```

```

ManualControlOutDiscreteTerminal ISA ManualControlOutTerminal WITH
Manual, UMan ISA SimpleOutput WITH
value TYPE DISCRETE Real;
END;

```

```

ReferenceTerminal ISA RecordTerminal WITH
Ref ISA SimpleInput;
Track ISA SimpleOutput;
uTrack ISA SimpleOutput;
END;

```

```

ControlTerminal ISA RecordTerminal WITH
u ISA SimpleOutput;
Track ISA SimpleInput;
uTrack ISA SimpleInput;
END;

```

```

%%-----
%% CSTR control system terminals

```

```

CSTRInControl ISA Base::RecordTerminal WITH
Feed ISA Base::SimpleInput;
Cool ISA Base::SimpleInput;
OutFlow ISA Base::SimpleInput;
END;

```

```

CSTROutControl ISA Base::RecordTerminal WITH
Feed ISA Base::SimpleOutput;
Cool ISA Base::SimpleOutput;
OutFlow ISA Base::SimpleOutput;
END;

```

```

CSTROutMeasure ISA Base::RecordTerminal WITH
Level ISA Base::SimpleOutput;
VTemp ISA Base::SimpleOutput;
JTemp ISA Base::SimpleOutput;
OutFlow ISA Base::SimpleOutput;
END;

```

```

CSTRInMeasure ISA Base::RecordTerminal WITH
Level ISA Base::SimpleInput;
VTemp ISA Base::SimpleInput;

```

```

JTemp ISA Base::SimpleInput;
OutFlow ISA Base::SimpleInput;
END;

```

```

%%-----
%% distillation control system terminals

```

```

DistInControl ISA Base::RecordTerminal WITH
Reflux ISA Base::SimpleInput;
Heat ISA Base::SimpleInput;
Top ISA Base::SimpleInput;
Bottom ISA Base::SimpleInput;
END;

```

```

DistOutControl ISA Base::RecordTerminal WITH
Reflux ISA Base::SimpleOutput;
Heat ISA Base::SimpleOutput;
Top ISA Base::SimpleOutput;
Bottom ISA Base::SimpleOutput;
END;

```

```

DistOutMeasure ISA Base::RecordTerminal WITH
DrumLevel ISA Base::SimpleOutput;
BoilerLevel ISA Base::SimpleOutput;
TopComp ISA Base::SimpleOutput;
BottomComp ISA Base::SimpleOutput;
END;

```

```

DistInMeasure ISA Base::RecordTerminal WITH
DrumLevel ISA Base::SimpleInput;
BoilerLevel ISA Base::SimpleInput;
TopComp ISA Base::SimpleInput;
BottomComp ISA Base::SimpleInput;
END;

```

```

%%-----
%% Pretret section control system terminals

```

```

PtsInControl ISA Base::RecordTerminal WITH
%% Control into process
Afeed ISA Base::SimpleInput;
Recycle ISA Base::SimpleInput;
END;

```

```

PtsOutControl ISA Base::RecordTerminal WITH
%% Control out from controller
Afeed ISA Base::SimpleOutput;
Recycle ISA Base::SimpleOutput;
END;

```

```

PtsOutMeasure ISA Base::RecordTerminal WITH
%% measure out from process
AComp ISA Base::SimpleOutput;
Level ISA Base::SimpleOutput;
Outflow ISA Base::SimpleOutput;
Afeed ISA Base::SimpleOutput;
END;

```

```

PtsInMeasure ISA Base::RecordTerminal WITH
%% measure into controller
AComp ISA Base::SimpleInput;
Level ISA Base::SimpleInput;
Outflow ISA Base::SimpleInput;

```



```
Afeed ISA Base::SimpleInput;  
END;
```

```

LIBRARY ReactionModelLib;
USES ModelClassTreeLib, ProcessTerminalLib;
%% Contain classes for a family of
%% reaction models used in reactor
%% models.
%%
%% Design: Bernt Nilsson, 13 jan 93.
%%
%%-----
%% reaction models
%%-----

ReactionOrderIClass ISA ReactionClass WITH
%% First order kinetics super class.
icon:
  Graphic ISA Layout WITH
  bitmap TYPE String := "iconreactionmedium";
END;
structure_parameter:
  NumberOfComponents TYPE Integer;
terminal:
  MMT ISA ReactionReactorTerminal WITH
  NOC := NumberOfComponents;
  Graphic ISA Base::Layout WITH
  attributes:
    x_pos := 0;
    y_pos := 175;
    invisible := 1;
  END;
END;
parameters:
  Density, MoleWeight, Cp ISA RowParameter WITH
  n := NumberOfComponents;
END;
equations:
  MMT.Density = Density*MMT.Comp;
  MMT.MoleWeight = MoleWeight*MMT.Comp;
  MMT.Cp = Cp*MMT.Comp;
END;

ReactionloiModel ISA ReactionOrderIClass WITH
%% First order kinetics of a simple
%% irreversible reaction, A -> B.
parameters:
  KO, R, Ea, Hreac ISA Parameter;
variable:
  rr TYPE Real;
equations:
  %% reaction rate
  %% temp in celcius
  rr = -KO*exp(-Ea/(R*(MMT.Temp+273))) * MMT.Conc[1];
  MMT.ReactionRate = [rr; -rr; 0];
  %% energy production
  MMT.EnergyProd = Hreac*rr;
END;

ReactionlorModel ISA ReactionOrderIClass WITH
%% First order kinetics of a simple
%% reversible reaction, A <-> B.
parameters:
  KO, R, Ea, Hreac, alfa ISA Parameter;
variables:
  Kreaction, rr ISA Variable;

```

```

equations:
  %% reaction rate
  Kreaction = -KO*exp(-Ea/(R*(MMT.Temp+273)));
  rr = Kreaction*(MMT.Conc[1] - alfa*MMT.Conc[2]);
  MMT.ReactionRate = [rr; -rr; 0];
  %% energy production
  MMT.EnergyProd = Hreac*rr;
END;

```

```

%%-----
%% reaction descriptions
%%-----

```

```

AtoBReactionModel ISA ReactionloiModel WITH
%% A irreversible parameterized reaction.
%% From "PROCESSTEKNIK" pp: 2.17.
structure_parameter:
  NumberOfComponents := 3;
parameters:
  Density.default := [792, 791, 999]; % kg / m^3
  MoleWeight.default := [58, 46, 18]; % kg / kmole
  Cp.default := [2.20, 2.430, 4.180]; % kJ / C kg
  KO.default := 6.99E10;
  R.default := 0.00833;
  Ea.default := 69.418;
  Hreac.default := -69.9e+3;
END;

```

```

ZeroReactionModel ISA ReactionloiModel WITH
%% A irreversible parameterized reaction.
%% From "PROCESSTEKNIK" pp: 2.17.
structure_parameter:
  NumberOfComponents := 3;
parameters:
  Density.default := [792, 791, 999]; % kg / m^3
  MoleWeight.default := [58, 46, 18]; % kg / kmole
  Cp.default := [2.20, 2.430, 4.180]; % kJ / C kg
  KO.default := 6.99E10;
  R.default := 0.00833;
  Ea.default := 69.418;
  Hreac.default := -69.9e+3;
END;

```

```

AeqBReactionModel ISA ReactionlorModel WITH
%% A reversible parameterized reaction
structure_parameter:
  NumberOfComponents := 3;
parameters:
  Density ISA RowParameter WITH default := [792, 791, 999]; END;
  MoleWeight ISA RowParameter WITH default := [58, 46, 18]; END;
  Cp ISA RowParameter WITH default := [2.20, 2.430, 4.180]; END;
  KO ISA Parameter WITH default := 6.99E10; END;
  R ISA Parameter WITH default := 0.00833; END;
  Ea ISA Parameter WITH default := 69.418; END;
  Hreac ISA Parameter WITH default := -69.9e+3; END;
  alfa ISA Parameter WITH default := 0.0;
END;

```

```

AeqBReactionModel ISA ReactionlorModel WITH
%% A reversible parameterized reaction
structure_parameter:
  NumberOfComponents := 3;
parameters:
  Density ISA RowParameter WITH default := [792, 791, 999]; END;
  MoleWeight ISA RowParameter WITH default := [58, 46, 18]; END;
  Cp ISA RowParameter WITH default := [2.20, 2.430, 4.180]; END;
  KO ISA Parameter WITH default := 6.99E10; END;
  R ISA Parameter WITH default := 0.00833; END;
  Ea ISA Parameter WITH default := 69.418; END;
  Hreac ISA Parameter WITH default := -69.9e+3; END;
  alfa ISA Parameter WITH default := 0.0;
END;

```

```

%%-----

```

```

LIBRARY PhaseEquilib;
USES ModelClassTreeLib, ProcessTerminalLib;
  ** Contain models for phase equilibrium models
  ** for primary use in distillation applications.
  **
  ** Design: Bernt Nilsson, 4 may 1993.
  **
  **-----
  ** phase equilibrium models
  **-----
DistMediumIClass ISA PhaseEquilibriaClass WITH
icon:
  Graphic ISA Base::Layout WITH
  bitmap TYPE String := "iconphaseequil";
END;
structure parameters:
  NumberOfComponents TYPE Integer;
terminal:
  MMT ISA ProcessTerminalLib::MediumMachineTerminal WITH
  Graphic ISA Base::Layout WITH
  x_pos := 0;
  y_pos := 150;
  invisible := 1;
END;
NOC := outer::NumberOfComponents;
END;
END;

DistMediumModel ISA DistMediumIClass WITH
  ** A phase equilibrium model for
  ** three components based on
  ** relative volatility.
  ** A and B are components and
  ** S is solvent.
  structure parameter:
    NumberOfComponents := 3;
  parameter:
    ** alfa coefficients in a tertier medium
    Aab ISA Base::Parameter;
    Aas ISA Base::Parameter;
    ** enthalpy coefficients
    LiquidEnthalpy,Cpl,Hevap,CpV ISA RowParameter WITH
    n := outer::NumberOfComponents;
  END;
  Dens,MoleW ISA RowParameter WITH
  n := outer::NumberOfComponents;
  END;
  variables:
    K ISA Base::Variable;
  equations:
    ** vapor calculations, relative volatility
    K = Aas/(Aab*(1 + (Aas - 1)*MMT.LComp[1] - MMT.LComp[2]) + Aas*MMT.LComp[2]);
    MMT.VComp = [K*Aab*MMT.LComp[1];
      K*MMT.LComp[2];
      1 - K*(Aab*MMT.LComp[1] + MMT.LComp[2])];
    ** enthalpy description
    MMT.LiqMoleEn = LiquidEnthalpy*MMT.LComp*MMT.MoleWeight;
    MMT.Temp = MMT.LiqMoleEn/(Cpl*MMT.LComp*MMT.MoleWeight);
    MMT.VapMoleEn = (Hevap + CpV*MMT.Temp)*MMT.VComp*MoleW*MMT.VComp;
    ** density and mole weight descriptions
    MMT.Density = Dens*MMT.LComp;
    MMT.MoleWeight = MoleW*MMT.LComp;
  END;

```

```

  **-----
  ** a liquid-vapor equilibrium
  **
  ABSPhaseEquilData ISA DistMediumModel WITH
  Aab.default := 0.37;
  Aas.default := 1.1;
  LiquidEnthalpy := [124, 191, 418];
  Cpl := [2.20, 2.430, 4.180];
  Hevap := [515, 841, 2260];
  CpV := [1.0, 1.20, 1.850];
  Dens := [792, 791, 999];
  MoleW := [58, 46, 18];
  END;

```



```

Comp.n := ChemDim;
Flow.default := 0;
Comp.default := [0;0;1];
MoleEnergy.default := 0;
Pressure.default := 0;
END;
Lout ISA LiquidOutTerminal WITH
  Graphic ISA Base::Layout WITH
    x_pos := 200;
    y_pos := 0;
    invisible := 1;
  END;
Lout ISA LiquidOutTerminal WITH
  Graphic ISA Base::Layout WITH
    x_pos := 400;
    y_pos := 140;
    invisible := 1;
  END;
Comp.n := ChemDim;
END;
parameter:
  Pressure ISA Base::Parameter;
variable:
  Flow ISA Variable;
q TYPE DISCRETE Real;
event:
  Init ISAN Event;
equations:
  %% static mass balance
  Lout.Flow = Lin1.Flow + Lin2.Flow + Lin3.Flow;
  %% Test if flow is zero then it is set to one
  ONEVENT Init DO new(q):=0; END;
  ONEVENT Lout.Flow<0.1 DO new(q):=0; END;
  ONEVENT Lout.Flow>0.1 DO new(q):=1; END;
  Flow = q*Lout.Flow + (1-q);
  %% static component balance
  Lout.Comp = (Lin1.Flow*Lin1.Comp + Lin2.Flow*Lin2.Comp +
    Lin3.Flow*Lin3.Comp)/Flow;
  Lout.MoleEnergy = (Lin1.Flow*Lin1.MoleEnergy + Lin2.Flow*Lin2.MoleEnergy +
    Lin3.Flow*Lin3.MoleEnergy)/Flow;
  Lout.Pressure = Pressure;
END;

MixerVesselModel ISA FlowEquipClass WITH
  %% A dynamic mixer model with three liquid
  %% inflow and one liquid outflow.
  %% Uses the "liquid"-terminals.
  icon:
    Graphic ISA Base::Layout WITH bitmap TYPE String := "iconmixervessel";
  END;
  parameter:
    ChemDim TYPE Integer;
  terminals:
    Lin1 ISA LiquidInTerminal WITH
      Graphic ISA Base::Layout WITH
        x_pos := 200;
        y_pos := 300;
        invisible := 1;
      END;
    Comp.n := ChemDim;
  END;
  Lin2 ISA LiquidInTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 0;
      y_pos := 150;
      invisible := 1;
    END;
  Comp.n := ChemDim;
  END;
  %% optional connection

```

```

Lin3 ISA LiquidInTerminal WITH
  Graphic ISA Base::Layout WITH
    x_pos := 200;
    y_pos := 0;
    invisible := 1;
  END;
Comp.n := ChemDim;
Flow.default := 0;
Comp.default := [0;0;1];
MoleEnergy.default := 0;
Pressure.default := 0;
END;
Lout ISA LiquidOutTerminal WITH
  Graphic ISA Base::Layout WITH
    x_pos := 400;
    y_pos := 140;
    invisible := 1;
  END;
Comp.n := ChemDim;
END;
parameter:
  Pressure, TotMole ISA Base::Parameter;
equations:
  %% static mass balance
  Lout.Flow = Lin1.Flow + Lin2.Flow + Lin3.Flow;
  %% static component balance
  Lout.Comp' = (Lin1.Flow*Lin1.Comp + Lin2.Flow*Lin2.Comp +
    Lin3.Flow*Lin3.Comp - Lout.Flow*Lout.Comp) / TotMole;
  Lout.MoleEnergy' = (Lin1.Flow*Lin1.MoleEnergy + Lin2.Flow*Lin2.MoleEnergy +
    Lin3.Flow*Lin3.MoleEnergy - Lout.Flow*Lout.MoleEnergy) /
    TotMole;
  % Lout.Pressure = Pressure;
  END;
  %%-----
  %% drum models
  RefluxDrumIClass ISA FlowEquipClass WITH
    %% Interface class for the reflux drum models.
    icon:
      Graphic ISA Base::Layout WITH
        bitmap TYPE String := "icondrum";
      END;
    structure parameter:
      ChemDim TYPE Integer;
    terminals:
      Lin ISA LiquidInTerminal WITH
        Graphic ISA Base::Layout WITH
          x_pos := 200.0;
          y_pos := 300.0;
          invisible := 1;
        END;
      Comp.n := ChemDim;
    END;
    Lout ISA LiquidOutTerminal WITH
      Graphic ISA Base::Layout WITH
        x_pos := 200;
        y_pos := 0;
        invisible := 1;
      END;
      Comp.n := ChemDim;
    END;
  END;

```

```

DrumMachineModel ISA RefluxDrumIClass WITH
%% A machine model for the reflux drum.
%% Uses physical properties in medium model.
terminal:
MMT ISA ProcessTerminalLib::MediumMachineTerminal WITH
  Graphic ISA Base::Layout WITH
    x_pos := 400;
    y_pos := 150;
    invisible := 1;
  END;
  NoC := ChemDim;
END;

parameters:
DrumArea ISA Base::Parameter;
Pressure ISA Base::Parameter;
variables:
  mole ISA Base::Variable;
  height ISA Base::Variable;
  Xmole ISA ColumnVectorClass WITH n := ChemDim; END;
  Comp ISA ColumnVectorClass WITH n := ChemDim; END;
equations:
  %% mole component balances
  Xmole' = Lin.Flow*Lin.Comp - LOut.Flow*LOut.Comp;
  %% total properties
  mole := sumabs(Xmole);
  Comp := Xmole*1/mole;
  height := mole*MMT.MoleWeight/(MMT.Density*DrumArea);
  %% phase equilibrium description in medium model
  %% (used to find mole weight and density)
  MMT.LComp := Comp;
  MMT.Pressure = Pressure;
  %% liquid outflow
  LOut.Comp := Comp;
  LOut.Pressure = Pressure;
  LOut.MoleEnergy = MMT.LiqMoleEn;
END;

RefluxDrumModel ISA RefluxDrumIClass WITH
%% Composite model of a reflux drum.
  Graphic ISA super::Graphic;
structure_parameters:
  ChemDim := MediumModel.NumberOfComponents;
  Drum.ChemDim := MediumModel.NumberOfComponents;
submodels:
  Drum ISA DrumMachineModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 100.0;
      y_pos := 150.0;
    END;
  END;
  MediumModel ISA DistMediumModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 300.0;
      y_pos := 150.0;
    END;
  END;
connections:
  C1 ISA Base::Connection WITH
    Lin AT Drum.LIn;
    bpoints TYPE Matrix [4, 2] := [199, 299; 199, 232; 99, 232; 99, 186];
  END;
  C2 ISA Base::Connection WITH

```

```

LOut AT Drum.LOut;
bpoints TYPE Matrix [5, 2] := [199, 0; 199, 22; 199, 58; 99, 58; 99, 112];
END;
C3 ISA Base::Connection WITH
  Drum.MMT AT MediumModel.MMT;
  bpoints TYPE Matrix [2, 2] := [174, 149; 244, 155];
END;
END;

```

```

LIBRARY EnergyEquipmentLib;
USES ModelClassTreeLib, ProcessTerminalLib, ControlTerminalLib,
    PhaseEquilibLib, FlowEquipmentLib;
%% Contains classes for process equipment
%% for energy transfer.
%%
%% Design: Bernt Nilsson, 13 may 1993.
%%
%%-----
%% heat transfer models

HeatTransferIClass ISA ModelClassTreeLib::SubEnergyEquipClass WITH
%% Interface class for the heat
%% transfer objects.
icon:
    Graphic ISA Base::Layout WITH
        bitmap TYPE String := "iconheattransfer";
    END;
terminals:
    HTIn ISA ProcessTerminalLib::HeatTransferInTerminal WITH
        Graphic ISA Base::Layout WITH
            x_pos := 400;
            y_pos := 150;
            invisible := 1;
        END;
    END;
    HTOut ISA ProcessTerminalLib::HeatTransferOutTerminal WITH
        Graphic ISA Base::Layout WITH
            x_pos := 0;
            y_pos := 150;
            invisible := 1;
        END;
    END;

HeatTransferModel ISA EnergyEquipmentLib::HEXPartIClass WITH
%% A heat/cool volume medium model .
parameters:
    Cp ISA Base::Parameter;
    Volume ISA Base::Parameter;
    Density ISA Base::Parameter;
variable:
    Temp ISA Base::Variable;
equations:
    In.Flow = Out.Flow;
    (Cp*Volume*Density*Temp)' =
        Cp*In.Flow*Density*(In.Temp - Temp) + HTIn.Qtrans;
    Out.Temp = Temp;
    HTIn.Temp = Temp;
    In.Pres = Out.Pres;
    END;
END;

JacketModel ISA EnergyEquipmentLib::HEXPartModel WITH
icon:
    Graphic ISA Base::Layout WITH
        bitmap TYPE String := "iconjacket";
    END;
END;

%%-----
%% boiler models

BoilerIClass ISA ModelClassTreeLib::SubEnergyEquipClass WITH
%% Interface class for the boiler models.
icon:
    Graphic ISA Base::Layout WITH
        bitmap TYPE String := "iconboiler";
    END;
    structure_parameter:
        ChemDim TYPE Integer;
terminals:
    LIIn ISA ProcessTerminalLib::LiquidInTerminal WITH
        Graphic ISA Base::Layout WITH
            x_pos := 220;
            y_pos := 0;
            invisible := 1;
        END;
    Comp.n := ChemDim;
    END;
END;

```



```

IOut ISA ProcessTerminalLib::LiquidOutTerminal WITH
  Graphic ISA Base::Layout WITH
    x_pos := 180;
    y_pos := 0;
    invisible := 1;
  END;
  Comp.n := ChemDim;
END;
Vout ISA ProcessTerminalLib::VaporOutTerminal WITH
  Graphic ISA Base::Layout WITH
    x_pos := 200;
    y_pos := 300;
    invisible := 1;
  END;
  Comp.n := ChemDim;
END;
Vout ISA ProcessTerminalLib::VaporOutTerminal WITH
  Graphic ISA Base::Layout WITH
    x_pos := 200;
    y_pos := 300;
    invisible := 1;
  END;
  Comp.n := ChemDim;
END;
END;

BoilerMachineIClass ISA EnergyEquipmentLib::BoilerIClass WITH
  %% An interface class for the boiler machine model.
  terminals:
    Heat ISA ProcessTerminalLib::HeatTransferInTerminal WITH
      Graphic ISA Base::Layout WITH
        x_pos := 0;
        y_pos := 200;
        invisible := 1;
      END;
    END;
  END;
  NoC := ChemDim;
END;
END;

MMT ISA ProcessTerminalLib::MediumMachineTerminal WITH
  Graphic ISA Base::Layout WITH
    x_pos := 400;
    y_pos := 150;
    invisible := 1;
  END;
  NoC := ChemDim;
END;
END;

BoilerMachineModel ISA EnergyEquipmentLib::BoilerMachineIClass WITH
  %% A primitive model of a boiler.
  %% The entering heat is used to
  %% evaporate the medium.
  parameters:
    BoilerArea ISA Base::Parameter;
    Pressure ISA Base::Parameter;
  variables:
    mole ISA Base::Variable;
    height ISA Base::Variable;
    Xmole ISA ProcessTerminalLib::ColumnVectorClass WITH n := ChemDim;
    Comp ISA ProcessTerminalLib::ColumnVectorClass WITH n := ChemDim;
  equations:
    %% mole component balances
    Xmole' = Lin.Flow*Lin.Comp - LOut.Flow*IOut.Comp - VOut.Flow*VOut.Comp;
    %% total properties
    mole = sumabs(Xmole);
    Comp = Xmole*1/mole;
    height = mole*MMT.MoleWeight/(MMT.Density*BoilerArea);
    %% energy balance (function of composition)
    Vout.Flow = Heat.Qtrans/(MMT.VapMoleEn - MMT.LiqMoleEn);
    Heat.Temp = MMT.Temp;
    %% phase equilibrium description in medium model
    MMT.LComp = Comp;
    MMT.Pressure = Pressure;

```

```

    %% liquid outflow
    LOut.Comp = Comp;
  %
  % LOut.Pressure = Pressure;
  % LOut.MoleEnergy = MMT.LiqMoleEn;
  %% vapor outflow (no vapour dynamics and neglected vapour holdup)
  Vout.Comp = MMT.VComp;
  Vout.Pressure = MMT.Pressure;
  Vout.MoleEnergy = MMT.VapMoleEn;
END;

%%-----
%% composite boiler models

BoilerModel ISA EnergyEquipmentLib::BoilerIClass WITH
  %% A composite boiler model.
  icon:
    Graphic ISA super::Graphic;
  structure_parameters:
    ChemDim := MediumModel.NumberOfComponents;
    BoilerSide.ChemDim := MediumModel.NumberOfComponents;
  terminals:
    HeatIn ISA ProcessTerminalLib::FlowInTerminal WITH
      Graphic ISA super::Graphic WITH
        x_pos := 0;
        y_pos := 230;
        invisible := 1;
      END;
    END;
  submodels:
    BoilerSide ISA EnergyEquipmentLib::BoilerMachineModel WITH
      Graphic ISA super::Graphic WITH
        x_pos := 225.0;
        y_pos := 150.0;
      END;
    HeatTrans ISA EnergyEquipmentLib::HeatTransferModel WITH
      Graphic ISA super::Graphic WITH
        x_pos := 150.0;
        y_pos := 150.0;
      END;
    HeatSide ISA EnergyEquipmentLib::HEXPartModel WITH
      Graphic ISA super::Graphic WITH
        x_pos := 75.0;
        y_pos := 150.0;
      END;
    MediumModel ISA PhaseEquilibLib::DistMediumModel WITH
      Graphic ISA super::Graphic WITH
        x_pos := 325.0;
        y_pos := 150.0;
      END;
  connections:
    C1 ISA Base::Connection WITH
      MediumModel.MMT AT BoilerSide.MMT;
    bpoints TYPE Matrix [2, 2] := [295.0, 149.0; 245.0, 149.0];
  END;
  C2 ISA Base::Connection WITH
    Vout AT BoilerSide.Vout;
    bpoints TYPE Matrix [4, 2] := [199.0, 299.0; 199.0, 225.0; 224.0, 225.0; 224.0, 224.0;
    ^ 170.0];
  END;
END;

```

```

C5 ISA Base::Connection WITH
  BoilerSide.Heat AT HeatTrans.HTIn;
  bpoints TYPE Matrix [4, 2] := [203.0, 156.0; 188.0, 156.0; 188.0, 149.0; 173.0,$
    ^ 149.0];
END;

C7 ISA Base::Connection WITH
  HeatTrans.HTOut AT HeatSide.HTIn;
  bpoints TYPE Matrix [4, 2] := [124.0, 149.0; 105.0, 149.0; 105.0, 153.0; 88.0,$
    ^ 153.0];
END;

C8 ISA Base::Connection WITH
  HeatIn AT HeatSide.In;
  bpoints TYPE Matrix [4, 2] := [0.0, 229.0; 34.0, 229.0; 34.0, 157.0; 59.0, 157.0];
END;

C3 ISA Base::Connection WITH
  LOut AT BoilerSide.LOut;
  bpoints TYPE Matrix [4, 2] := [222.0, 128.0; 222.0, 90.0; 179.0, 90.0; 179.0, 0.0];
END;

C4 ISA Base::Connection WITH
  LIn AT BoilerSide.LIn;
  bpoints TYPE Matrix [4, 2] := [226.0, 128.0; 226.0, 50.0; 219.0, 50.0; 219.0, 0.0];
END;

BoilersimProblem ISA EnergyEquipmentLib::BoilerModel WITH
  %% A test of the boiler model.
  Graphic ISA super::Graphic;
  parameters:
    FlowPar ISA Base::Parameter WITH default := 100; END;
    OutFlowPar ISA Base::Parameter WITH default := 20; END;
    LHPar ISA Base::Parameter WITH default := 10; END;
    HTPar ISA Base::Parameter WITH default := 400; END;
    BoilerSide.BoilerArea.default := 3.14;
    BoilerSide.Pressure.default := 671;
    BoilerSide.Xmole.initial := [5; 5; 5];
    MediumModel.Aab.default := 1.2;
    MediumModel.Aas.default := 1.5;
    MediumModel.LiquidEnthalpy := [124, 191, 418];
    MediumModel.CpL := [2.2, 2.43, 4.18];
    MediumModel.Hevap := [515, 841, 2260];
    MediumModel.CpV := [1.0, 1.2, 1.85];
    MediumModel.Dens := [792, 791, 999];
    MediumModel.MoleW := [56, 46, 18];
    HeatTrans.TransArea.default := 1;
    HeatTrans.Kappa.default := 2000;
    HeatSide.Cp := 4.18;
    HeatSide.Volume.default := 1;
    HeatSide.Density := 1000;
    HeatSide.Temp.initial := 360;
  terminal_defaults:
    LIn.Flow = FlowPar;
    LOut.Flow = OutFlowPar;
    LIn.Comp := [0.34; 0.33; 0.33];
    LIn.Pressure = 140000.0;
    LIn.MoleEnergy = LHPar;
    HeatIn.Flow = 10;
    HeatIn.Pres = 140000.0;
    HeatIn.Temp = HTPar;
  END;

  %% -----
  %% condenser models
  TotalCondenserIClass ISA ModelClassTreeLib::SubEnergyEquipClass WITH
    %% A condenser interface class.
    icon:
      Graphic ISA Base::Layout WITH
        bitmap TYPE String := "iconboiler";
      END;
    parameter:
      ChemDim TYPE Integer;
    terminal:
      LOut ISA ProcessTerminalLib::LiquidOutTerminal WITH
        Graphic ISA Base::Layout WITH
          x_pos := 200;
          y_pos := 0;
          invisible := 1;
        END;
      Comp.n := ChemDim;
    END;
    Vin ISA ProcessTerminalLib::VaporInTerminal WITH
      Graphic ISA Base::Layout WITH
        x_pos := 200.0;
        y_pos := 300.0;
        invisible := 1;
      END;
      Comp.n := ChemDim;
    END;
    TotalCondMachineModel ISA EnergyEquipmentLib::TotalCondenserIClass WITH
      %% A total condenser machine model.
      %% The vapor is totally condensed and
      %% the behavior is described to be static.
      %% (no vapor dynamics, static pressure)
      icon:
        Graphic ISA super::Graphic;
      parameter:
        Pressure ISA Base::Parameter;
      terminal:
        MMT ISA ProcessTerminalLib::MediumMachineTerminal WITH
          Graphic ISA Base::Layout WITH
            x_pos := 400;
            y_pos := 150;
            invisible := 1;
          END;
          Noc := ChemDim;
        END;
        equations:
          %% static condensing
          LOut.Flow = Vin.Flow;
          LOut.Comp = Vin.Comp;
          LOut.Pressure = Pressure;
          LOut.MoleEnergy = MMT.LiqMoleEn;
          %% MMT connections
          MMT.LComp = IF Vin.Flow == 0 THEN [1;0;0] ELSE LOut.Comp;
          MMT.Pressure = Pressure;
        END;
      TotalCondenserModel ISA EnergyEquipmentLib::TotalCondenserIClass WITH
        %% A composite model of a total condenser.
        icon:
          Graphic ISA super::Graphic;
        structure_parameters:
          ChemDim := MediumModel.NumberOfComponents;
          Condside.ChemDim := MediumModel.NumberOfComponents;

```

```

submodels:
  Condside ISA EnergyEquipmentLib::TotalCondMachineModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 100.0;
      y_pos := 150.0;
    END;
  END;
  MediumModel ISA PhaseEquilib::DistMediumModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 300.0;
      y_pos := 150.0;
    END;
  END;
  connections:
    C1 ISA Base::Connection WITH
      Vin AT Condside.Vin;
      bpoints TYPE Matrix [4, 2] := [199, 299; 199, 232; 99, 232; 99, 186];
    END;
    C2 ISA Base::Connection WITH
      Lout AT Condside.Lout;
      bpoints TYPE Matrix [5, 2] := [199, 0; 199, 22; 199, 58; 99, 58; 99, 112];
    END;
    C3 ISA Base::Connection WITH
      Condside.MMT AT MediumModel.MMT;
      bpoints TYPE Matrix [2, 2] := [174, 149; 244, 155];
    END;
  END;

CondConfigModel ISA ModelClassTreeLib::EnergyEquipClass WITH
  %% A distillation column top configuration
  %% with a total condenser and a reflux drum.
  icon:
    Graphic ISA super::Graphic;
  structure parameter:
    ChemDim TYPE Integer;
  terminals:
    Vin ISA ProcessTerminalLib::VaporInTerminal WITH
      Graphic ISA super::Graphic WITH
        x_pos := 200.0;
        y_pos := 300.0;
      END;
    Comp.n := ChemDim;
  END;
  Reflux ISA ProcessTerminalLib::LiquidOutTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 0.0;
      y_pos := 75.0;
    END;
  Comp.n := ChemDim;
  END;
  Top ISA ProcessTerminalLib::LiquidOutTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 400.0;
      y_pos := 75.0;
    END;
  Comp.n := ChemDim;
  END;

submodels:
  Condenser ISA EnergyEquipmentLib::TotalCondenserModel WITH
    MediumModel ISA PhaseEquilib::ABSPHASEEquilData;
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 225.0;
    END;
  End;
  Drum ISA FlowEquipmentLib::RefluxDrumModel WITH
    MediumModel ISA PhaseEquilib::ABSPHASEEquilData;
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 150.0;
    END;
  END;
  RefluxValve ISA FlowEquipmentLib::ControlValveModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 100.0;
      y_pos := 75.0;
    END;
  ChemDim := outer::ChemDim;
  END;
  TopValve ISA FlowEquipmentLib::ControlValveModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 300.0;
      y_pos := 75.0;
    END;
  ChemDim := outer::ChemDim;
  END;
  connections:
    C1 ISA Base::Connection WITH
      Vin AT Condenser.Vin;
      bpoints TYPE Matrix [3, 2] := [200.0, 300.0; 199.0, 278.0; 199.0, 245.0];
    END;
    C2 ISA Base::Connection WITH
      Condenser.Lout AT Drum.Lin;
      bpoints TYPE Matrix [2, 2] := [199.0, 203.0; 199.0, 164.0];
    END;
    C3 ISA Base::Connection WITH
      Drum.Lout AT RefluxValve.In;
      bpoints TYPE Matrix [3, 2] := [199.0, 135.0; 199.0, 66.0; 82.0, 66.0];
    END;
    C4 ISA Base::Connection WITH
      Drum.Lout AT TopValve.In;
      bpoints TYPE Matrix [3, 2] := [199.0, 135.0; 199.0, 66.0; 282.0, 66.0];
    END;
    C5 ISA Base::Connection WITH
      Top AT TopValve.Out;
      bpoints TYPE Matrix [4, 2] := [316.0, 66.0; 354.0, 66.0; 354.0, 75.0; 400.0, 75.0];
    END;
    C6 ISA Base::Connection WITH
      Reflux AT RefluxValve.Out;
      bpoints TYPE Matrix [4, 2] := [116.0, 66.0; 48.0, 66.0; 48.0, 75.0; 0.0, 75.0];
    END;
  END;

CondSimProblem ISA EnergyEquipmentLib::CondConfigModel WITH
  %% A test of the condenser configuration.
  ChemDim := 3;
  Condenser ISA EnergyEquipmentLib::TotalCondenserModel WITH
    MediumModel ISA PhaseEquilib::ABSPHASEEquilData;
    Condside.Pressure.default := 671;
  END;
  Drum ISA FlowEquipmentLib::RefluxDrumModel WITH
    MediumModel ISA PhaseEquilib::ABSPHASEEquilData;
    Drum.DrumArea.default := 3.14;
    Drum.Pressure.default := 671;
    Drum.Xmole.initial := [5; 5; 5];
  END;

```

```
TopValve.Qmax := 50;  
TopValve.Control := 0.5;  
RefluxValve.Qmax := 50;  
RefluxValve.Control := 0.5;  
Vin.Flow := 50;  
Vin.Comp := [0.33; 0.33; 0.34];  
Vin.Pressure := 100;  
Vin.MoleEnergy := 10;  
END;
```

```

LIBRARY CSTRLib;
USES ModelClassFreeLib, ProcessTerminalLib, ControlTerminalLib,
    EnergyEquipmentLib, ReactionModelLib;
%% Contain classes for a family of
%% continuous stirred tank reactors, CSTR.
%%
%% Design: Bernt Nilsson, 13 Jan 93.
%-----
% tank reactor classes
%
TankReactorClass ISA ReactorClass WITH
structure_parameter:
  ChemDim TYPE Integer;
END;

SubTankReactorClass ISA SubReactorClass WITH
structure_parameter:
  ChemDim TYPE Integer;
END;

%-----
% tank reactor machine models
%
TankReactorMachineClass ISA SubTankReactorClass WITH
%% This is a reactor machine interface class
%% for a family of CSTR machines that uses
%% the reaction/reactor terminal.
icon:
  Graphic ISA Layout WITH
    bitmap TYPE String := "iconreactormachine";
  END;
terminals:
  In ISA ProcessTerminalLib::LiquidInTerminal WITH
    Graphic ISA Base::Layout WITH
      attributes:
        x_pos := 100;
        y_pos := 300;
        invisible := 1;
      END;
    Comp.n := ChemDim;
  END;
  Out ISA ProcessTerminalLib::LiquidOutTerminal WITH
    attributes:
      Graphic ISA Base::Layout WITH
        attributes:
          x_pos := 200;
          y_pos := 0;
          invisible := 1;
        END;
      Comp.n := ChemDim;
    END;
  MMT ISA ReactionReactorTerminal WITH
    attributes:
      Graphic ISA Base::Layout WITH
        attributes:
          x_pos := 400;
          y_pos := 150;
          invisible := 1;
        END;
      NoC := ChemDim;
    END;
  HTOut ISA HeatTransferOutTerminal WITH

```

```

attributes:
  Graphic ISA Base::Layout WITH
    attributes:
      x_pos := 0;
      y_pos := 150;
      invisible := 1;
    END;
  END;
%-----
TankReactorMachineModel ISA TankReactorMachineClass WITH
%% This is a reactor machine model that can be connected
%% to reaction descriptions using the reaction/reactor terminal.
%% Two chemical components, A and B, are mixed in a solvent.
%% ( A = Comp[1], B = Comp[2], S = Comp[3] ).
parameters:
  CrossArea ISA Parameter;
variables:
  Xmole, Comp ISA ColumnVectorClass WITH
    n := ChemDim;
  END;
  mole, volume, level, energy, temp ISA Variable;
equations:
  %% component mole balances
  Xmole' = In.Flow*In.Comp - Out.Flow*Out.Comp + volume*MMT.ReactionRate;
  %% total properties
  mole = SUMABS(Xmole);
  volume = mole*MMT.MoleWeight/MMT.Density;
  level = volume/CrossArea;
  Comp = Xmole*(1/mole);
  %% energy balance
  energy' = In.Flow*In.MoleEnergy - Out.Flow*Out.MoleEnergy +
    volume*MMT.EnergyProd - HTOut.Qtrans;
  temp = energy/(volume*MMT.Cp*MMT.Density);
  %% heat transfer connection
  HTOut.Temp = temp;
  %% reactor pressure
  In.Pressure = 0.0;
  %% out flow
  Out.Comp = Comp;
  Out.Pressure = 0.0;
  Out.MoleEnergy = energy/mole;
  %% MMT-connections
  %% (reaction rate is concentration based)
  MMT.Conc = Xmole*(1/volume);
  MMT.Comp = Comp;
  MMT.Pressure = In.Pressure;
  MMT.Temp = temp;
END;

%-----
%% reactor vessel model
%
TankReactorVesselModel ISA SubTankReactorClass WITH
%% Composite model of a tank reactor vessel with
%% one reactor machine and one reaction model.
%% They communicate through a reaction/reactor terminal.
icon:
  Graphic ISA Base::Layout WITH
    bitmap TYPE String := "iconreactorvessel";
  END;
structure_parameter:
  ChemDim := AtoBReaction.NumberOfComponents;

```

```

ReactorMachine.ChemDim := AtoBReaction.NumberOfComponents;
submodels:
ReactorMachine ISA CSTRLib::TankReactorMachineModel WITH
  Graphic ISA super::Graphic WITH
    x_pos := 200.0;
    y_pos := 150.0;
  END;
END;
AtoBReaction ISA ReactionModelLib::AtoBReactionModel WITH
  Graphic ISA super::Graphic WITH
    x_pos := 325.0;
    y_pos := 150.0;
  END;
END;
terminals:
In ISA ProcessTerminalLib::LiquidInTerminal WITH
  Graphic ISA Base::Layout WITH
    x_pos := 100;
    y_pos := 298;
    invisible := 1;
  END;
Comp.n := ChemDim;
END;
Out ISA ProcessTerminalLib::LiquidOutTerminal WITH
  Graphic ISA Base::Layout WITH
    x_pos := 200;
    y_pos := 0;
    invisible := 1;
  END;
Comp.n := ChemDim;
END;
HTOut ISA ProcessTerminalLib::HeatTransferOutTerminal WITH
  Graphic ISA Base::Layout WITH
    x_pos := 0;
    y_pos := 150;
    invisible := 1;
  END;
parameter:
CrossArea ISA Parameter;
parameter.equation:
ReactorMachine.CrossArea := CrossArea;
connections:
C5429672 ISA Base::Connection WITH
  HTOut AT ReactorMachine.HTOut;
bpoints TYPE Matrix [2, 2] := [0.0, 149.0; 169.0, 149.0];
END;
C1 ISA Base::Connection WITH
  In AT ReactorMachine.In;
bpoints TYPE Matrix [4, 2] :=
  [100.0, 297.0; 100.0, 200; 180.0, 200.0; 180.0, 178.0];
END;
C2 ISA Base::Connection WITH
  ReactorMachine.Out AT Out;
bpoints TYPE Matrix [2, 2] := [199.0, 119.0; 199.0, 0.0];
END;
C3 ISA Base::Connection WITH
  ReactorMachine.MMT AT AtoBReaction.MMT;
bpoints TYPE Matrix [5, 2] :=
  [228.0, 149.0; 250.0, 149.0; 250.0, 153.0; 299.0, 153.0];
END;
END;

```

```

%%-----
%% tank reactor model

TankReactorIClass ISA CSTRLib::TankReactorIClass WITH
%% Interface class for a continuous stirred tank reactor, CSTR.
icon:
  Graphic ISA Base::Layout WITH
    bitmap TYPE String := "icontankreactor";
  END;
terminals:
In ISA ProcessTerminalLib::LiquidInTerminal WITH
  Graphic ISA Base::Layout WITH
    x_pos := 100;
    y_pos := 300;
    invisible := 1;
  END;
Comp.n := ChemDim;
END;
Out ISA ProcessTerminalLib::LiquidOutTerminal WITH
  Graphic ISA Base::Layout WITH
    x_pos := 200;
    y_pos := 1;
    invisible := 1;
  END;
Comp.n := ChemDim;
END;
Cool ISA ProcessTerminalLib::FlowInTerminal WITH
  Graphic ISA Base::Layout WITH
    x_pos := 1;
    y_pos := 150;
    invisible := 1;
  END;
END;
TankReactorModel ISA CSTRLib::TankReactorIClass WITH
%% Composite model of a jacket cooled
%% continuous stirred tank reactor, CSTR.
structure_parameter:
  ChemDim := ReactorVessel.ChemDim;
submodels:
  ReactorVessel ISA CSTRLib::TankReactorVesselModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 275;
      y_pos := 150;
    END;
  END;
  Wall ISA EnergyEquipmentLib::HeatTransferModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 175.0;
      y_pos := 150.0;
    END;
  END;
  Jacket ISA EnergyEquipmentLib::JacketModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 75.0;
      y_pos := 150.0;
    END;
  END;
  Level ISA SimpleOutput WITH
    Graphic ISA Base::Layout WITH
      x_pos := 399;
      y_pos := 249;
    END;
  END;

```

```

invisible := 1;
END;
END;
Temp ISA SimpleOutput WITH
Graphic ISA Base::Layout WITH
x_pos := 399;
y_pos := 199;
invisible := 1;
END;
END;
OutFlow ISA SimpleOutput WITH
Graphic ISA Base::Layout WITH
x_pos := 399;
y_pos := 150;
invisible := 1;
END;
END;
invisible connections:
Level := ReactorVessel.ReactorMachine.level;
Temp := ReactorVessel.ReactorMachine.temp;
OutFlow := Out.Flow;
connections:
C1 ISA Base::Connection WITH
In AT ReactorVessel.In;
bpoints TYPE Matrix [4, 2] :=
[99.0, 299.0; 99.0, 229.0; 260.0, 229.0; 260.0, 178.0];
END;
C2 ISA Base::Connection WITH
ReactorVessel.Out AT Out;
bpoints TYPE Matrix [4, 2] :=
[274.0, 120.0; 274.0, 53.0; 199.0, 53.0; 199.0, 0.0];
END;
C3 ISA Base::Connection WITH
Cool AT Jacket.In;
bpoints TYPE Matrix [4, 2] :=
[0.0, 149.0; 26.0, 149.0; 26.0, 158.0; 44.0, 158.0];
END;
C4 ISA Base::Connection WITH
Jacket.HTIn AT Wall.HTOut;
bpoints TYPE Matrix [4, 2] :=
[103.0, 153.0; 125.0, 153.0; 125.0, 149.0; 149.0, 149.0];
END;
C5 ISA Base::Connection WITH
Wall.HTIn AT ReactorVessel.HTOut;
bpoints TYPE Matrix [2, 2] := [198.0, 149.0; 245.0, 149.0];
END;
END;
%%-----
%% cstr unit with control valves.
%%-----
%%CSTR unit
CSTRIClass ISA TankReactorClass WITH
%% Interface class to CSTR classes.
icon:
Graphic ISA Base::Layout WITH
bitmap TYPE String := "icontankreactor";
END;
terminals:
Feed ISA ProcessTerminalLib::LiquidInTerminal WITH
Graphic ISA Base::Layout WITH

```

```

x_pos := 0.0;
y_pos := 200.0;
invisible := 1;
END;
Comp.n := ChemDim;
END;
out ISA ProcessTerminalLib::LiquidOutTerminal WITH
Graphic ISA Base::Layout WITH
x_pos := 400.0;
y_pos := 75.0;
invisible := 1;
END;
Comp.n := ChemDim;
END;
Cool ISA ProcessTerminalLib::FlowInTerminal WITH
Graphic ISA Base::Layout WITH
x_pos := 0.0;
y_pos := 125.0;
invisible := 1;
END;
END;
CSTRUnitModel ISA CSTRIClass WITH
%% A CSTR unit model. It is composed of a
%% tank reactor, and three control valves.
icon:
Graphic ISA super::Graphic;
structure parameter:
ChemDim := CSTR.ChemDim;
terminals:
Control ISA ControlTerminalLib::CSTRInControl WITH
Graphic ISA Base::Layout WITH
x_pos := 350.0;
y_pos := 300.0;
invisible := 1;
END;
END;
Measure ISA ControlTerminalLib::CSTROutMeasure WITH
Graphic ISA Base::Layout WITH
x_pos := 100.0;
y_pos := 300.0;
invisible := 1;
END;
END;
submodels:
CSTR ISA CSTRLib::TankReactorModel WITH
Graphic ISA super::Graphic WITH
x_pos := 200.0;
y_pos := 150.0;
END;
END;
FeedValve ISA FlowEquipmentLib::ControlValveModelV WITH
Graphic ISA super::Graphic WITH
x_pos := 75.0;
y_pos := 200.0;
END;
ChemDim := outer::ChemDim;
END;
CoolValve ISA FlowEquipmentLib::CoolControlValveModel WITH
Graphic ISA super::Graphic WITH
x_pos := 125.0;
y_pos := 150.0;

```

```

END;
END;
OutValve ISA FlowEquipmentLib::ControlValveModelV WITH
  Graphic ISA super::Graphic WITH
    x_pos := 300.0;
    y_pos := 75.0;
  END;
END;
ChemDim := outer::ChemDim;
END;
connections:
  C1 ISA Base::Connection WITH
    Feed AT FeedValve.In;
    bpoints TYPE Matrix [4, 2] := [0, 200; 33, 200; 33, 190; 57, 190];
  END;
  C3 ISA Base::Connection WITH
    Cool AT CoolValve.In;
    bpoints TYPE Matrix [4, 2] := [0, 124; 84, 124; 84, 141; 107, 141];
  END;
  C4 ISA Base::Connection WITH
    CoolValve.Out AT CSTR.Cool;
    bpoints TYPE Matrix [4, 2] := [141, 141; 157, 141; 157, 149; 170, 149];
  END;
  C5 ISA Base::Connection WITH
    FeedValve.Out AT CSTR.In;
    bpoints TYPE Matrix [3, 2] := [91, 190; 184, 190; 184, 179];
  END;
  C6 ISA Base::Connection WITH
    CSTR.Out AT OutValve.In;
    bpoints TYPE Matrix [3, 2] := [199, 120; 199, 66; 282, 66];
  END;
  C7 ISA Base::Connection WITH
    Out AT OutValve.Out;
    bpoints TYPE Matrix [4, 2] := [316, 66; 346, 66; 346, 75; 400, 75];
  END;
invisible_connections:
  FeedValve.Control := Control.Feed;
  CoolValve.Control := Control.Cool;
  OutValve.Control := Control.OutFlow;
  Measure.Level := CSTR.Level;
  Measure.VTemp := CSTR.Temp;
  Measure.JTemp := CSTR.Jacket.Temp;
  Measure.OutFlow := CSTR.OutFlow;
END;
%%-----
%% A buffer tank as a tank reactor vessel with no reaction
BufferTankModel ISA FlowEquipClass WITH
  %% Composite model of a tank reactor vessel with
  %% one reactor machine and one reaction model.
  %% They communicate through a reaction/reactor terminal.
  icon:
    Graphic ISA Base::Layout WITH
      bitmap TYPE String := "iconvessel";
    END;
  structure_parameter:
    ChemDim TYPE Integer;
    ChemDim := ZeroReaction.NumberOfComponents;
    ReactorMachine.ChemDim := ZeroReaction.NumberOfComponents;
  submodels:
    ReactorMachine ISA CSTRLib::TankReactorMachineModel WITH
      Graphic ISA super::Graphic WITH

```

```

    x_pos := 200.0;
    y_pos := 150.0;
  END;
END;
ZeroReaction ISA ReactionModelLib::ZeroReactionModel WITH
  Graphic ISA super::Graphic WITH
    x_pos := 325.0;
    y_pos := 150.0;
  END;
END;
terminals:
  In ISA ProcessTerminalLib::LiquidInTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 100;
      y_pos := 298;
      invisible := 1;
    END;
  Comp.n := ChemDim;
  END;
  Out ISA ProcessTerminalLib::LiquidOutTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 200;
      y_pos := 0;
      invisible := 1;
    END;
  Comp.n := ChemDim;
  END;
  parameter:
    CrossArea ISA Parameter;
    parameter equation:
      ReactorMachine.CrossArea := CrossArea;
  connections:
    C1 ISA Base::Connection WITH
      In AT ReactorMachine.In;
      bpoints TYPE Matrix [4, 2] :=
        [100.0, 297.0; 100.0, 200; 180.0, 200.0; 180.0, 178.0];
    END;
    C2 ISA Base::Connection WITH
      ReactorMachine.Out AT Out;
      bpoints TYPE Matrix [2, 2] := [199.0, 119.0; 199.0, 0.0];
    END;
    C3 ISA Base::Connection WITH
      ReactorMachine.MMT AT ZeroReaction.MMT;
      bpoints TYPE Matrix [5, 2] :=
        [228.0, 149.0; 250.0, 149.0; 250.0, 149.0; 250.0, 153.0; 299.0, 153.0];
    END;
  terminal_defaults:
    %% no energy interaction
    ReactorMachine.HTOut.Qtrans := 0;
  END;

```



```

LIBRARY DistillationLib;

USES ModelClassTreeLib, ProcessTerminalLib, ControlTerminalLib, PhaseEquilibLib, $
    ^ FlowEquipmentLib, EnergyEquipmentLib;

%% Distillation library contain objects for
%% the construction of distillation column
%% units. The columns are tray based with
%% medium and machine decomposition and
%% abstract submodel class.
%%
%% Design: Bernt Nilsson, 4 may 1993.
%%-----
%% tray models

TrayIClass ISA ModelClassTreeLib::SubseparatorClass WITH
%% Interface class for tray models.
icon:
    Graphic ISA Base::Layout WITH bitmap TYPE String := "icontray"; END;
structure_parameter:
    ChemDim TYPE Integer;
terminals:
    Lin ISA ProcessTerminalLib::LiquidInTerminal WITH
        Graphic ISA Base::Layout WITH
            x_pos := 100;
            y_pos := 300;
            invisible := 1;
        END;
    Comp.n := ChemDim;
END;

Lout ISA ProcessTerminalLib::LiquidOutTerminal WITH
    Graphic ISA Base::Layout WITH
        x_pos := 100;
        y_pos := 0;
        invisible := 1;
    END;
    Comp.n := ChemDim;
END;

Vin ISA ProcessTerminalLib::VaporInTerminal WITH
    Graphic ISA Base::Layout WITH
        x_pos := 300;
        y_pos := 0;
        invisible := 1;
    END;
    Comp.n := ChemDim;
END;

Vout ISA ProcessTerminalLib::VaporOutTerminal WITH
    Graphic ISA Base::Layout WITH
        x_pos := 300;
        y_pos := 300;
        invisible := 1;
    END;
    Comp.n := ChemDim;
END;

TrayMachineIClass ISA DistillationLib::TrayIClass WITH
%% Tray machine interface class.
%% Tray machine interface class.
MMT ISA ProcessTerminalLib::MediumMachineTerminal WITH
    Graphic ISA Base::Layout WITH
        x_pos := 400;
        y_pos := 150;
        invisible := 1;
    END;
END;

TrayMachineModel ISA DistillationLib::TrayMachineIClass WITH
%% A tray machine model.
%% can be connected to a distillation
%% medium model from the PhaseEquilibLib.
parameters:
    TrayArea ISA Base::Parameter;
    WeirLength ISA Base::Parameter;
    WeirHeight ISA Base::Parameter;
    GravConst ISA Base::Parameter;
    PressureDrop ISA Base::Parameter;
variables:
    mole ISA Base::Variable;
    OutFlow ISA Base::Variable;
    height ISA Base::Variable;
    Xmole ISA ProcessTerminalLib::ColumnVectorClass WITH n := ChemDim; END;
    Comp ISA ProcessTerminalLib::ColumnVectorClass WITH n := ChemDim; END;
equations:
    %% mole component balances
    Xmole' = Lin.Flow*Lin.Comp + Vin.Flow*Vin.Comp - Lout.Flow*Lout.Comp - $
        ^ Vout.Flow*Vout.Comp;
    %% total properties
    mole = sumabs(Xmole);
    Comp = Xmole*1/mole;
    height = mole*MMT.MoleWeight/(MMT.Density*TrayArea);
    %% phase equilibrium description in medium model
    MMT.LComp = Comp;
    MMT.Pressure = Vin.Pressure - PressureDrop;
    %% liquid outflow
    OutFlow = if height < WeirHeight then 0 else WeirLength/1.5*sqrt(2*GravConst*(height-$
        ^ WeirHeight)^3);
    Lout.Flow = 3600*MMT.MoleWeight*MMT.Density*OutFlow;
    Lout.Comp = Comp;
    Lout.Pressure = MMT.Pressure;
    Lout.MoleEnergy = MMT.LiqMoleEn;
    %% vapor outflow (no vapour dynamics and neglected vapor holdup)
    Vout.Flow = Vin.Flow;
    Vout.Comp = MMT.VComp;
    Vout.Pressure = MMT.Pressure;
    Vout.MoleEnergy = MMT.VapMoleEn;
END;

%%-----
%% composite tray models

TrayModel ISA DistillationLib::TrayIClass WITH
    %% Composite model for a tray.
    icon:
        Graphic ISA super::Graphic;
    structure_parameters:
        ChemDim := MediumModel.NumberOfComponents;
        MachineModel.ChemDim := MediumModel.NumberOfComponents;
    submodels:
        MachineModel ISA DistillationLib::TrayMachineModel WITH
            Graphic ISA super::Graphic WITH
                x_pos := 125;
                y_pos := 150;
                invisible := 1;
            END;
        END;
END;

```



```

Vout ISA ProcessTerminalLib::VaporOutTerminal WITH
  Graphic ISA super::Graphic WITH
    x_pos := 200.0;
    y_pos := 300.0;
    invisible := 1;
  END;
  Comp.n := ChemDim;
END;

Iout ISA ProcessTerminalLib::LiquidOutTerminal WITH
  Graphic ISA super::Graphic WITH
    x_pos := 200.0;
    y_pos := 0.0;
    invisible := 1;
  END;
  Comp.n := ChemDim;
END;

Vin ISA ProcessTerminalLib::VaporInTerminal WITH
  Graphic ISA super::Graphic WITH
    x_pos := 0.0;
    y_pos := 25.0;
    invisible := 1;
  END;
  Comp.n := ChemDim;
END;

Column3TrayModel ISA DistillationLib::ColumnIClass WITH
  %% A tray based distillation column with three trays.
  icon:
    Graphic ISA super::Graphic;
  structure parameter:
    ChemDim := MediumModel.NumberOfComponents;
  abstract_submodel:
    MediumModel ISA PhaseEquilib::ABSPHASEEquilData WITH
      Graphic ISA super::Graphic WITH
        x_pos := 50.0;
        y_pos := 340;
      END;
    END;
  MediumModel.MMT.LComp := [0.33; 0.33; 0.34];
  MediumModel.MMT.Pressure := 1000;
  submodels:
    FeedTray2 ISA DistillationLib::FeedTrayModel WITH
      MediumModel ISA outer::MediumModel WITH
        Graphic ISA super::Graphic WITH
          x_pos := 275.0;
          y_pos := 100.0;
        END;
      END;
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 150.0;
    END;
  Column3TrayModel ISA DistillationLib::TrayModel WITH
    MediumModel ISA outer::MediumModel WITH
      Graphic ISA super::Graphic WITH
        x_pos := 301;
        y_pos := 151;
      END;
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
    END;

Vout ISA ProcessTerminalLib::VaporOutTerminal WITH
  Graphic ISA super::Graphic WITH
    x_pos := 225.0;
  END;
  END;
  Tray1 ISA DistillationLib::TrayModel WITH
    MediumModel ISA outer::MediumModel WITH
      Graphic ISA super::Graphic WITH
        x_pos := 301;
        y_pos := 151;
      END;
    END;
  Graphic ISA super::Graphic WITH
    x_pos := 200.0;
    y_pos := 75.0;
  END;
  connections:
    C1 ISA Base::Connection WITH
      Feed AT FeedTray2.Feed;
      bpoints TYPE Matrix [2, 2] := [0.0, 149.0; 169.0, 149.0];
    END;
    C3 ISA Base::Connection WITH
      Tray3.Iout AT FeedTray2.Lin;
      bpoints TYPE Matrix [2, 2] := [184.0, 210.0; 184.0, 163.0];
    END;
    C4 ISA Base::Connection WITH
      FeedTray2.Iout AT Tray1.Lin;
      bpoints TYPE Matrix [2, 2] := [184.0, 134.0; 184.0, 89.0];
    END;
    C5 ISA Base::Connection WITH
      Reflux AT Tray3.Ilin;
      bpoints TYPE Matrix [3, 2] := [399.0, 274.0; 184.0, 274.0; 184.0, 239.0];
    END;
    C10 ISA Base::Connection WITH
      Tray1.Vout AT FeedTray2.Vin;
      bpoints TYPE Matrix [2, 2] := [214.0, 89.0; 213.0, 134.0];
    END;
    C11 ISA Base::Connection WITH
      FeedTray2.Vout AT Tray3.Vin;
      bpoints TYPE Matrix [2, 2] := [213.0, 163.0; 214.0, 210.0];
    END;
    C16 ISA Base::Connection WITH
      Vout AT Tray3.Vout;
      bpoints TYPE Matrix [4, 2] := [214.0, 239.0; 214.0, 261.0; 199.0, 261.0; 199.0, $
        ^ 299.0];
    END;
    C17 ISA Base::Connection WITH
      Vin AT Tray1.Vin;
      bpoints TYPE Matrix [3, 2] := [0.0, 24.0; 214.0, 24.0; 214.0, 60.0];
    END;
    C18 ISA Base::Connection WITH
      Iout AT Tray1.Lout;
      bpoints TYPE Matrix [4, 2] := [184.0, 60.0; 184.0, 41.0; 199.0, 41.0; 199.0, 0.0];
    END;
  END;
  Column3TrayModel ISA DistillationLib::ColumnIClass WITH
    %% A tray based distillation column with nine trays.
    C21 ISA Base::Connection WITH
      Feed AT FeedTray6.Feed;
      bpoints TYPE Matrix [4, 2] := [0.0, 249.0; 90.0, 249.0; 90.0, 299.0; 170.0, 299.0];
    END;
  icon:
    Graphic ISA super::Graphic WITH y_size := 500; END;

```

```

structure_parameter:
  ChemDim := MediumModel.NumberOfComponents;
terminals:
  Feed ISA ProcessTerminalLib::LiquidInTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 0.0;
      y_pos := 250.0;
      invisible := 1;
    END;
  Comp.n := ChemDim;
END;
Reflux ISA ProcessTerminalLib::LiquidInTerminal WITH
  Graphic ISA super::Graphic WITH
    x_pos := 400.0;
    y_pos := 475.0;
    invisible := 1;
  END;
Comp.n := ChemDim;
Vout ISA ProcessTerminalLib::VaporOutTerminal WITH
  Graphic ISA super::Graphic WITH
    x_pos := 200.0;
    y_pos := 500.0;
    invisible := 1;
  END;
Comp.n := ChemDim;
abstract_submodel:
  MediumModel ISA PhaseEquilib::ABSPHASEEquilData WITH
    Graphic ISA super::Graphic WITH
      x_pos := 50.0;
      y_pos := 540;
    END;
END;
MediumModel.MMT.LComp := [0.33; 0.33; 0.34];
MediumModel.MMT.Pressure := 1000;
submodels:
  FeedTray6 ISA DistillationLib::FeedTrayModel WITH
    MediumModel ISA outer::MediumModel WITH
      Graphic ISA super::Graphic WITH
        x_pos := 275.0;
        y_pos := 100.0;
      END;
    END;
  Graphic ISA super::Graphic WITH
    x_pos := 200.0;
    y_pos := 300.0;
  END;
  Tray1 ISA DistillationLib::TrayModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 50.0;
    END;
  Tray2 ISA DistillationLib::TrayModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 100.0;
    END;
  Tray3 ISA DistillationLib::TrayModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 150.0;
    END;
  Tray4 ISA DistillationLib::TrayModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 200.0;
    END;
  Tray5 ISA DistillationLib::TrayModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 250.0;
    END;
  Tray6 ISA DistillationLib::TrayModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 300.0;
    END;
  Tray7 ISA DistillationLib::TrayModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 350.0;
    END;
  Tray8 ISA DistillationLib::TrayModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 400.0;
    END;
  Tray9 ISA DistillationLib::TrayModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 450.0;
    END;
  connections:
    C1 ISA Base::Connection WITH
      Reflux AT Tray9.LIn;
      bpoints TYPE Matrix [3, 2] := [399.0, 474.0; 184.0, 474.0; 184.0, 464.0];
    END;
    C2 ISA Base::Connection WITH
      Tray9.LOut AT Tray8.LIn;
      bpoints TYPE Matrix [2, 2] := [184.0, 435.0; 184.0, 413.0];
    END;
    C3 ISA Base::Connection WITH
      Tray8.LOut AT Tray7.LIn;
      bpoints TYPE Matrix [2, 2] := [184.0, 384.0; 184.0, 364.0];
    END;
    C4 ISA Base::Connection WITH
      Tray7.LOut AT FeedTray6.LIn;
      bpoints TYPE Matrix [2, 2] := [184.0, 335.0; 184.0, 313.0];
    END;
    C5 ISA Base::Connection WITH
      FeedTray6.LOut AT Tray5.LIn;
      bpoints TYPE Matrix [2, 2] := [184.0, 284.0; 184.0, 264.0];
    END;
    C6 ISA Base::Connection WITH
      Tray5.LOut AT Tray4.LIn;
      bpoints TYPE Matrix [2, 2] := [184.0, 235.0; 184.0, 214.0];
    END;
    C7 ISA Base::Connection WITH
      Tray4.LOut AT Tray3.LIn;
      bpoints TYPE Matrix [2, 2] := [184.0, 185.0; 184.0, 164.0];
    END;

```

```

C8 ISA Base::Connection WITH
  Tray3.LOut AT Tray2.LIn;
  bpoints TYPE Matrix [2, 2] := [184.0, 135.0; 184.0, 114.0];
END;
C9 ISA Base::Connection WITH
  Tray2.LOut AT Tray1.LIn;
  bpoints TYPE Matrix [2, 2] := [184.0, 85.0; 184.0, 64.0];
END;
C10 ISA Base::Connection WITH
  LOut AT Tray1.LOut;
  bpoints TYPE Matrix [3, 2] := [184.0, 35.0; 184.0, 8.0; 199.0, 0.0];
END;
C11 ISA Base::Connection WITH
  Vin AT Tray1.VIn;
  bpoints TYPE Matrix [3, 2] := [0.0, 24.0; 214.0, 24.0; 214.0, 35.0];
END;
C12 ISA Base::Connection WITH
  Tray1.VOut AT Tray2.VIn;
  bpoints TYPE Matrix [2, 2] := [214.0, 64.0; 214.0, 85.0];
END;
C13 ISA Base::Connection WITH
  Tray2.VOut AT Tray3.VIn;
  bpoints TYPE Matrix [2, 2] := [214.0, 114.0; 214.0, 135.0];
END;
C14 ISA Base::Connection WITH
  Tray3.VOut AT Tray4.VIn;
  bpoints TYPE Matrix [2, 2] := [214.0, 164.0; 214.0, 185.0];
END;
C15 ISA Base::Connection WITH
  Tray4.VOut AT Tray5.VIn;
  bpoints TYPE Matrix [2, 2] := [214.0, 214.0; 214.0, 235.0];
END;
C16 ISA Base::Connection WITH
  Tray5.VOut AT FeedTray6.VIn;
  bpoints TYPE Matrix [2, 2] := [214.0, 264.0; 213.0, 284.0];
END;
C17 ISA Base::Connection WITH
  FeedTray6.VOut AT Tray7.VIn;
  bpoints TYPE Matrix [2, 2] := [213.0, 313.0; 214.0, 335.0];
END;
C18 ISA Base::Connection WITH
  Tray7.VOut AT Tray8.VIn;
  bpoints TYPE Matrix [2, 2] := [214.0, 364.0; 213.0, 384.0];
END;
C19 ISA Base::Connection WITH
  Tray8.VOut AT Tray9.VIn;
  bpoints TYPE Matrix [2, 2] := [213.0, 413.0; 214.0, 435.0];
END;
C20 ISA Base::Connection WITH
  VOut AT Tray9.VOut;
  bpoints TYPE Matrix [3, 2] := [214.0, 464.0; 214.0, 489.0; 199.0, 499.0];
END;
END;

%%-----
%% unit configuration

DistillationUnitIClass ISA ModelClassTreeLib::SeparatorClass WITH
  %% Interface class of a distillation unit.
  icon:
    Graphic ISA Base::Layout WITH
      bitmap TYPE String := "Iconcolumn2";
      y_size := 500;

```

```

END;
structure_parameter:
  ChemDim TYPE Integer;
terminals:
  Feed ISA ProcessTerminalLib::LiquidInTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 0.0;
      y_pos := 250.0;
      invisible := 1;
  END;
  Comp.n := ChemDim;
  END;
  Distillate ISA ProcessTerminalLib::LiquidOutTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 400.0;
      y_pos := 475.0;
      invisible := 1;
  END;
  Comp.n := ChemDim;
  END;
  Bottom ISA ProcessTerminalLib::LiquidOutTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 400.0;
      y_pos := 25.0;
      invisible := 1;
  END;
  Comp.n := ChemDim;
  END;
  Distillation3TUnitModel ISA DistillationLib::DistillationUnitIClass WITH
    %% Distillation unit model with a tray based column (3 trays),
    %% total condenser and reboiler.
    icon:
      Graphic ISA super::Graphic;
    structure_parameter:
      ChemDim := MediumModel.NumberOfComponents;
    terminals:
      Control ISA ControlTerminalLib::DistInControl WITH
        Graphic ISA super::Graphic WITH
          x_pos := 350.0;
          y_pos := 500.0;
          invisible := 1;
        END;
      END;
      Measurement ISA ControlTerminalLib::DistOutMeasure WITH
        Graphic ISA super::Graphic WITH
          x_pos := 150.0;
          y_pos := 500.0;
          invisible := 1;
        END;
      END;
    abstract submodel:
      MediumModel ISA PhaseEquilibLib::ABSPHaseEquilData WITH
        Graphic ISA super::Graphic WITH
          x_pos := 50.0;
          y_pos := 540;
        END;
      END;
      MediumModel.MMT.IComp := [0.33; 0.33; 0.34];
      MediumModel.MMT.Pressure := 1000;
    submodels:
      TrayColumn ISA DistillationLib::Column3TrayModel WITH

```

```

MediumModel ISA outer::MediumModel WITH
  Graphic ISA super::Graphic WITH
    x_pos := 50.0;
    y_pos := 340;
  END;
END;
END;
Graphic ISA super::Graphic WITH
  x_pos := 150.0;
  y_pos := 250.0;
END;
END;
RefluxDrum ISA FlowEquipmentLib::RefluxDrumModel WITH
  MediumModel ISA outer::MediumModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 300.0;
      y_pos := 150.0;
    END;
  END;
END;
Graphic ISA super::Graphic WITH
  x_pos := 275.0;
  y_pos := 350.0;
END;
END;
ReBoiler ISA EnergyEquipmentLib::BoilerModel WITH
  MediumModel ISA outer::MediumModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 350.0;
      y_pos := 200.0;
    END;
  END;
END;
Graphic ISA super::Graphic WITH
  x_pos := 100.0;
  y_pos := 125.0;
END;
END;
Condenser ISA EnergyEquipmentLib::TotalCondenserModel WITH
  MediumModel ISA outer::MediumModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 300.0;
      y_pos := 150.0;
    END;
  END;
END;
Graphic ISA super::Graphic WITH
  x_pos := 275.0;
  y_pos := 400.0;
END;
END;
RefluxValve ISA FlowEquipmentLib::ControlValveModelV WITH
  Graphic ISA super::Graphic WITH
    x_pos := 225.0;
    y_pos := 300.0;
  END;
  ChemDim := outer::ChemDim;
END;
TopValve ISA FlowEquipmentLib::ControlValveModelV WITH
  Graphic ISA super::Graphic WITH
    x_pos := 325.0;
    y_pos := 300.0;
  END;
  ChemDim := outer::ChemDim;
END;
BottomValve ISA FlowEquipmentLib::ControlValveModelV WITH
  Graphic ISA super::Graphic WITH
    x_pos := 250.0;
    y_pos := 150.0;
  END;
  ChemDim := outer::ChemDim;
END;
HeatValve ISA FlowEquipmentLib::CoolControlValveModel WITH
  Graphic ISA super::Graphic WITH
    x_pos := 25.0;
    y_pos := 150.0;
  END;
END;
invisible_connections:
  Measurement.DrumLevel := RefluxDrum.Drum.height;
  Measurement.BoilerLevel := ReBoiler.BoilerSide.height;
  Measurement.TopComp := RefluxDrum.Drum.Comp[1];
  Measurement.BottomComp := ReBoiler.BoilerSide.Comp[1];
  RefluxValve.Control := Control.Reflux;
  HeatValve.Control := Control.Heat;
  TopValve.Control := Control.Top;
  BottomValve.Control := Control.Bottom;
connections:
  C1 ISA Base::Connection WITH
    Feed AT TrayColumn.Feed;
    bpoints TYPE Matrix [2, 2] := [0.0, 249.0; 124.0, 249.0];
  END;
  C3 ISA Base::Connection WITH
    Condenser.IOut AT RefluxDrum.IIn;
    bpoints TYPE Matrix [2, 2] := [274.0, 378.0; 274.0, 364.0];
  END;
  C4 ISA Base::Connection WITH
    RefluxDrum.LOut AT TopValve.in;
    bpoints TYPE Matrix [3, 2] := [274.0, 334.0; 274.0, 290.0; 307.0, 290.0];
  END;
  C5 ISA Base::Connection WITH
    RefluxDrum.LOut AT RefluxValve.in;
    bpoints TYPE Matrix [3, 2] := [274.0, 334.0; 274.0, 290.0; 207.0, 290.0];
  END;
  C6 ISA Base::Connection WITH
    RefluxValve.out AT TrayColumn.Reflux;
    bpoints TYPE Matrix [4, 2] := [241.0, 290.0; 192.0, 331.0; 173.0, 173.0; 331.0;
    ^ 331.0];
  END;
  C7 ISA Base::Connection WITH
    Distillate AT TopValve.out;
    bpoints TYPE Matrix [4, 2] := [399.0, 474.0; 364.0, 474.0; 291.0; 341.0, 341.0; 291.0];
  END;
  C8 ISA Base::Connection WITH
    Bottom AT BottomValve.out;
    bpoints TYPE Matrix [4, 2] := [266.0, 41.0; 338.0, 41.0; 338.0, 24.0; 399.0, 24.0];
  END;
  C10 ISA Base::Connection WITH
    ReBoiler.IOut AT BottomValve.in;
    bpoints TYPE Matrix [3, 2] := [99.0, 103.0; 99.0, 41.0; 232.0, 41.0];
  END;
  C11 ISA Base::Connection WITH
    TrayColumn.VIn AT ReBoiler.VOut;
    bpoints TYPE Matrix [3, 2] := [125.0, 166.0; 99.0, 166.0; 99.0, 145.0];
  END;
  C12 ISA Base::Connection WITH
    TrayColumn.IOut AT ReBoiler.IIn;
    bpoints TYPE Matrix [4, 2] := [149.0, 150.0; 149.0, 88.0; 99.0, 88.0; 99.0, 103.0];
  END;

```

```

C13 ISA Base::Connection WITH
HeatValve.out AT ReBoiler.HeatIn;
bpoints TYPE Matrix [4, 2] := [41.0, 141.0; 58.0, 135.0; 78.0, 135.0];
END;

C14 ISA Base::Connection WITH
TrayColumn.Vout AT Condenser.VIn;
bpoints TYPE Matrix [4, 2] := [149.0, 349.0; 149.0, 440.0; 274.0, 440.0; 274.0, $
^ 420.0];
END;
END;

Distillation9TUnitModel ISA DistillationLib::DistillationUnitIClass WITH
%% Distillation unit model with a tray based column (9 trays),
%% total condenser and reboiler.
%% The column has nine trays.
icon:
Graphic ISA super::Graphic;
structure_parameter:
ChemDim := MediumModel.NumberOfComponents;
terminals:
Control ISA ControlTerminalLib::DistInControl WITH
Graphic ISA super::Graphic WITH
x_pos := 350.0;
y_pos := 500.0;
invisible := 1;
END;
END;
Measurement ISA ControlTerminalLib::DistOutMeasure WITH
Graphic ISA super::Graphic WITH
x_pos := 150.0;
y_pos := 500.0;
invisible := 1;
END;
END;
abstract_submodel:
MediumModel ISA PhaseEquilib::ABSPHASEEquilData WITH
Graphic ISA super::Graphic WITH
x_pos := 50.0;
y_pos := 540;
END;
END;
MediumModel.MWT.iComp := [0.33; 0.33; 0.34];
MediumModel.MWT.Pressure := 1000;
submodels:
TrayColumn ISA DistillationLib::Column9TrayModel WITH
Graphic ISA super::Graphic WITH
x_pos := 150.0;
y_pos := 250.0;
END;
END;
RefluxDrum ISA FlowEquipmentLib::RefluxDrumModel WITH
MediumModel ISA outer::MediumModel WITH
Graphic ISA super::Graphic WITH
x_pos := 300.0;
y_pos := 150.0;
END;
END;
Graphic ISA super::Graphic WITH
x_pos := 275.0;
y_pos := 350.0;
END;
END;
ReBoiler ISA EnergyEquipmentLib::BoilerModel WITH

```

```

MediumModel ISA outer::MediumModel WITH
Graphic ISA super::Graphic WITH
x_pos := 350.0;
y_pos := 200.0;
END;
END;
Graphic ISA super::Graphic WITH
x_pos := 100.0;
y_pos := 125.0;
END;
END;
Condenser ISA EnergyEquipmentLib::TotalCondenserModel WITH
MediumModel ISA outer::MediumModel WITH
Graphic ISA super::Graphic WITH
x_pos := 300.0;
y_pos := 150.0;
END;
END;
Graphic ISA super::Graphic WITH
x_pos := 275.0;
y_pos := 400.0;
END;
END;
RefluxValve ISA FlowEquipmentLib::ControlValveModel WITH
Graphic ISA super::Graphic WITH
x_pos := 225.0;
y_pos := 300.0;
END;
ChemDim := outer::ChemDim;
END;
TopValve ISA FlowEquipmentLib::ControlValveModel WITH
Graphic ISA super::Graphic WITH
x_pos := 325.0;
y_pos := 300.0;
END;
ChemDim := outer::ChemDim;
END;
BottomValve ISA FlowEquipmentLib::ControlValveModel WITH
Graphic ISA super::Graphic WITH
x_pos := 250.0;
y_pos := 50.0;
END;
ChemDim := outer::ChemDim;
END;
HeatValve ISA FlowEquipmentLib::CoolControlValveModel WITH
Graphic ISA super::Graphic WITH
x_pos := 25.0;
y_pos := 150.0;
END;
END;
invisible_connections:
Measurement.DrumLevel := RefluxDrum.Drum.height;
Measurement.BoilerLevel := ReBoiler.BoilerSide.height;
Measurement.TopComp := RefluxDrum.Drum.Comp[2];
Measurement.BottomComp := ReBoiler.BoilerSide.Comp[2];
RefluxValve.Control := Control.Reflux;
HeatValve.Control := Control.Heat;
TopValve.Control := Control.Top;
BottomValve.Control := Control.Bottom;
connections:
C1 ISA Base::Connection WITH
Feed AT TrayColumn.Feed;
bpoints TYPE Matrix [2, 2] := [0.0, 249.0; 124.0, 249.0];

```

```

END;
C3 ISA Base::Connection WITH
  Condenser.IOut AT RefluxDrum.LIn;
  bpoints TYPE Matrix [2, 2] := [274.0, 378.0; 274.0, 364.0];
END;
C4 ISA Base::Connection WITH
  RefluxDrum.IOut AT TopValve.in;
  bpoints TYPE Matrix [3, 2] := [274.0, 334.0; 274.0, 290.0; 307.0, 290.0];
END;
C5 ISA Base::Connection WITH
  RefluxDrum.IOut AT RefluxValve.in;
  bpoints TYPE Matrix [3, 2] := [274.0, 334.0; 274.0, 290.0; 207.0, 290.0];
END;
C6 ISA Base::Connection WITH
  RefluxValve.out AT TrayColumn.Reflux;
  bpoints TYPE Matrix [4, 2] := [241.0, 290.0; 192.0, 290.0; 192.0, 331.0; 173.0, $
    ^ 331.0];
END;
C7 ISA Base::Connection WITH
  Distillate AT TopValve.out;
  bpoints TYPE Matrix [4, 2] := [399.0, 474.0; 364.0, 474.0; 364.0, 291.0; 341.0, $
    ^ 291.0];
END;
C8 ISA Base::Connection WITH
  Bottom AT BottomValve.out;
  bpoints TYPE Matrix [4, 2] := [266.0, 41.0; 338.0, 41.0; 338.0, 24.0; 399.0, 24.0];
END;
C10 ISA Base::Connection WITH
  ReBoiler.IOut AT BottomValve.in;
  bpoints TYPE Matrix [3, 2] := [99.0, 103.0; 99.0, 41.0; 232.0, 41.0];
END;
C11 ISA Base::Connection WITH
  TrayColumn.VIn AT ReBoiler.VOut;
  bpoints TYPE Matrix [3, 2] := [125.0, 166.0; 99.0, 166.0; 99.0, 145.0];
END;
C12 ISA Base::Connection WITH
  TrayColumn.IOut AT ReBoiler.LIn;
  bpoints TYPE Matrix [4, 2] := [149.0, 150.0; 149.0, 88.0; 99.0, 88.0; 99.0, 103.0];
END;
C13 ISA Base::Connection WITH
  HeatValve.out AT ReBoiler.HeatIn;
  bpoints TYPE Matrix [4, 2] := [41.0, 141.0; 58.0, 141.0; 58.0, 135.0; 78.0, 135.0];
END;
C14 ISA Base::Connection WITH
  TrayColumn.VOut AT Condenser.VIn;
  bpoints TYPE Matrix [4, 2] := [149.0, 349.0; 149.0, 440.0; 274.0, 440.0; 274.0, $
    ^ 420.0];
END;
END;

```



```

LIBRARY ControlSystemLib;
USES ModelClassTreeLib, ProcessTerminalLib, ControlTerminalLib;

%% This a library containing classes for
%% control system modules.
%% The library contain in order classes for:
%% terminals, controllers, other models.
%%
%% Design: Bernt Nilsson
%%-----
%% Variable Class
DiscreteVariable ISA Base::Variable WITH
  value TYPE DISCRETE Real;
  initial TYPE DISCRETE Real := 0;
END;

%%-----
%% PID algorithms
PIDClass ISA SubContControllerClass WITH
  %% An empty PID module.
  icon:
    Graphic ISA Base::Layout WITH
      bitmap TYPE String := "iconcontroller";
    END;
  terminals:
    SetPoint ISA ControlTerminalLib::ReferenceTerminal WITH
      Graphic ISA Base::Layout WITH
        x_pos := 0;
        y_pos := 250;
        invisible := 1;
      END;
    END;
  Measure ISA Base::SimpleInput WITH
    Graphic ISA Base::Layout WITH
      x_pos := 0;
      y_pos := 150;
      invisible := 1;
    END;
  Control ISA ControlTerminalLib::ControlTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 400;
      y_pos := 150;
      invisible := 1;
    END;
  parameters:
    K ISA Base::Parameter;
    Ti ISA Base::Parameter;
    Td ISA Base::Parameter;
    b ISA Base::Parameter;
    tr ISA Base::Parameter;
    N ISA Base::Parameter;
    Ion ISA Base::Parameter;
    Don ISA Base::Parameter;
    uReverse ISA Base::Parameter;
    uHigh ISA Base::Parameter;
  END;

PIDAnalogAlgorithm ISA ControlSystemLib::PIDClass WITH
  %% An analog PID algorithm with tracking anti-windup

```

```

%% and noise filtering based on KJA:s module.
variables:
  p ISA Base::Variable;
  i ISA Base::Variable;
  yf ISA Base::Variable;
  d ISA Base::Variable;
  v ISA Base::Variable;
equations:
  p = K*(b*SetPoint.Ref - Measure);
  i' = K/Ti*(SetPoint.Ref - Measure) +
    (Control.uTrack - Control.u)/tr*Control.Track;
  yf' = N/Td*(Measure - yf);
  d = -K*N*(Measure - yf);
  v = p + Ion*i + Don*d;
  Control.u = uReverse*(uHigh - v) + (1 - uReverse)*v;
  SetPoint.Track = Control.Track;
  SetPoint.uTrack = Control.uTrack;
END;

PIDDiscreteAlgorithm ISA ControlSystemLib::PIDClass WITH
  %% A discrete PID algorithm with tracking anti-windup
  %% and noise filtering based on KJA:s module.
parameters:
  h ISA Base::Parameter;
variables:
  p ISA ControlSystemLib::DiscreteVariable;
  i ISA ControlSystemLib::DiscreteVariable;
  yf ISA ControlSystemLib::DiscreteVariable;
  d ISA ControlSystemLib::DiscreteVariable;
  v ISA ControlSystemLib::DiscreteVariable;
events:
  Init ISA Base::Event;
  Sample ISA Base::Event;
  ONEVENT Init CAUSE Sample;
algorithm:
  ONEVENT Sample DO
    new(p) := K*(b*SetPoint.Ref - Measure);
    new(i) := i + K*h/Ti*(SetPoint.Ref - Measure) +
      h/tr*(Control.uTrack - Control.u)*Control.Track;
    new(yf) := yf + h*N/Td*(Measure - yf);
    new(d) := -K*N*(Measure - new(yf));
    new(v) := new(p) + Ion*i + Don*d;
    new(Control.u) := if uReverse > 0.50 then uHigh - new(v) else new(v);
    new(SetPoint.Track) := Control.Track;
    new(SetPoint.uTrack) := Control.uTrack;
    schedule(Sample, h);
  END;
END;

%%-----
%% analog blocks
Limiter ISA AnalogBlockClass WITH
  icon:
    Graphic ISA Base::Layout WITH
      bitmap TYPE String := "iconlimiter";
    END;
  terminals:
    In ISA ControlTerminalLib::ReferenceTerminal WITH
      Graphic ISA Base::Layout WITH
        x_pos := 0;
        y_pos := 150;
      END;

```

```

invisible := 1;
END;
Out ISA Base::SimpleOutput WITH
  Graphic ISA Base::Layout WITH
    x_pos := 400;
    y_pos := 150;
    invisible := 1;
  END;
END;

Parameters:
  Umin ISA Base::Parameter WITH
    default := 0;
  END;
  Umax ISA Base::Parameter WITH
    default := 1;
  END;
$variables:
  % min,run,max TYPE DISCRETE Integer;
  %event:
  % Init ISAN Event;
equation:
  Out = if In.Ref < Umin then Umin else
    if In.Ref > Umax then Umax else In.Ref;
  % ONEVENT Init DO new(run) := 1;END;
  % ONEVENT In.Ref<Umin DO
    % new(min) := 1;
    % new(run) := 0;
    % new(max) := 0;
  % END;
  % ONEVENT (In.Ref-Umin)*(Umax-In.Ref)>0 DO
    % new(min) := 0;
    % new(run) := 1;
    % new(max) := 0;
  % END;
  % ONEVENT In.Ref>Umax DO
    % new(min) := 0;
    % new(run) := 0;
    % new(max) := 1;
  % END;
  Out = min*Umin + run*In.Ref + max*Umax;
  In.Track = min + max;
  In.Track = if In.Ref==Out then 0 else 1;
  In.uTrack = Out;
END;

Switch ISA AnalogBlockClass WITH
  icon:
    Graphic ISA Base::Layout WITH
      bitmap TYPE String := "Iconswitch";
    END;
  terminals:
    Channel ISA Base::SimpleInput WITH
      % value TYPE Integer;
      % default TYPE Integer;
      Graphic ISA Base::Layout WITH
        x_pos := 200;
        y_pos := 300;
        invisible := 1;
      END;
    END;
  END;
  In0 ISA ControlTerminalLib::ReferenceTerminal WITH
    Graphic ISA Base::Layout WITH

```

```

    x_pos := 0;
    y_pos := 100;
    invisible := 1;
  END;
  In1 ISA ControlTerminalLib::ReferenceTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 0;
      y_pos := 200;
      invisible := 1;
    END;
  END;
  Out ISA ControlTerminalLib::ControlTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 400;
      y_pos := 150;
      invisible := 1;
    END;
  END;
equations:
  Out.u = (1 - Channel)*In0.Ref + Channel*In1.Ref;
  In0.Track = Out.Track;
  In0.uTrack = Out.uTrack;
  In1.Track = Out.Track;
  In1.uTrack = Out.uTrack;
END;

ConstantSignal ISA AnalogBlockClass WITH
  %% A signal generator for a
  %% constant value.
  icon:
    Graphic ISA Base::Layout WITH
      bitmap TYPE String := "iconconstant";
    END;
  terminals:
    source ISA Base::SimpleOutput WITH
      Graphic ISA Base::Layout WITH
        x_pos := 0;
        y_pos := 150;
        invisible := 1;
      END;
    END;
  parameter:
    value ISA Base::Parameter WITH
      default := 0.50;
    END;
  equation:
    source = value;
  END;
  %%-----
  %% P I D - Controller with (almost) every thing
  PIDControllerModel ISA SISOControllerClass WITH
    %% This is a PID controller which uses the PID algorithm
    %% and can have reversed action, manual/auto mode with
    %% tracking and have a limiter on the control output.
    %% It can be used as a single controller and should not
    %% be used in composite controllers.
    %%
    %% Design: Bernt Nilsson
    %% Reference: KJ Astrom, Implementation of PID Regulator.
    icon:

```

```

Graphic ISA Base::Layout WITH
  bitMap TYPE String := "iconcontroller";
END;
terminals:
  Measure ISA Base::SimpleInput WITH
    Graphic ISA Base::Layout WITH
      x_pos := 1;
      y_pos := 150;
      invisible := 1;
  END;
submodels:
  Control ISA Base::SimpleOutput WITH
    Graphic ISA Base::Layout WITH
      x_pos := 400;
      y_pos := 150;
      invisible := 1;
  END;
  Control ISA Base::SimpleOutput WITH
    Graphic ISA Base::Layout WITH
      x_pos := 400;
      y_pos := 150;
      invisible := 1;
  END;
  SetPoint ISA Base::SimpleInput WITH
    Graphic ISA Base::Layout WITH
      x_pos := 1.0;
      y_pos := 226.0;
      invisible := 1;
  END;
  submodels:
    PID_Module ISA ControlSystemLib::PIDanalogalgorithm WITH
      Graphic ISA super::Graphic WITH
        x_pos := 125.0;
        y_pos := 150.0;
      END;
    Limiter ISA ControlSystemLib::Limiter WITH
      Graphic ISA super::Graphic WITH
        x_pos := 325.0;
        y_pos := 150.0;
      END;
    Switch ISA ControlSystemLib::Switch WITH
      Graphic ISA super::Graphic WITH
        x_pos := 250.0;
        y_pos := 150.0;
      END;
  connections:
    C3 ISA Base::Connection WITH
      Measure AT PID_Module.Measure;
      bpoints TYPE Matrix [2, 2] := [0, 149; 107, 149];
    END;
    C1 ISA Base::Connection WITH
      SetPoint AT PID_Module.SetPoint.Ref;
      bpoints TYPE Matrix [4, 2] := [0, 225; 40, 225; 40, 160; 107, 160];
    END;
    C8 ISA Base::Connection WITH
      AutoMan.UMan AT Switch.Inl.Ref;
      bpoints TYPE Matrix [3, 2] := [200.0, 299.0; 200.0, 155.0; 232.0, 155.0];
    END;
  C9 ISA Base::Connection WITH
    AutoMan.Manual AT Switch.Channel;
    bpoints TYPE Matrix [3, 2] := [200.0, 299.0; 249.0, 276.0; 249.0, 166.0];
  END;
C10 ISA Base::Connection WITH
  Switch.Out AT Limiter.In;
  bpoints TYPE Matrix [2, 2] := [266.0, 149.0; 307.0, 149.0];
END;
C11 ISA Base::Connection WITH
  Limiter.Out AT Control;
  bpoints TYPE Matrix [2, 2] := [341.0, 149.0; 399.0, 150.0];
END;
C5 ISA Base::Connection WITH
  PID_Module.Control AT Switch.In0;
  bpoints TYPE Matrix [4, 2] := [141, 149; 176, 149; 176, 232; 143];
END;
END;

PIDModule ISA PIDIClass WITH
  %% This is a PID controller which uses the PID algorithm
  %% and can have reversed action, manual/auto mode with
  %% tracking and have a limiter on the control output.
  %% It should be used in composite controllers and not
  %% in stand alone.
  %%
  %% Design: Bernt Nilsson
  %% Reference: KJ Astrom, Implementation of PID Regulator.
  terminals:
    AutoMan ISA ControlTerminalLib::ManualControlInTerminal WITH
      Graphic ISA Base::Layout WITH
        x_pos := 200;
        y_pos := 300;
        invisible := 1;
      END;
    submodels:
      PID_Module ISA ControlSystemLib::PIDanalogalgorithm WITH
        Graphic ISA super::Graphic WITH
          x_pos := 125.0;
          y_pos := 150.0;
        END;
      Switch ISA ControlSystemLib::Switch WITH
        Graphic ISA super::Graphic WITH
          x_pos := 250.0;
          y_pos := 150.0;
        END;
    connections:
      C3 ISA Base::Connection WITH
        Measure AT PID_Module.Measure;
        bpoints TYPE Matrix [2, 2] := [0, 149; 107, 149];
      END;
      C1 ISA Base::Connection WITH
        SetPoint AT PID_Module.SetPoint;
        bpoints TYPE Matrix [4, 2] := [0, 225; 40, 225; 40, 160; 107, 160];
      END;
      C8 ISA Base::Connection WITH
        AutoMan.UMan AT Switch.Inl.Ref;
        bpoints TYPE Matrix [3, 2] := [200.0, 299.0; 200.0, 155.0; 232.0, 155.0];
      END;
      C9 ISA Base::Connection WITH
        AutoMan.Manual AT Switch.Channel;
        bpoints TYPE Matrix [3, 2] := [200.0, 299.0; 249.0, 276.0; 249.0, 166.0];
      END;
    END;

```

```

AutoMan.Manual AT Switch.Channel;
bpoints TYPE Matrix [3, 2] := [200.0, 299.0; 249.0, 276.0; 249.0, 166.0];
END;
C10 ISA Base::Connection WITH
Switch.Out AT Control;
bpoints TYPE Matrix [2, 2] := [266.0, 149.0; 400, 150];
END;
C6 ISA Base::Connection WITH
PID.Module.Control AT Switch.In0;
bpoints TYPE Matrix [4, 2] := [141, 149; 171, 149; 171, 143; 232, 143];
END;
END;
%%-----
PIDCascadeModel ISA MISOCntrollerClass WITH
C7 ISA Base::Connection WITH
Manual2 AT PIDInner.AutoMan;
bpoints TYPE Matrix [2, 2] := [249, 299; 249, 166];
END;
C11 ISA Base::Connection WITH
Manual1 AT PIDouter.AutoMan;
bpoints TYPE Matrix [4, 2] := [174, 299; 174, 200; 124, 200; 124, 166];
END;
C12 ISA Base::Connection WITH
PIDouter.Control AT PIDinner.SetPoint;
bpoints TYPE Matrix [4, 2] := [141, 149; 184, 149; 184, 157; 232, 157];
END;
C13 ISA Base::Connection WITH
Measure2 AT PIDinner.Measure;
bpoints TYPE Matrix [4, 2] := [0, 99; 211, 99; 211, 149; 232, 149];
END;
icon:
Graphic ISA Base::Layout;
terminals:
SetPoint ISA Base::SimpleInput WITH
Graphic ISA Base::Layout WITH
x_pos := 0.0;
y_pos := 250.0;
END;
END;
Measure1 ISA Base::SimpleInput WITH
Graphic ISA Base::Layout WITH
x_pos := 0.0;
y_pos := 175.0;
END;
END;
Measure2 ISA Base::SimpleInput WITH
Graphic ISA Base::Layout WITH
x_pos := 0.0;
y_pos := 175.0;
END;
%%-----
%% sensor models
SimpleSensorModel ISA SensorClass WITH
terminals:
In ISA SimpleInput WITH
attributes:
Graphic ISA Base::Layout WITH
attributes:
x_pos := 0;
y_pos := 150;
invisible := 1;
END;
END;
Out ISA SimpleOutput WITH
attributes:
Graphic ISA Base::Layout WITH
END;

```

```

attributes:
  x_pos := 400;
  y_pos := 150;
  invisible := 1;
END;
END;
icon:
  Graphic ISA Layout WITH
    bitmap TYPE String := "lsensor";
  END;
equation:
  Out = In;
END;

FlowSensorModel ISA SensorClass WITH
  %% Flow sensor that uses the
  %% "pipe"-terminals.
terminals:
  InFlow ISA PipeInTerminal WITH
    attributes:
      Graphic ISA Base::Layout WITH
        attributes:
          x_pos := 0;
          y_pos := 70;
          invisible := 1;
        END;
      END;
  OutFlow ISA PipeOutTerminal WITH
    attributes:
      Graphic ISA Base::Layout WITH
        attributes:
          x_pos := 400;
          y_pos := 70;
          invisible := 1;
        END;
      END;
END;

Flow ISA SimpleOutput WITH
  attributes:
    Graphic ISA Base::Layout WITH
      attributes:
        x_pos := 200;
        y_pos := 300;
        invisible := 1;
      END;
    END;
  icon:
    Graphic ISA Layout WITH
      bitmap TYPE String := "fsensor";
    END;
  equation:
    OutFlow.Flow = InFlow.Flow;
    OutFlow.Pres = InFlow.Pres;
    OutFlow.AConc = InFlow.AConc;
    OutFlow.BConc = InFlow.BConc;
    OutFlow.Temp = InFlow.Temp;
    Flow = InFlow.Flow;
  END;

```

```

LIBRARY GrafcetLib;
%% A library for grafcet primitives.
%% Use steps and transitions to develop
%% sequences inside grafcet.
%%
%% Design: Mats Andersson
%% Modified 930302, Bernt Nilsson

```

```

ParallelSubGrafcetClass ISA SubGrafcetClass;

```

```

%-----
% Terminals

```

```

DiscIntTerminal ISA SimpleTerminal WITH
value TYPE DISCRETE Integer;
default TYPE Integer;
END;

```

```

ConditionTerminal ISA SimpleTerminal;

```

```

DiscBooleanTerminal ISA SimpleTerminal WITH
value TYPE DISCRETE Real;
END;

```

```

StepLTerm ISA RecordTerminal WITH
State ISA DiscIntTerminal;
Trigg ISAN EventInput;
END;

```

```

StepUTerm ISA RecordTerminal WITH
Trigg ISAN EventInput;
END;

```

```

TransUTerm ISA RecordTerminal WITH
State ISA DiscIntTerminal;
Trigg ISAN EventOutput;
END;

```

```

TransITerm ISA RecordTerminal WITH
Trigg ISAN EventOutput;
END;

```

```

GrafcetIntTerminal ISA RecordTerminal WITH
Start, Stop ISAN EventInput;
END;

```

```

GrafcetOutTerminal ISA RecordTerminal WITH
Start, Stop ISAN EventOutput;
END;

```

```

%-----
% Transition

```

```

TransitionIClass ISA SubGrafcetClass WITH
%% Transition super class
terminal:

```

```

Upper ISA TransUTerm WITH
Graphic ISA Base::Layout WITH
x_pos := 200;
y_pos := 300;
invisible := 1;
END;
END;

```

```

Lower ISA TransITerm WITH
Graphic ISA Base::Layout WITH
x_pos := 200;
y_pos := 0;
invisible := 1;
END;
END;
END;

```

```

TransitionC ISA TransitionIClass WITH
%% Condition based transition.
%% The condition is an expression
%% that switch sign.
terminal:
Condition ISA ConditionTerminal WITH
Graphic ISA Base::Layout WITH
x_pos := 400;
y_pos := 150;
invisible := 1;
END;
END;

```

```

behaviour:
OnEvent Condition > 0 AND Upper.State > 0.5 CAUSE
Upper.Trigg, Lower.Trigg;
graphics:
Graphic ISA Layout WITH
bitmap TYPE String := "icontrans";
END;
END;

```

```

TransitionE ISA TransitionIClass WITH
%% Event based transition.
%% Condition is an event input
terminal:
Condition ISA EventInput WITH
Graphic ISA Base::Layout WITH
x_pos := 400;
y_pos := 150;
invisible := 1;
END;
END;

```

```

event:
Init ISAN Event;
variable:
fire TYPE DISCRETE Real;
behaviour:
ONEVENT Init DO new(fire)=0; END;
ONEVENT Condition DO new(fire)=1; END;
ONEVENT fire > 0.5 AND Upper.State > 0.5 CAUSE Upper.Trigg, Lower.Trigg;
graphics:
Graphic ISA Layout WITH
bitmap TYPE String := "iconetrans";
END;
END;

```

```

%-----
% Steps

```

```

StepIClass ISA SubGrafcetClass WITH
%% The basic step object in Grafkets.
terminals:
Upper ISA StepUTerm WITH

```

```

Graphic ISA Base::Layout WITH
  x_pos := 200;
  y_pos := 300;
  invisible := 1;
END;

%-----
% Fork and Sync

Sync 2 ISA ParallelSubGrafcetClass WITH
terminals:
  Upper 1 ISA TransUTerm WITH
    Graphic ISA Base::Layout WITH
      x_pos := 37;
      y_pos := 300;
      invisible := 1;
    END;
  END;
END;

Upper 2 ISA TransUTerm WITH
  Graphic ISA Base::Layout WITH
    x_pos := 365;
    y_pos := 300;
    invisible := 1;
  END;
END;

Lower ISA StepLTerm WITH
  Graphic ISA Base::Layout WITH
    x_pos := 200;
    y_pos := 0;
    invisible := 1;
  END;
END;

behaviour:
  Lower.State := min(Upper 1.State, Upper 2.State);
  OnEvent Lower.Trigg CAUSE Upper 1.Trigg, Upper 2.Trigg;
graphics:
  Graphic ISA Layout WITH
    bitmap TYPE String := "iconsync2";
  END;
END;

Sync 3 ISA ParallelSubGrafcetClass WITH
terminals:
  Upper 1 ISA TransUTerm WITH
    Graphic ISA Base::Layout WITH
      x_pos := 35;
      y_pos := 300;
      invisible := 1;
    END;
  END;
END;

Upper 2 ISA TransUTerm WITH
  Graphic ISA Base::Layout WITH
    x_pos := 365;
    y_pos := 300;
    invisible := 1;
  END;
END;

Upper 3 ISA TransUTerm WITH
  Graphic ISA Base::Layout WITH
    x_pos := 200;
    y_pos := 300;
    invisible := 1;
  END;
END;

Lower ISA StepLTerm WITH
  Graphic ISA Base::Layout WITH
    x_pos := 200;
  END;

```

```

Graphic ISA Base::Layout WITH
  x_pos := 200;
  y_pos := 300;
  invisible := 1;
END;

Lower ISA StepLTerm WITH
  Graphic ISA Base::Layout WITH
    x_pos := 200;
    y_pos := 0;
    invisible := 1;
  END;
END;

State ISA DiscIntTerminal WITH
  Graphic ISA Base::Layout WITH
    x_pos := 200;
    y_pos := 150;
    invisible := 1;
  END;
END;

Step ISA StepIClass WITH
%% The basic step object in Grafquets.
event:
  Action ISAN Event;
behaviour:
  OnEvent Upper.Trigg DO new(State):=1;END;
  OnEvent Upper.Trigg CAUSE Action;
  OnEvent Lower.Trigg DO new(State):=0;END;
  Lower.State:=State;
graphics:
  Graphic ISA Layout WITH
    bitmap TYPE String := "iconstep";
  END;
END;

Initstep ISA step WITH
%% An init step object.
%% Assigns the state true at initialization.
events:
  Init, Start ISAN Event;
behaviour:
  OnEvent Init DO schedule(Start, 0.0); END;
  OnEvent Start DO new(State):=1; END;
  OnEvent Start CAUSE Action;
graphics:
  Graphic ISA Layout WITH
    bitmap TYPE String := "iconinitstep";
  END;
END;

Macrostep ISA StepIClass WITH
%% The macro step object in Grafquets.
%% New steps and transitions are
%% inserted between the terminals.
behaviour:
  OnEvent Upper.Trigg DO new(State):=1;END;
  OnEvent Lower.Trigg DO new(State):=0;END;
graphics:
  Graphic ISA Layout WITH
    bitmap TYPE String := "iconmacrostep";
  END;

```



```

END;
END;
Out ISA DiscBooleanTerminal WITH
  Graphic ISA Base::Layout WITH
    x_pos := 400;
    y_pos := 200;
  END;
END;
InvOut ISA DiscBooleanTerminal WITH
  Graphic ISA Base::Layout WITH
    x_pos := 400;
    y_pos := 100;
  END;
END;
event:
  Timeout, Start, Init ISAN Event;
parameter:
  PulseTime ISA Parameter WITH default := 1.0; END;
behaviour:
  OnEvent In > 0.5 CAUSE Start;
  OnEvent Start DO
    new(out) := 1.0;
    new(invOut) := 0.0;
    schedule(Timeout, PulseTime);
  END;
  OnEvent Timeout DO
    new(out) := 0.0;
    new(invOut) := 1.0;
  END;
  OnEvent Init DO new(invOut) := 1.0; END;
END;

%-----
% grafcet applications

GrafcetClass ISA GrafcetControllerClass WITH
  %% A super class for grafcet applications.
  Graphic ISA Layout WITH
    x_size := 400;
    y_size := 600;
    bitmap TYPE String := "icongrafcet";
  END;
END;

```

```

LIBRARY CSTRControlLib;

USES ModelClassTreeLib, ProcessTerminalLib, ControlTerminalLib, EnergyEquipmentLib, $
    ^ ReactionModelLib, CSTRLib;

%% This library contains classes
%% for an simple application of an
%% CSTR unit with control system.
%%-----
%% CSTR controllers

CSTRCController ISA ModelClassTreeLib::UnitController WITH
    %% CSTR continuous controller with three
    %% individual PID controllers.
    icon:
        Graphic ISA super::Graphic;
    parameter:
        Lref ISA Base::Parameter;
        Tref ISA Base::Parameter;
        Fref ISA Base::Parameter;
    equation:
        LevelPID.SetPoint := Lref;
        TempPID.SetPoint := Tref;
        FlowPID.SetPoint := Fref;
    terminals:
        Measure ISA ControlTerminalLib::CSTRInMeasure WITH
            Graphic ISA super::Graphic WITH
                x_pos := 0.0;
                y_pos := 150.0;
            END;
        Control ISA ControlTerminalLib::CSTROutControl WITH
            Graphic ISA super::Graphic WITH
                x_pos := 400.0;
                y_pos := 150.0;
            END;
        submodels:
            LevelPID ISA ControlSystemLib::PIDControllerModel WITH
                Graphic ISA super::Graphic WITH
                    x_pos := 250.0;
                    y_pos := 75.0;
                END;
            TempPID ISA ControlSystemLib::PIDControllerModel WITH
                Graphic ISA super::Graphic WITH
                    x_pos := 200.0;
                    y_pos := 150.0;
                END;
            FlowPID ISA ControlSystemLib::PIDControllerModel WITH
                Graphic ISA super::Graphic WITH
                    x_pos := 150.0;
                    y_pos := 225.0;
                END;
        connections:
            C1 ISA Base::Connection WITH
                Measure.OutFlow AT FlowPID.Measure;
                bpoints TYPE Matrix [4, 2] := [0, 149; 34, 174; 34, 224; 132, 224];
            END;
            C2 ISA Base::Connection WITH
                Control.OutFlow AT FlowPID.Control;
        END;
    END;

bpoints TYPE Matrix [4, 2] := [399, 149; 367, 179; 367, 224; 166, 224];
END;

C11 ISA Base::Connection WITH
    Measure.VTemp AT TempPID.Measure;
    bpoints TYPE Matrix [2, 2] := [0, 149; 182, 149];
END;

C12 ISA Base::Connection WITH
    Measure.Level AT LevelPID.Measure;
    bpoints TYPE Matrix [4, 2] := [0, 149; 32, 120; 32, 74; 232, 74];
END;

C13 ISA Base::Connection WITH
    Control.Cool AT TempPID.Control;
    bpoints TYPE Matrix [2, 2] := [216, 149; 399, 149];
END;

C14 ISA Base::Connection WITH
    Control.Feed AT LevelPID.Control;
    bpoints TYPE Matrix [5, 2] := [399, 149; 382, 135; 368, 121; 368, 74; 266, 74];
END;

CControlCSTRModel ISA CSTRLib::CSTRIClass WITH
    %% A CSTR with a continuous control system.
    structure parameter:
        ChemDim := CSTRUnit.ChemDim;
    icon:
        Graphic ISA super::Graphic;
    submodels:
        CSTRUnit ISA CSTRLib::CSTRUnitModel WITH
            Graphic ISA super::Graphic WITH
                x_pos := 175.0;
                y_pos := 100.0;
            END;
        Controller ISA CSTRControlLib::CSTRCController WITH
            Graphic ISA super::Graphic WITH
                x_pos := 225.0;
                y_pos := 200.0;
            END;
    connections:
        C4 ISA Base::Connection WITH
            Feed AT CSTRUnit.Feed;
            bpoints TYPE Matrix [4, 2] := [0, 199; 117, 199; 117, 109; 145, 109];
        END;
        C5 ISA Base::Connection WITH
            out AT CSTRUnit.out;
            bpoints TYPE Matrix [4, 2] := [204, 84; 319, 84; 319, 75; 400, 75];
        END;
        C6 ISA Base::Connection WITH
            Cool AT CSTRUnit.Cool;
            bpoints TYPE Matrix [4, 2] := [0, 100; 83, 100; 83, 94; 145, 94];
        END;
        C15 ISA Base::Connection WITH
            CSTRUnit.Measure AT Controller.Measure;
            bpoints TYPE Matrix [3, 2] := [159, 129; 159, 199; 194, 199];
        END;
        C16 ISA Base::Connection WITH
            Controller.Control AT CSTRUnit.Control;
            bpoints TYPE Matrix [5, 2] := [253, 199; 285, 199; 285, 149; 196, 149; 129];
        END;
    END;
    %%-----

```

```

%%sequence and continuous control

CSTRGrafcet ISA GrafcetLib::GrafcetClass WITH
terminals:
  OutFlow ISA ControlTerminalLib::ManualControlOutDiscreteTerminal WITH
    x_pos := 400.0;
    y_pos := 225.0;
    invisible := 1;
  END;
END;

InFlow ISA ControlTerminalLib::ManualControlOutDiscreteTerminal WITH
  x_pos := 400.0;
  y_pos := 525.0;
  invisible := 1;
END;

CoolFlow ISA ControlTerminalLib::ManualControlOutDiscreteTerminal WITH
  x_pos := 400.0;
  y_pos := 375.0;
  invisible := 1;
END;

Ref ISA Base::RecordTerminal WITH
  x_pos := 200.0;
  y_pos := 0.0;
  invisible := 1;
END;

Lref ISA Base::SimpleOutput WITH value TYPE DISCRETE Real; END;
Tref ISA Base::SimpleOutput WITH value TYPE DISCRETE Real; END;
Fref ISA Base::SimpleOutput WITH value TYPE DISCRETE Real; END;

Level ISA Base::SimpleInput WITH
  x_pos := 0.0;
  y_pos := 400.0;
  invisible := 1;
END;

SuperControl ISA GrafcetLib::GrafcetInTerminal WITH
  x_pos := 275.0;
  y_pos := 600.0;
  invisible := 1;
END;

% ONEVENT SuperControl.Start CAUSE StartTransition.Condition;
% ONEVENT SuperControl.Stop CAUSE StopTransition.Condition;
parameters:
  StartTime ISA Base::Parameter;
  StopTime ISA Base::Parameter;
  LevelRef ISA Base::Parameter;
  FlowRef ISA Base::Parameter;
  TempRef ISA Base::Parameter;
  TempReflow ISA Base::Parameter;
events:
  Init ISA Base::Event;
  Local ISA Base::Event;
  %% At local control add following in subclass

ONEVENT Init CAUSE Local;
ONEVENT Local DO
  schedule(StartTransition.Condition, StartTime);
  schedule(StopTransition.Condition, StopTime);
END;

equations:
  OutFlow.Manual := 1;
  Ref.Pref := FlowRef;
submodels:
  Wait ISA GrafcetLib::InitStep WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 550.0;
  END;
  ONEVENT Action DO
    new(OutFlow.UMan) := 0;
    new(InFlow.Manual) := 1;
    new(InFlow.UMan) := 0;
    new(Ref.Iref) := LevelRef;
    new(CoolFlow.Manual) := 1;
    new(CoolFlow.UMan) := 0;
  END;
END;

StartTransition ISA GrafcetLib::TransitionE WITH
  Graphic ISA super::Graphic WITH
    x_pos := 200.0;
    y_pos := 500.0;
  END;
END;

Start ISA GrafcetLib::Step WITH
  Graphic ISA super::Graphic WITH
    x_pos := 200.0;
    y_pos := 450.0;
  END;
  ONEVENT Action DO
    new(InFlow.Manual) := 0;
    new(Ref.Iref) := LevelRef;
    new(Ref.Tref) := TempRef;
  END;
END;

ProdTransition ISA GrafcetLib::TransitionC WITH
  Graphic ISA super::Graphic WITH
    x_pos := 200.0;
    y_pos := 400.0;
  END;
  Condition := Level - 0.9*LevelRef;
END;

Production ISA GrafcetLib::Step WITH
  Graphic ISA super::Graphic WITH
    x_pos := 200.0;
    y_pos := 350.0;
  END;
  WHEN Action DO
    new(OutFlow.UMan) := FlowRef;
    new(CoolFlow.Manual) := 0;
    new(Ref.Tref) := TempRef;
  END;
END;

StopTransition ISA GrafcetLib::TransitionE WITH
  Graphic ISA super::Graphic WITH
    x_pos := 200.0;
    y_pos := 300.0;
  END;

```

```

END;
stop ISA GrafcetLib::Step WITH
  Graphic ISA super::Graphic WITH
    x_pos := 200.0;
    y_pos := 250.0;
  END;
WHEN Action DO
  new(InFlow.Manual) := 1;
  new(CoolFlow.Manual) := 1;
  new(CoolFlow.UMan) := 1;
END;
END;
WaitTransition ISA GrafcetLib::TransitionC WITH
  Graphic ISA super::Graphic WITH
    x_pos := 200.0;
    y_pos := 200.0;
  END;
  Condition := -(Level - 0.1*LevelRef);
END;
state:
  State ISA Base::Variable;
  State = Wait.State + 2*Start.State + 3*Production.State + 4*Stop.State;
connections:
  C1 ISA Base::Connection WITH
    Wait.Lower AT StartTransition.Upper;
    bpoints TYPE Matrix [2, 2] := [199, 532; 199, 507];
  END;
  C2 ISA Base::Connection WITH
    StartTransition.Lower AT Start.Upper;
    bpoints TYPE Matrix [2, 2] := [199, 491; 199, 466];
  END;
  C3 ISA Base::Connection WITH
    Start.Lower AT ProdTransition.Upper;
    bpoints TYPE Matrix [2, 2] := [199, 432; 199, 407];
  END;
  C4 ISA Base::Connection WITH
    ProdTransition.Lower AT Production.Upper;
    bpoints TYPE Matrix [2, 2] := [199, 391; 199, 366];
  END;
  C6 ISA Base::Connection WITH
    Production.Lower AT StopTransition.Upper;
    bpoints TYPE Matrix [2, 2] := [199, 332; 199, 307];
  END;
  C7 ISA Base::Connection WITH
    StopTransition.Lower AT Stop.Upper;
    bpoints TYPE Matrix [2, 2] := [199, 291; 199, 266];
  END;
  C8 ISA Base::Connection WITH
    Stop.Lower AT WaitTransition.Upper;
    bpoints TYPE Matrix [2, 2] := [199, 232; 199, 207];
  END;
  C10 ISA Base::Connection WITH
    WaitTransition.Lower AT Wait.Upper;
    bpoints TYPE Matrix [6, 2] := [199, 191; 199, 174; 150, 174; 150, 586; 199, 586; $
      ^ 199, 566];
  END;
END;
END;
CSTRIController ISA ModelClassTreeLib::UnitController WITH
  %% An integrated CSRR unit controller with
  %% start up and shot down sequence and
  %% continuous controllers.
  icon:
    invisible_connections:
      LevelPID.SetPoint := Grafcet.Ref.Iref;
      TempPID.SetPoint := Grafcet.Ref.Tref;
      FlowPID.SetPoint := Grafcet.Ref.Fref;
    connections:
      C1 ISA Base::Connection WITH
        Measure.OutFlow AT FlowPID.Measure;

```

```

bpoints TYPE Matrix [2, 2] := [0, 149; 182, 149];
END;
C2 ISA Base::Connection WITH
  FlowPID.Control AT Control.OutFlow;
bpoints TYPE Matrix [2, 2] := [216, 149; 399, 149];
END;
C3 ISA Base::Connection WITH
  Measure.VTemp AT TempPID.Measure;
bpoints TYPE Matrix [3, 2] := [0, 149; 66, 99; 232, 99];
END;
C4 ISA Base::Connection WITH
  SuperControl AT Grafcet.SuperControl;
bpoints TYPE Matrix [2, 2] := [150.0, 300.0; 155.0, 266.0];
END;
C5 ISA Base::Connection WITH
  Measure.Level AT LevelPID.Measure;
bpoints TYPE Matrix [4, 2] := [0, 149; 23, 100; 23, 49; 282, 49];
END;
C7 ISA Base::Connection WITH
  Control.Feed AT LevelPID.Control;
bpoints TYPE Matrix [4, 2] := [399, 149; 372, 119; 372, 49; 316, 49];
END;
C8 ISA Base::Connection WITH
  Control.Cool AT TempPID.Control;
bpoints TYPE Matrix [4, 2] := [399, 149; 347, 124; 347, 99; 266, 99];
END;
C9 ISA Base::Connection WITH
  Measure.Level AT Grafcet.Level;
bpoints TYPE Matrix [5, 2] := [0, 149; 21, 165; 33, 180; 33, 254; 132, 254];
END;
C16 ISA Base::Connection WITH
  Grafcet.OutFlow AT FlowPID.AutoMan;
bpoints TYPE Matrix [3, 2] := [166, 245; 199, 245; 199, 166];
END;
C17 ISA Base::Connection WITH
  Grafcet.CoolFlow AT TempPID.AutoMan;
bpoints TYPE Matrix [3, 2] := [166, 253; 249, 253; 249, 116];
END;
C18 ISA Base::Connection WITH
  Grafcet.InFlow AT LevelPID.AutoMan;
bpoints TYPE Matrix [3, 2] := [166, 262; 299, 262; 299, 66];
END;
END;

IControlCSTRModel ISA CSTRLib::CSTRIClass WITH
  %% A CSTR unit with an integrated control system.
  %% Sequence with start up and shot down and
  %% three continuous controllers.
  structure_parameter:
    ChemDim := CSTRUnit.ChemDim;
  icon:
    Graphic ISA super::Graphic;
  terminals:
    SuperControl ISA GrafcetLib::GrafcetInTerminal WITH
      Graphic ISA super::Graphic WITH
        x_pos := 225.0;
        y_pos := 300.0;
        invisible := 1;
    END;
  END;
  submodels:
    CSTRUnit ISA CSTRLib::CSTRUnitModel WITH
      Graphic ISA super::Graphic WITH

```

```

    x_pos := 175.0;
    y_pos := 100.0;
  END;
END;
Controller ISA CSTRControlLib::CSTRIController WITH
  Graphic ISA super::Graphic WITH
    x_pos := 225.0;
    y_pos := 200.0;
  END;
END;
connections:
  C4 ISA Base::Connection WITH
    Feed AT CSTRUnit.Feed;
  bpoints TYPE Matrix [4, 2] := [0, 199; 117, 199; 117, 109; 145, 109];
  END;
  C5 ISA Base::Connection WITH
    out AT CSTRUnit.out;
  bpoints TYPE Matrix [4, 2] := [204, 84; 319, 84; 319, 75; 400, 75];
  END;
  C6 ISA Base::Connection WITH
    Cool AT CSTRUnit.Cool;
  bpoints TYPE Matrix [4, 2] := [0, 100; 83, 100; 83, 94; 145, 94];
  END;
  C15 ISA Base::Connection WITH
    CSTRUnit.Measure AT Controller.Measure;
  bpoints TYPE Matrix [3, 2] := [159, 129; 159, 199; 194, 199];
  END;
  C16 ISA Base::Connection WITH
    Controller.Control AT CSTRUnit.Control;
  bpoints TYPE Matrix [5, 2] := [253, 199; 285, 199; 285, 149; 196, 149; 129];
  END;
  C7 ISA Base::Connection WITH
    SuperControl AT Controller.SuperControl;
  bpoints TYPE Matrix [4, 2] := [224.0, 299.0; 224.0, 249.0; 217.0, 249.0; 217.0, 219.0];
  END;
END;
END;

```

```

LIBRARY CSTRWosp;

USES ModelClassTreeLib, ProcessTerminalLib, ControlTerminalLib, EnergyEquipmentLib, $
    ^ ReactionModelLib, CSTRLib, CSTRControlLib;

%% This knowledge base contains classes
%% for an simple application of an open
%% loop CSTR.

VesselSimProblem ISA CSTRLib::TankReactorVesselModel WITH
    In.Flow := 24; % kmole / h
    In.MoleEnergy := 2380; % kJ / kmole
    In.Comp := [0.375;0;0.625]; % kmole / kmole
    Out.Flow := 24;
    HTOut.QTrans := 0;
    CrossArea := 1;
    ReactorMachine ISA super::ReactorMachine WITH
        Xmole.initial := [0;0;72.2]; % kmole
        energy.initial := 114000; % kJ
    END;
END;

TankReactorSimProblem ISA CSTRLib::TankReactorModel WITH
    Wall.Kappa.default := 3070;
    Wall.TransArea.default := 23;
    Jacket.Cp.default := 4.190;
    Jacket.Volume.default := 0.110;
    Jacket.Density.default := 1000;
    Jacket.Temp.initial := 294;
    ReactorVessel.CrossArea.default := 1;
END;

TankReactorSimProblem2 ISA CSTRWosp::TankReactorSimProblem WITH
    Flow ISA Base::Parameter WITH
        default := 24;
    END;
    Cool.Flow := 1.40;
    Cool.Pres := 0;
    Cool.Temp := 294;
    In.Flow := Flow;
    In.MoleEnergy := 2380;
    In.Comp := [0.375;0;0.625];
    Out.Flow := Flow;
    ReactorVessel.ReactorMachine.Xmole.initial := [0;0;72.2];
    ReactorVessel.ReactorMachine.energy.initial := 114000;
END;

%%-----
%%CSTR unit

CSTRSimProblem ISA CSTRLib::CSTRUnitModel WITH
    CSTR ISA super::CSTR WITH
        Wall.Kappa.default := 3070;
        Wall.TransArea.default := 23;
        Jacket.Cp.default := 4.190;
        Jacket.Volume.default := 0.110;
        Jacket.Density.default := 1000;
        Jacket.Temp.initial := 294;
        ReactorVessel ISA super::ReactorVessel WITH
            CrossArea.default := 1;
            ReactorMachine ISA super::ReactorMachine WITH
                Xmole.initial := [0;0;72.2];
            END;
        END;
    END;

energy.initial := 114000;
END;

Control.Cool := 0.50;
CoolValve.Qmax := 2.80;
Cool.Pres := 0;
Cool.Temp := 21;
Control.Feed := 0.48;
FeedValve.Qmax := 50;
Feed.MoleEnergy := 2380;
Feed.Comp := [0.375;0;0.625];
Control.OutFlow := 0.48;
OutValve.Qmax := 50;
END;

%%-----
%% controlled unit

CControlCSTRSimProblem ISA CSTRControlLib::CControlCSTRModel WITH
    CSTRUnit ISA super::CSTRUnit WITH
        CSTR ISA super::CSTR WITH
            Wall.Kappa.default := 3070;
            Wall.TransArea.default := 23;
            Jacket.Cp.default := 4.190;
            Jacket.Volume.default := 0.110;
            Jacket.Density.default := 1000;
            Jacket.Temp.initial := 294;
            ReactorVessel ISA super::ReactorVessel WITH
                CrossArea.default := 1;
                ReactorMachine.Xmole.initial := [0;0;72.2];
                ReactorMachine.energy.initial := 114000;
            END;
            Graphic ISA super::Graphic;
        END;
        CoolValve.Qmax.default := 2.80;
        FeedValve.Qmax.default := 50;
        OutValve.Qmax.default := 50;
        Graphic ISA super::Graphic;
    END;
    Controller ISA super::Controller WITH
        Channel ISA Base::Parameter;
        LevelPID ISA super::LevelPID WITH
            PIDModule ISA super::PIDModule WITH
                uHigh := 1;
                uReverse := 0;
            Don := 0;
            Ion.default := 1;
            N := 5;
            tr.default := 0.050;
            b := 1;
            Td := 5;
            Ti.default := 0.010;
            K.default := 100;
        END;
        Graphic ISA super::Graphic;
    END;
    TempPID ISA super::TempPID WITH
        PIDModule ISA super::PIDModule WITH
            uHigh := 1;
            uReverse.default := 1;
            Don := 0;

```

```

Ion.default := 1;
N := 5;
tr.default := 10;
b := 1;
Td := 5;
Ti.default := 10;
K.default := 1;
END;
Graphic ISA super::Graphic;
END;
FlowPID ISA super::FlowPID WITH
PID Module ISA super::PID_Module WITH
uHigh := 1;
uReverse.default := 0;
Don := 0;
Ion.default := 0;
N := 5;
tr.default := 10;
b := 1;
Td := 5;
Ti.default := 10;
K.default := 1;
Graphic ISA super::Graphic;
END;
Graphic ISA super::Graphic;
END;
Lref.default := 1.30;
Tref.default := 27;
Fref.default := 0.48;
LevelPID.AutoMan.Manual := Channel;
LevelPID.AutoMan.UMan := 0.50;
TempPID.AutoMan.Manual := Channel;
TempPID.AutoMan.UMan := 0.50;
FlowPID.AutoMan.Manual := 1;
FlowPID.AutoMan.UMan := Fref;
Graphic ISA super::Graphic;
END;
Cool.Pres := 0;
Cool.Temp := 21;
Feed.MoleEnergy := 2380;
Feed.Comp := [0.375;0;0.625];
Graphic ISA super::Graphic;
END;

**-----
**sequence and continuous control
**-----

IControlCSTRSimProblem ISA CSTRControlLib::IControlCSTRModel WITH
CSTRUnit ISA super::CSTRUnit WITH
CSTR ISA super::CSTR WITH
Wall.Kappa.default := 3070;
Wall.TransArea.default := 23;
Jacket.Cp.default := 4.190;
Jacket.Volume.default := 0.110;
Jacket.Density.default := 1000;
Jacket.Temp.initial := 21;
ReactorVessel ISA super::ReactorVessel WITH
CrossArea.default := 1;
ReactorMachine.Xmole.initial := [0;0;7.2];
ReactorMachine.energy.initial := 11400;
END;
Graphic ISA super::Graphic;
END;

Ion.default := 1;
CoolValve.Qmax.default := 2.80;
FeedValve.Qmax.default := 50;
OutValve.Qmax.default := 50;
Graphic ISA super::Graphic;
END;
Controller ISA super::Controller WITH
Grafcet ISA super::Grafcet WITH
StartTime.default := 1;
StopTime.default := 45;
TempReflow := 21;
ONEVENT Init CAUSE Local;
END;
LevelPID ISA super::LevelPID WITH
PID Module ISA super::PID_Module WITH
uHigh := 1;
uReverse := 0;
Don := 0;
Ion.default := 1;
N := 5;
tr.default := 10;
b := 1;
Td := 5;
Ti.default := 1;
K.default := 3;
END;
Graphic ISA super::Graphic;
END;
TempPID ISA super::TempPID WITH
PID Module ISA super::PID_Module WITH
uHigh := 1;
uReverse.default := 1;
Don := 0;
Ion.default := 1;
N := 5;
tr.default := 10;
b := 1;
Td := 5;
Ti.default := 5;
K.default := 5;
END;
Graphic ISA super::Graphic;
END;
FlowPID ISA super::FlowPID WITH
PID Module ISA super::PID_Module WITH
uHigh := 1;
uReverse.default := 0;
Don := 0;
Ion.default := 0;
N := 5;
tr.default := 10;
b := 1;
Td := 5;
Ti.default := 10;
K.default := 1;
Graphic ISA super::Graphic;
END;
Lref.default := 1.30;
Tref.default := 67;
Fref.default := 0.50;
END;

```

```
Cool.Pres := 0;  
Cool.Temp := 21;  
Feed.MoleEnergy := 2380;  
Feed.Comp := [0.375;0;0.625];  
Graphic ISA super::Graphic;  
END;
```



```

LIBRARY DistillationControlLib;

USES ModelClassTreeLib, ProcessTerminalLib, ControlTerminalLib, PhaseEquilibLib,$
    ^ FlowEquipmentLib, EnergyEquipmentLib, GrafcetLib,$
    ^ ControlSystemLib, DistillationLib;

** This library contains classes
** for an simple application of an
** distillation unit with control system.
**-----
** distillation controllers

DistCController ISA ModelClassTreeLib::UnitController WITH
    ** Distillation unit continuous control system.
    ** Composed of four PID controller.
    Graphic ISA super::Graphic;
terminals:
    Measure ISA ControlTerminalLib::DistInMeasure WITH
        Graphic ISA super::Graphic WITH
            x_pos := 0.0;
            y_pos := 150.0;
        END;
    END;
    Control ISA ControlTerminalLib::DistOutControl WITH
        Graphic ISA super::Graphic WITH
            x_pos := 400.0;
            y_pos := 150.0;
        END;
    END;
submodels:
    BoilerLevelPID ISA ControlSystemLib::PIDControllerModel WITH
        Graphic ISA super::Graphic WITH
            x_pos := 250.0;
            y_pos := 50.0;
        END;
    END;
    BottomCompPID ISA ControlSystemLib::PIDControllerModel WITH
        Graphic ISA super::Graphic WITH
            x_pos := 175.0;
            y_pos := 75.0;
        END;
    END;
    DrumLevelPID ISA ControlSystemLib::PIDControllerModel WITH
        Graphic ISA super::Graphic WITH
            x_pos := 250.0;
            y_pos := 150.0;
        END;
    END;
    TopCompPID ISA ControlSystemLib::PIDControllerModel WITH
        Graphic ISA super::Graphic WITH
            x_pos := 175.0;
            y_pos := 175.0;
        END;
    END;
connections:
    C1 ISA Base::Connection WITH
        Measure.BoilerLevel AT BoilerLevelPID.Measure;
        bpoints TYPE Matrix [4, 2] := [0.0, 150.0; 24.0, 111.0; 24.0, 49.0; 232.0, 49.0];
    END;
    C2 ISA Base::Connection WITH
        Measure.BottomComp AT BottomCompPID.Measure;
        bpoints TYPE Matrix [4, 2] := [0.0, 150.0; 42.0, 124.0; 42.0, 74.0; 157.0, 74.0];
    END;

```

```

C6 ISA Base::Connection WITH
    BottomCompPID.Control AT Control.Heat;
    bpoints TYPE Matrix [4, 2] := [191.0, 74.0; 345.0, 74.0; 345.0, 110.0; 400.0,$
        ^ 150.0];
END;
C7 ISA Base::Connection WITH
    BoilerLevelPID.Control AT Control.Bottom;
    bpoints TYPE Matrix [4, 2] := [266.0, 49.0; 373.0, 49.0; 373.0, 111.0; 400.0,$
        ^ 150.0];
END;
C8 ISA Base::Connection WITH
    Measure.DrumLevel AT DrumLevelPID.Measure;
    bpoints TYPE Matrix [2, 2] := [0.0, 150.0; 232.0, 149.0];
END;
C9 ISA Base::Connection WITH
    DrumLevelPID.Control AT Control.Top;
    bpoints TYPE Matrix [2, 2] := [266.0, 149.0; 400.0, 150.0];
END;
C10 ISA Base::Connection WITH
    Measure.TopComp AT TopCompPID.Measure;
    bpoints TYPE Matrix [3, 2] := [0.0, 150.0; 41.0, 174.0; 157.0, 174.0];
END;
C12 ISA Base::Connection WITH
    TopCompPID.Control AT Control.Reflux;
    bpoints TYPE Matrix [3, 2] := [191.0, 174.0; 367.0, 174.0; 400.0, 150.0];
END;
END;

CControlDist3TModel ISA ModelClassTreeLib::SeparatorClass WITH
    icon:
        Graphic ISA super::Graphic;
    submodels:
        Controller ISA DistillationControlLib::DistCController WITH
            Graphic ISA super::Graphic WITH
                x_pos := 225.0;
                y_pos := 275.0;
            END;
        END;
        DistUnit ISA DistillationLib::Distillation3TUnitModel WITH
            Graphic ISA super::Graphic WITH
                x_pos := 175.0;
                y_pos := 125.0;
            END;
        END;
    connections:
        C1 ISA Base::Connection WITH
            Controller.Measure AT DistUnit.Measurement;
            bpoints TYPE Matrix [3, 2] := [194.0, 274.0; 167.0, 274.0; 167.0, 223.0];
        END;
        C2 ISA Base::Connection WITH
            Controller.Control AT DistUnit.Control;
            bpoints TYPE Matrix [5, 2] := [253.0, 274.0; 288.0, 274.0; 288.0, 236.0; 192.0,$
                ^ 236.0; 192.0, 223.0];
        END;
    END;
END;

CControlDist9TModel ISA ModelClassTreeLib::SeparatorClass WITH
    icon:
        Graphic ISA super::Graphic;
    submodels:
        Controller ISA DistillationControlLib::DistCController WITH
            Graphic ISA super::Graphic WITH
                x_pos := 225.0;

```

```

        y_pos := 275.0;
    END;
END;
DistUnit ISA DistillationLib::Distillation9UnitModel WITH
    Graphic ISA super::Graphic WITH
        x_pos := 175.0;
        y_pos := 125.0;
    END;
END;
connections:
    C1 ISA Base::Connection WITH
        Controller.Measure AT DistUnit.Measurement;
        bpoints TYPE Matrix [3, 2] := [194.0, 274.0; 167.0, 274.0; 167.0, 223.0];
    END;
    C2 ISA Base::Connection WITH
        Controller.Control AT DistUnit.Control;
        bpoints TYPE Matrix [5, 2] := [253.0, 274.0; 288.0, 274.0; 288.0, 236.0; 192.0, 236.0; 192.0, 223.0];
    END;
END;
END;
%%-----
%% distillation sequential controller
DistGrafcet ISA GrafcetLib::GrafcetClass WITH
    %% A Grafcet sequential controller for a
    %% distillation column.
    Graphic ISA super::Graphic;
terminals:
    BoilerLevelPID ISA ControlTerminalLib::ManualControlOutDiscreteTerminal WITH
        Graphic ISA super::Graphic WITH
            x_pos := 400.0;
            y_pos := 225.0;
            invisible := 1;
    END;
    BottomCompPID ISA ControlTerminalLib::ManualControlOutDiscreteTerminal WITH
        Graphic ISA super::Graphic WITH
            x_pos := 400.0;
            y_pos := 325.0;
            invisible := 1;
    END;
    DrumLevelPID ISA ControlTerminalLib::ManualControlOutDiscreteTerminal WITH
        Graphic ISA super::Graphic WITH
            x_pos := 400.0;
            y_pos := 425.0;
            invisible := 1;
    END;
    TopCompPID ISA ControlTerminalLib::ManualControlOutDiscreteTerminal WITH
        Graphic ISA super::Graphic WITH
            x_pos := 400.0;
            y_pos := 525.0;
            invisible := 1;
    END;
    Measure ISA Base::RecordTerminal WITH
        Graphic ISA super::Graphic WITH
            x_pos := 0.0;
            y_pos := 400.0;
            invisible := 1;
    END;

```

```

    LB ISA Base::SimpleInput;
    LD ISA Base::SimpleInput;
END;
SuperControl ISA GrafcetLib::GrafcetInTerminal WITH
    Graphic ISA super::Graphic WITH
        x_pos := 275.0;
        y_pos := 600.0;
        invisible := 1;
    END;
END;
% ONEVENT SuperControl.Start CAUSE StartTransition.Condition;
% ONEVENT SuperControl.Stop CAUSE Local;
parameters:
    StartTime ISA Base::Parameter;
    StopTime ISA Base::Parameter;
    Lbmin ISA Base::Parameter;
    Ldmax ISA Base::Parameter;
    Ldmin ISA Base::Parameter;
events:
    Init ISA Base::Event;
    Local ISA Base::Event;
    %% At local control add following in subclass
    ONEVENT Init CAUSE Local;
    ONEVENT Local DO
        schedule(StartTransition.Condition, StartTime);
        schedule(StopTransition.Condition, StopTime);
    END;
submodels:
    Wait ISA GrafcetLib::InitStep WITH
        Graphic ISA super::Graphic WITH
            x_pos := 200.0;
            y_pos := 550.0;
    END;
    ONEVENT Action DO
        new(BoilerLevelPID.Manual) := 1;
        new(BoilerLevelPID.UMan) := 0;
        new(BottomCompPID.Manual) := 1;
        new(BottomCompPID.UMan) := 0;
        new(DrumLevelPID.Manual) := 1;
        new(DrumLevelPID.UMan) := 0;
        new(TopCompPID.Manual) := 1;
        new(TopCompPID.UMan) := 0;
    END;
END;
StartTransition ISA GrafcetLib::TransitionE WITH
    Graphic ISA super::Graphic WITH
        x_pos := 200.0;
        y_pos := 500.0;
    END;
END;
Start ISA GrafcetLib::Step WITH
    Graphic ISA super::Graphic WITH
        x_pos := 200.0;
        y_pos := 450.0;
    END;
    ONEVENT Action DO
        new(BoilerLevelPID.Manual) := 0;
        new(BottomCompPID.Manual) := 0;
    END;
END;
ProdTransition ISA GrafcetLib::TransitionC WITH
    Graphic ISA super::Graphic WITH
        x_pos := 200.0;
    END;

```



```

Graphic ISA super::Graphic WITH
  x_pos := 250.0;
  y_pos := 150.0;
END;
END;
TopCompPID ISA ControlSystemLib::PIDControllerModel WITH
Graphic ISA super::Graphic WITH
  x_pos := 175.0;
  y_pos := 175.0;
END;
END;
Grafcet ISA DistillationControlLib::DistGrafcet WITH
Graphic ISA super::Graphic WITH
  x_pos := 75.0;
  y_pos := 250.0;
END;
END;
equations:
  BoilerLevelPID.SetPoint := B1ref;
  DrumLevelPID.SetPoint := D1ref;
  BottomCompPID.SetPoint := B1ref;
  TopCompPID.SetPoint := T1ref;
connections:
  C3 ISA Base::Connection WITH
    Grafcet.TopCompPID AT TopCompPID.AutoMan;
    bpoints TYPE Matrix [3, 2] := [91.0, 261.0; 174.0, 261.0; 174.0, 191.0];
  END;
  C4 ISA Base::Connection WITH
    Grafcet.DrumLevelPID AT DrumLevelPID.AutoMan;
    bpoints TYPE Matrix [3, 2] := [91.0, 256.0; 249.0, 256.0; 249.0, 166.0];
  END;
  C5 ISA Base::Connection WITH
    Grafcet.BottomCompPID AT BottomCompPID.AutoMan;
    bpoints TYPE Matrix [5, 2] := [91.0, 250.0; 127.0, 250.0; 127.0, 132.0; 174.0, 132.0; 174.0, 91.0];
  END;
  C11 ISA Base::Connection WITH
    Grafcet.BoilerLevelPID AT BoilerLevelPID.AutoMan;
    bpoints TYPE Matrix [5, 2] := [91.0, 244.0; 119.0, 244.0; 119.0, 125.0; 249.0, 125.0; 249.0, 66.0];
  END;
  C13 ISA Base::Connection WITH
    Measure.BoilerLevel AT Grafcet.Measure.LB;
    Measure.DrumLevel AT Grafcet.Measure.ID;
    bpoints TYPE Matrix [4, 2] := [0.0, 149.0; 38.0, 189.0; 38.0, 254.0; 57.0, 254.0];
  END;
  C1 ISA Base::Connection WITH
    Measure.BoilerLevel AT BoilerLevelPID.Measure;
    bpoints TYPE Matrix [4, 2] := [0.0, 150.0; 24.0, 111.0; 24.0, 49.0; 232.0, 49.0];
  END;
  C2 ISA Base::Connection WITH
    Measure.BottomComp AT BottomCompPID.Measure;
    bpoints TYPE Matrix [4, 2] := [0.0, 150.0; 42.0, 124.0; 42.0, 74.0; 157.0, 74.0];
  END;
  C6 ISA Base::Connection WITH
    BottomCompPID.Control AT Control.Heat;
    bpoints TYPE Matrix [4, 2] := [191.0, 74.0; 345.0, 74.0; 345.0, 110.0; 400.0, 150.0];
  END;
  C7 ISA Base::Connection WITH
    BoilerLevelPID.Control AT Control.Bottom;
    bpoints TYPE Matrix [4, 2] := [266.0, 49.0; 373.0, 49.0; 373.0, 111.0; 400.0, 150.0];
  END;
END;
Graphic ISA super::Graphic WITH
  Measure.DrumLevel AT DrumLevelPID.Measure;
  bpoints TYPE Matrix [2, 2] := [0.0, 150.0; 232.0, 149.0];
END;
END;
C9 ISA Base::Connection WITH
  DrumLevelPID.Control AT Control.Top;
  bpoints TYPE Matrix [2, 2] := [266.0, 149.0; 400.0, 150.0];
END;
END;
C10 ISA Base::Connection WITH
  Measure.TopComp AT TopCompPID.Measure;
  bpoints TYPE Matrix [3, 2] := [0.0, 150.0; 41.0, 174.0; 157.0, 174.0];
END;
END;
C12 ISA Base::Connection WITH
  TopCompPID.Control AT Control.Reflux;
  bpoints TYPE Matrix [3, 2] := [191.0, 174.0; 367.0, 174.0; 400.0, 150.0];
END;
END;
C14 ISA Base::Connection WITH
  SuperControl AT Grafcet.SuperControl;
  bpoints TYPE Matrix [4, 2] := [200.0, 300.0; 200.0, 277.0; 80.0, 277.0; 80.0, 266.0];
END;
END;
IControlDistgTModel ISA DistillationLib::DistillationUnitIClass WITH
  Icon:
    Graphic ISA super::Graphic WITH y_size := 300; END;
  structure parameter:
    ChemDim := DistUnit.MediumModel.NumberOfComponents;
  terminals:
    Feed ISA super::Feed WITH
      Graphic ISA super::Graphic WITH y_pos := 150; END;
    END;
    Distillate ISA super::Distillate WITH
      Graphic ISA super::Graphic WITH y_pos := 275; END;
    END;
    SuperControl ISA GrafcetLib::GrafcetInTerminal WITH
      Graphic ISA super::Graphic WITH
        x_pos := 200.0;
        y_pos := 300.0;
        invisible := 1;
      END;
    END;
  submodels:
    Controller ISA DistillationControlLib::DistIController WITH
      Graphic ISA super::Graphic WITH
        x_pos := 250.0;
        y_pos := 250.0;
      END;
    END;
    DistUnit ISA DistillationLib::DistillationgTUnitModel WITH
      Graphic ISA super::Graphic WITH
        x_pos := 175.0;
        y_pos := 125.0;
      END;
    END;
  connections:
    C16 ISA Base::Connection WITH
      SuperControl AT Controller.SuperControl;
      bpoints TYPE Matrix [4, 2] := [199.0, 299.0; 199.0, 280.0; 249.0, 280.0; 249.0, 268.0];
    END;
    C17 ISA Base::Connection WITH

```

```

DistUnit.Measurement AT Controller.Measure;
  bpoints TYPE Matrix [3, 2] := [170.0, 224.0; 170.0, 249.0; 219.0, 249.0];
END;
C19 ISA Base::Connection WITH
  Distillate AT DistUnit.Distillate;
  bpoints TYPE Matrix [4, 2] := [189.0, 214.0; 345.0, 214.0; 345.0, 274.0; 399.0,$
    ^ 274.0];
END;
C20 ISA Base::Connection WITH
  Controller.Control AT DistUnit.Control;
  bpoints TYPE Matrix [7, 2] := [278.0, 249.0; 301.0, 249.0; 301.0, 225.0; 201.0,$
    ^ 225.0; 201.0, 235.0; 185.0, 235.0; 185.0, 224.0];
END;
C3 ISA Base::Connection WITH
  Feed AT DistUnit.Feed;
  bpoints TYPE Matrix [4, 2] := [0.0, 149.0; 95.0, 149.0; 95.0, 124.0; 150.0, 124.0];
END;
C7 ISA Base::Connection WITH
  Bottom AT DistUnit.Bottom;
  bpoints TYPE Matrix [4, 2] := [199.0, 34.0; 340.0, 34.0; 340.0, 24.0; 399.0, 24.0];
END;
END;

```

```

LIBRARY DistillationWosp;

USFS ModelClassTreeLib, ProcessTerminalLib, ControlTerminalLib, PhaseEquilibLib, $
    ^ FlowEquipmentLib, EnergyEquipmentLib, GrafcetLib, $
    ^ ControlsSystemLib, DistillationLib, DistillationControlLib;

%% Distillation library contain objects for
%% the construction of distillation column
%% units. The columns are tray based with
%% medium and machine decomposition and
%% submodel class pointers.
%%
%% Design: Bernt Nilsson, 4 may 1993.
%%
%%-----
%% a test case

TraysimProblem ISA DistillationLib::TrayModel WITH
    %% A test problem of a tray.
parameters:
    FlowPar ISA Base::Parameter WITH default := 40; END;
    MachineModel.TrayArea.default := 3.14;
    MachineModel.WeirLength.default := 1;
    MachineModel.WeirHeight.default := 0.02;
    MachineModel.GravConst.default := 9.81;
    MachineModel.PressureDrop.default := 671;
    MachineModel.Xmole.initial := [0.5; 0.5; 0.5];
    MediumModel.Aas.default := 1.2;
    MediumModel.Aas.default := 1.5;
    MediumModel.LiquidEnthalpy := [132, 145, 250];
    MediumModel.CpL := [2.2, 2.43, 4.18];
    MediumModel.Hevap := [515, 841, 2260];
    MediumModel.CpV := [1.0, 1.2, 1.85];
    MediumModel.Dens := [792, 791, 999];
    MediumModel.MoleW := [58, 46, 18];
terminal defaults:
    Lin.Flow = FlowPar;
    Lin.Comp := [0.34; 0.33; 0.33];
    Lin.Pressure = 140000.0;
    Lin.MoleEnergy = 4.5;
    Vin.Flow = FlowPar;
    Vin.Comp := [0.34; 0.33; 0.33];
    Vin.Pressure = 140000.0;
    Vin.MoleEnergy = 6;
END;

FeedTraysimProblem ISA DistillationLib::FeedTrayModel WITH
    %% A test problem of a tray.
parameters:
    FlowPar ISA Base::Parameter WITH default := 40; END;
    MachineModel.TrayArea.default := 3.14;
    MachineModel.WeirLength.default := 1;
    MachineModel.WeirHeight.default := 0.02;
    MachineModel.GravConst.default := 9.81;
    MachineModel.PressureDrop.default := 671;
    MachineModel.Xmole.initial := [0.5; 0.5; 0.5];
    MediumModel.Aas.default := 1.2;
    MediumModel.Aas.default := 1.5;
    MediumModel.LiquidEnthalpy := [132, 145, 250];
    MediumModel.CpL := [2.2, 2.43, 4.18];
    MediumModel.Hevap := [515, 841, 2260];
    MediumModel.CpV := [1.0, 1.2, 1.85];
    MediumModel.Dens := [792, 791, 999];
    MediumModel.MoleW := [58, 46, 18];
terminal defaults:
    Lin.Flow = FlowPar;
    Lin.Comp := [0.34; 0.33; 0.33];
    Lin.Pressure = 140000.0;
    Lin.MoleEnergy = 4.5;
    Vin.Flow = FlowPar;
    Vin.Comp := [0.34; 0.33; 0.33];
    Vin.Pressure = 140000.0;
    Vin.MoleEnergy = 6;
END;

```

```

MediumModel.Dens := [792, 791, 999];
MediumModel.MoleW := [58, 46, 18];
terminal defaults:
    Feed.Flow := go*FlowPar;
    Feed.Comp := [0.32; 0.33; 0.35];
    Feed.Pressure := 10000;
    Feed.MoleEnergy := 4;
    Lin.Flow := go*FlowPar;
    Lin.Comp := [0.34; 0.33; 0.33];
    Lin.Pressure := 140000.0;
    Lin.MoleEnergy := 4.5;
    Vin.Flow = FlowPar;
    Vin.Comp := [0.34; 0.33; 0.33];
    Vin.Pressure := 140000.0;
    Vin.MoleEnergy := 6;
events:
    go TYPE DISCRETE Integer;
    Init, start ISAN Event;
    OnEvent Init DO schedule(start,0.1); new(go):=0; END;
    ONEVENT start DO new(go):= 1; END;
END;

TrayData ISA DistillationLib::TrayModel WITH
parameters:
    MachineModel.TrayArea.default := 3.14;
    MachineModel.WeirLength.default := 1;
    MachineModel.WeirHeight.default := 0.02;
    MachineModel.GravConst.default := 9.81;
    MachineModel.PressureDrop.default := 671;
    MachineModel.Xmole.initial := [500; 500; 500];
END;

FeedTrayData ISA DistillationLib::FeedTrayModel WITH
parameters:
    MachineModel.TrayArea.default := 3.14;
    MachineModel.WeirLength.default := 1;
    MachineModel.WeirHeight.default := 0.02;
    MachineModel.GravConst.default := 9.81;
    MachineModel.PressureDrop.default := 671;
    MachineModel.Xmole.initial := [500; 500; 500];
END;

BoilerData ISA EnergyEquipmentLib::BoilerModel WITH
parameters:
    BoilerSide.BoilerArea.default := 3.14;
    BoilerSide.Pressure.default := 671;
    BoilerSide.Xmole.initial := [5; 5; 5];
    HeatTrans.TransArea.default := 1;
    HeatTrans.Kappa.default := 2000;
    HeatSide.Cp := 4.18;
    HeatSide.Volume.default := 1;
    HeatSide.Density := 1000;
    HeatSide.Temp.initial := 360;
END;

CondenserData ISA EnergyEquipmentLib::TotalCondenserModel WITH
parameters:
    CondSide.Pressure.default := 671;
END;

DrumData ISA FlowEquipmentLib::RefluxDrumModel WITH
parameters:
    Drum.DrumArea.default := 3.14;

```

```

Drum.Pressure.default := 671;
Drum.Xmole.initial := [5; 5; 5];
END;

DistPID1 ISA PIDControllerModel WITH
  AutoMan.Manual:=0;
  AutoMan.UMan:=0;
  * SetPoint := 0;
  PID_Module.K := 1;
  PID_Module.Ti := 10;
  PID_Module.Td := 0;
  PID_Module.b := 1;
  PID_Module.tr := 50;
  PID_Module.N := 5;
  PID_Module.Ion:= 0;
  PID_Module.Don:= 0;
  PID_Module.uReverse:= 0;
  PID_Module.uHigh:= 1;
END;

DistPID2 ISA PIDControllerModel WITH
  AutoMan.Manual:=0;
  AutoMan.UMan:=0;
  SetPoint := 1;
  PID_Module.K := 1;
  PID_Module.Ti := 10;
  PID_Module.Td := 0;
  PID_Module.b := 1;
  PID_Module.tr := 50;
  PID_Module.N := 5;
  PID_Module.Ion:= 0;
  PID_Module.Don:= 0;
  PID_Module.uReverse:= 1;
  PID_Module.uHigh:= 1;
END;

ColumnsSimProblem ISA Column3TrayModel WITH
  MediumModel ISA ABSPhaseEquilData;
  TrayModel3 ISA TrayData;
  FeedTrayModel1 ISA FeedTrayData;
  TrayModel2 ISA TrayData;
  Feed.Flow := 20;
  Feed.Comp := [0.33; 0.33; 0.34];
  Feed.MoleEnergy := 1000;
  Feed.Pressure := 1000;
  Reflux.Flow := 20;
  Reflux.Comp := [0.33; 0.33; 0.34];
  Reflux.MoleEnergy := 1000;
  Reflux.Pressure := 1000;
  Vin.Flow := 20;
  Vin.Comp := [0.33; 0.33; 0.34];
  Vin.MoleEnergy := 1000;
  Vin.Pressure := 1000;
END;

Distillation3TSimProblem ISA Distillation3TUnitModel WITH
  MediumModel ISA ABSPhaseEquilData;
  Reboiler ISA BoilerData;
  Condenser ISA CondenserData;
  RefluxDrum ISA DrumData;
  TrayColumn ISA super::TrayColumn WITH
    TrayModel3 ISA TrayData;
    FeedTrayModel1 ISA FeedTrayData;
    FeedTrayModel2 ISA TrayData;
    Feed.Flow := 20;
    Feed.Comp := [0.33; 0.33; 0.34];
    Feed.MoleEnergy := 1000;
    Feed.Pressure := 1000;
    Reflux.Flow := 20;
    Reflux.Comp := [0.33; 0.33; 0.34];
    Reflux.MoleEnergy := 1000;
    Reflux.Pressure := 1000;
    Vin.Flow := 20;
    Vin.Comp := [0.33; 0.33; 0.34];
    Vin.MoleEnergy := 1000;
    Vin.Pressure := 1000;
  END;

TrayModel2 ISA TrayData;
END;

Feed.Flow := 20;
Feed.Comp := [0.33; 0.33; 0.34];
Feed.MoleEnergy := 1000;
Feed.Pressure := 1000;
Reflux.Flow := 20;
Reflux.Comp := [0.33; 0.33; 0.34];
Reflux.MoleEnergy := 1000;
Reflux.Pressure := 1000;
Vin.Flow := 20;
Vin.Comp := [0.33; 0.33; 0.34];
Vin.MoleEnergy := 1000;
Vin.Pressure := 1000;
END;

TopCompPID ISA super::TopCompPID WITH
  * y = top composition, u = reflux valve
  AutoMan.Manual:=0;
  AutoMan.UMan:=0.1;
  SetPoint := 0.6;
  PID_Module.K := 10;
  PID_Module.Ti := 10;
  PID_Module.Td := 0;
  PID_Module.b := 1;
  PID_Module.tr := 50;
  PID_Module.N := 5;
  PID_Module.Ion:= 0;
  PID_Module.Don:= 0;
  PID_Module.uReverse:= 1;
  PID_Module.uHigh:= 1;
END;

DrumLevelPID ISA super::DrumLevelPID WITH
  * y = drum level, u = top valve
  AutoMan.Manual:=0;
  AutoMan.UMan:=0.5;
  SetPoint := 6;
  PID_Module.K := 10;
  PID_Module.Ti := 10;
  PID_Module.Td := 0;
  PID_Module.b := 1;
  PID_Module.tr := 50;
  PID_Module.N := 5;
  PID_Module.Ion:= 0;
  PID_Module.Don:= 0;
  PID_Module.uReverse:= 1;
  PID_Module.uHigh:= 1;
END;

CControlDist3TSimProblem ISA CControlDist3TModel WITH
  Controller ISA super::Controller WITH
    BoilerLevelPID ISA super::BoilerLevelPID WITH
      * y = boiler level, u = bottom valve
      AutoMan.Manual:=0;
      AutoMan.UMan:=0.5;
      SetPoint := 1;
      PID_Module.K := 10;
      PID_Module.Ti := 10;
      PID_Module.Td := 0;
      PID_Module.b := 1;
      PID_Module.tr := 50;
      PID_Module.N := 5;
      PID_Module.Ion:= 0;
      PID_Module.Don:= 0;
      PID_Module.uReverse:= 1;
      PID_Module.uHigh:= 1;
    END;
  END;

```

```

PID_Module.N := 5;
PID_Module.Ion:= 0;
PID_Module.Don:= 0;
PID_Module.uReverse:= 0;
PID_Module.uHigh:= 1;
END;

BottomCompPID ISA super::BottomCompPID WITH
%% y = bottom composition, u = heat valve
AutoMan.Manual:=0;
AutoMan.UMan:=1.0;
SetPoint := 0.2;
PID_Module.K := 10;
PID_Module.Ti := 10;
PID_Module.Td := 0;
PID_Module.b := 1;
PID_Module.tr := 50;
PID_Module.N := 5;
PID_Module.Ion:= 0;
PID_Module.Don:= 0;
PID_Module.uReverse:= 1;
PID_Module.uHigh:= 1;
END;

DistUnit ISA super::DistUnit WITH
MediumModel ISA ABSPhaseEquilData;
Reboiler ISA super::Reboiler WITH
BoilerSide.BoilerArea.default := 3.14;
BoilerSide.Pressure.default := 671;
BoilerSide.Xmole.initial := [20; 20; 20];
HeatTrans.TransArea.default := 15;
HeatTrans.Kappa.default := 5000;
HeatSide.Cp := 4.18;
HeatSide.Volume.default := 1;
HeatSide.Density := 1000;
HeatSide.Temp.initial := 450;
END;

Condenser.CondSide.Pressure.default := 671;
RefluxDrum ISA super::RefluxDrum WITH
Drum.DrumArea.default := 3.14;
Drum.Pressure.default := 671;
Drum.Xmole.initial := [150; 150; 150];
END;

TrayColumn ISA super::TrayColumn WITH
Tray1, Tray3 ISA TrayModel WITH
MachineModel.TrayArea.default := 3.14;
MachineModel.WeirLength.default := 1;
MachineModel.WeirHeight.default := 0.02;
MachineModel.GravConst.default := 9.81;
MachineModel.PressureDrop.default := 671;
MachineModel.Xmole.initial := [5; 5; 5];
END;

FeedTray2 ISA FeedTrayModel WITH
MachineModel.TrayArea.default := 3.14;
MachineModel.WeirLength.default := 1;
MachineModel.WeirHeight.default := 0.02;
MachineModel.GravConst.default := 9.81;
MachineModel.PressureDrop.default := 671;
MachineModel.Xmole.initial := [5; 5; 5];
END;

terminal_definition;
Feed.Flow := 20;
Feed.Comp := [0.33; 0.33; 0.34];

```

```

Feed.MoleEnergy := 1000;
Feed.Pressure := 1000;
RefluxValve.Qmax.default := 50;
TopValve.Qmax.default := 50;
BottomValve.Qmax.default := 50;
HeatValve.Qmax.default := 10;
HeatValve.In.Temp := 450;
HeatValve.In.Pres := 0;
END;

%%-----
%% nine tray column

CControlDist9TsimProblem ISA CControlDist9TModel WITH
Controller ISA super::Controller WITH
BL ISA Parameter WITH default:=1; END;
DL ISA Parameter WITH default:=6; END;
BC ISA Parameter WITH default:=0.2; END;
TC ISA Parameter WITH default:=0.6; END;
BoilerLevelPID ISA super::BoilerLevelPID WITH
%% y = boiler level, u = bottom valve
AutoMan.Manual:=0;
AutoMan.UMan:=0.5;
SetPoint := BL;
PID_Module.K.default := 10;
PID_Module.Ti.default := 10;
PID_Module.Td := 0;
PID_Module.b := 1;
PID_Module.tr.default := 50;
PID_Module.N := 5;
PID_Module.Ion.default:= 0;
PID_Module.Don:= 0;
PID_Module.uReverse:= 1;
PID_Module.uHigh:= 1;
END;

DrumLevelPID ISA super::DrumLevelPID WITH
%% y = drum level, u = top valve
AutoMan.Manual:=0;
AutoMan.UMan:=0.5;
SetPoint := DL;
PID_Module.K.default := 10;
PID_Module.Ti.default := 10;
PID_Module.Td := 0;
PID_Module.b := 1;
PID_Module.tr.default := 50;
PID_Module.N := 5;
PID_Module.Ion.default:= 0;
PID_Module.Don:= 0;
PID_Module.uReverse:= 1;
PID_Module.uHigh:= 1;
END;

TopCompPID ISA super::TopCompPID WITH
%% y = top composition, u = reflux valve
AutoMan.Manual:=0;
AutoMan.UMan:=0.1;
SetPoint := TC;
PID_Module.K.default := 30;
PID_Module.Ti.default := 10;
PID_Module.Td := 0;
PID_Module.b := 1;
PID_Module.tr.default := 50;
PID_Module.N := 5;

```



```

PID Module.Ion.default:= 0;
PID Module.Don:= 0;
PID Module.uReverse:= 0;
PID Module.uHigh:= 1;
END;
BottomCompPID ISA super::BottomCompPID WITH
  %% y = bottom composition, u = heat valve
  AutoMan.Manual:=0;
  AutoMan.UMan:=1.0;
  SetPoint := BC;
  PID Module.K.default := 30;
  PID Module.Ti.default := 10;
  PID Module.Td := 0;
  PID Module.b := 1;
  PID Module.tr.default := 50;
  PID Module.N := 5;
  PID Module.Ion.default:= 0;
  PID Module.Don:= 0;
  PID Module.uReverse:= 1;
  PID Module.uHigh:= 1;
END;
END;
DistUnit ISA super::DistUnit WITH
  MediumModel ISA ABSPhaseEquilData;
  Reboiler ISA super::Reboiler WITH
    BoilerSide.BoilerArea.default := 3.14;
    BoilerSide.Pressure.default := 671;
    BoilerSide.Xmole.initial := [14.17;24.65;34.76];
    HeatTrans.TransArea.default := 15;
    HeatTrans.Kappa.default := 5000;
    HeatSide.Cp := 4.18;
    HeatSide.Volume.default := 1;
    HeatSide.Density := 1000;
    HeatSide.Temp.initial := 450;
END;
Condenser.CondSide.Pressure.default := 671;
RefluxDrum ISA super::RefluxDrum WITH
  Drum.DrumArea.default := 3.14;
  Drum.Pressure.default := 671;
  Drum.Xmole.initial := [170.2;99.36;45.63];
END;
TrayColumn ISA super::TrayColumn WITH
  Tray9.MachineModel.TrayArea.default := 3.14;
  Tray8.MachineModel.TrayArea.default := 3.14;
  Tray7.MachineModel.TrayArea.default := 3.14;
  FeedTray6.MachineModel.TrayArea.default := 3.14;
  Tray5.MachineModel.TrayArea.default := 3.14;
  Tray4.MachineModel.TrayArea.default := 3.14;
  Tray3.MachineModel.TrayArea.default := 3.14;
  Tray2.MachineModel.TrayArea.default := 3.14;
  Tray1.MachineModel.TrayArea.default := 3.14;
  Tray9.MachineModel.WeirLength.default := 1;
  Tray8.MachineModel.WeirLength.default := 1;
  Tray7.MachineModel.WeirLength.default := 1;
  FeedTray6.MachineModel.WeirLength.default := 1;
  Tray5.MachineModel.WeirLength.default := 1;
  Tray4.MachineModel.WeirLength.default := 1;
  Tray3.MachineModel.WeirLength.default := 1;
  Tray2.MachineModel.WeirLength.default := 1;
  Tray1.MachineModel.WeirLength.default := 1;
  Tray9.MachineModel.WeirHeight.default := 0.02;
  Tray8.MachineModel.WeirHeight.default := 0.02;
  Tray7.MachineModel.WeirHeight.default := 0.02;

```

```

FeedTray6.MachineModel.WeirHeight.default := 0.02;
Tray5.MachineModel.WeirHeight.default := 0.02;
Tray4.MachineModel.WeirHeight.default := 0.02;
Tray3.MachineModel.WeirHeight.default := 0.02;
Tray2.MachineModel.WeirHeight.default := 0.02;
Tray1.MachineModel.WeirHeight.default := 0.02;
Tray9.MachineModel.GravConst.default := 9.81;
Tray8.MachineModel.GravConst.default := 9.81;
Tray7.MachineModel.GravConst.default := 9.81;
FeedTray6.MachineModel.GravConst.default := 9.81;
Tray5.MachineModel.GravConst.default := 9.81;
Tray4.MachineModel.GravConst.default := 9.81;
Tray3.MachineModel.GravConst.default := 9.81;
Tray2.MachineModel.GravConst.default := 9.81;
Tray1.MachineModel.GravConst.default := 9.81;
Tray9.MachineModel.PressureDrop.default := 671;
Tray8.MachineModel.PressureDrop.default := 671;
Tray7.MachineModel.PressureDrop.default := 671;
FeedTray6.MachineModel.PressureDrop.default := 671;
Tray5.MachineModel.PressureDrop.default := 671;
Tray4.MachineModel.PressureDrop.default := 671;
Tray3.MachineModel.PressureDrop.default := 671;
Tray2.MachineModel.PressureDrop.default := 671;
Tray1.MachineModel.PressureDrop.default := 671;
Tray9.MachineModel.Xmole.initial := [0.5357;0.3766;0.2122];
Tray8.MachineModel.Xmole.initial := [0.5015;0.4080;0.2724];
Tray7.MachineModel.Xmole.initial := [0.4733;0.4378;0.3331];
FeedTray6.MachineModel.Xmole.initial := [0.4509;0.4461;0.3926];
Tray5.MachineModel.Xmole.initial := [0.4376;0.4586;0.4108];
Tray4.MachineModel.Xmole.initial := [0.4212;0.4728;0.4375];
Tray3.MachineModel.Xmole.initial := [0.4011;0.4886;0.4768];
Tray2.MachineModel.Xmole.initial := [0.3763;0.5052;0.5353];
Tray1.MachineModel.Xmole.initial := [0.3455;0.5213;0.6225];
END;
terminal_definition:
Feed.Flow := 20;
Feed.Comp := [0.33; 0.33; 0.34];
Feed.MoleEnergy := 1000;
Feed.Pressure := 1000;
RefluxValve.Qmax.default := 50;
TopValve.Qmax.default := 50;
BottomValve.Qmax.default := 50;
HeatValve.Qmax.default := 10;
HeatValve.In.Temp := 450;
HeatValve.In.Pres := 0;
plot_vectors:
AC,BC,SC TYPE column [9];
AC:= [TrayColumnn.Tray9.IOut.Comp[1];TrayColumnn.Tray8.IOut.Comp[1];
      TrayColumnn.Tray7.IOut.Comp[1];TrayColumnn.FeedTray6.IOut.Comp[1];
      TrayColumnn.Tray5.IOut.Comp[1];TrayColumnn.Tray4.IOut.Comp[1];
      TrayColumnn.Tray3.IOut.Comp[1];TrayColumnn.Tray2.IOut.Comp[1];
      TrayColumnn.Tray1.IOut.Comp[1]];
BC:= [TrayColumnn.Tray9.IOut.Comp[2];TrayColumnn.Tray8.IOut.Comp[2];
      TrayColumnn.Tray7.IOut.Comp[2];TrayColumnn.FeedTray6.IOut.Comp[2];
      TrayColumnn.Tray5.IOut.Comp[2];TrayColumnn.Tray4.IOut.Comp[2];
      TrayColumnn.Tray3.IOut.Comp[2];TrayColumnn.Tray2.IOut.Comp[2];
      TrayColumnn.Tray1.IOut.Comp[2]];
SC:= [TrayColumnn.Tray9.IOut.Comp[3];TrayColumnn.Tray8.IOut.Comp[3];
      TrayColumnn.Tray7.IOut.Comp[3];TrayColumnn.FeedTray6.IOut.Comp[3];
      TrayColumnn.Tray5.IOut.Comp[3];TrayColumnn.Tray4.IOut.Comp[3];
      TrayColumnn.Tray3.IOut.Comp[3];TrayColumnn.Tray2.IOut.Comp[3];
      TrayColumnn.Tray1.IOut.Comp[3]];
END;

```

```

END;

IControlDist9TSimProblem ISA IControlDist9TModel WITH
%% A integrated control of a distillation unit
%% with parameter settings for a dynamic simulation.
Controller ISA super::Controller WITH
  Buref.default:=1;
  Duref.default:=6;
  Bcref.default:=0.2;
  Tcref.default:=0.7;
BoilerLevelPID ISA super::BoilerLevelPID WITH
  %% y = boiler level, u = bottom valve
  PID_Module.K.default := 10;
  PID_Module.Ti.default := 10;
  PID_Module.Td := 0;
  PID_Module.b := 1;
  PID_Module.tr.default := 50;
  PID_Module.N := 5;
  PID_Module.Ion.default:= 0;
  PID_Module.Don:= 0;
  PID_Module.uReverse:= 1;
  PID_Module.uHigh:= 1;
END;
DrumLevelPID ISA super::DrumLevelPID WITH
  %% y = drum level, u = top valve
  PID_Module.K.default := 10;
  PID_Module.Ti.default := 10;
  PID_Module.Td := 0;
  PID_Module.b := 1;
  PID_Module.tr.default := 50;
  PID_Module.N := 5;
  PID_Module.Ion.default:= 0;
  PID_Module.Don:= 0;
  PID_Module.uReverse:= 1;
  PID_Module.uHigh:= 1;
END;
TopCompPID ISA super::TopCompPID WITH
  %% y = top composition, u = reflux valve
  PID_Module.K.default := 30;
  PID_Module.Ti.default := 10;
  PID_Module.Td := 0;
  PID_Module.b := 1;
  PID_Module.tr.default := 50;
  PID_Module.N := 5;
  PID_Module.Ion.default:= 0;
  PID_Module.Don:= 0;
  PID_Module.uReverse:= 0;
  PID_Module.uHigh:= 1;
END;
BottomCompPID ISA super::BottomCompPID WITH
  %% y = bottom composition, u = heat valve
  PID_Module.K.default := 30;
  PID_Module.Ti.default := 10;
  PID_Module.Td := 0;
  PID_Module.b := 1;
  PID_Module.tr.default := 50;
  PID_Module.N := 5;
  PID_Module.Ion.default:= 0;
  PID_Module.Don:= 0;
  PID_Module.uReverse:= 1;
  PID_Module.uHigh:= 1;
END;
Graftet ISA super::Graftet WITH
  StartTime.default := 0.5;
  StopTime.default := 45;
  IDmin.default := 0.5;
  IDmax.default := 6.5;
  IDmin.default := 4;
  ONEVENT Init CAUSE Local;
END;
END;
DistUnit ISA super::DistUnit WITH
  MediumModel ISA ABSPhaseEquilData;
  Reboiler ISA super::Reboiler WITH
    Boilerside.BoilerArea.default := 3.14;
    Boilerside.Pressure.default := 671;
    Boilerside.Xmole.initial := [12.4;16.9;68.8];
    HeatTrans.TransArea.default := 15;
    HeatTrans.Kappa.default := 5000;
    HeatSide.Cp := 4.18;
    HeatSide.Volume.default := 1;
    HeatSide.Density := 1000;
    HeatSide.Temp.initial := 450;
  END;
  Condenser.Condsie.Pressure.default := 671;
  RefluxDrum ISA super::RefluxDrum WITH
    Drum.DrumArea.default := 3.14;
    Drum.Pressure.default := 671;
    Drum.Xmole.initial := [28.2;172.8;46.9];
  END;
  TrayColumn ISA super::TrayColumn WITH
    Tray9.MachineModel.TrayArea.default := 3.14;
    Tray8.MachineModel.TrayArea.default := 3.14;
    Tray7.MachineModel.TrayArea.default := 3.14;
    FeedTray6.MachineModel.TrayArea.default := 3.14;
    Tray5.MachineModel.TrayArea.default := 3.14;
    Tray4.MachineModel.TrayArea.default := 3.14;
    Tray3.MachineModel.TrayArea.default := 3.14;
    Tray2.MachineModel.TrayArea.default := 3.14;
    Tray1.MachineModel.TrayArea.default := 3.14;
    Tray9.MachineModel.WeirLength.default := 1;
    Tray8.MachineModel.WeirLength.default := 1;
    Tray7.MachineModel.WeirLength.default := 1;
    FeedTray6.MachineModel.WeirLength.default := 1;
    Tray5.MachineModel.WeirLength.default := 1;
    Tray4.MachineModel.WeirLength.default := 1;
    Tray3.MachineModel.WeirLength.default := 1;
    Tray2.MachineModel.WeirLength.default := 1;
    Tray1.MachineModel.WeirLength.default := 0.02;
    Tray8.MachineModel.WeirHeight.default := 0.02;
    Tray7.MachineModel.WeirHeight.default := 0.02;
    FeedTray6.MachineModel.WeirHeight.default := 0.02;
    Tray5.MachineModel.WeirHeight.default := 0.02;
    Tray4.MachineModel.WeirHeight.default := 0.02;
    Tray3.MachineModel.WeirHeight.default := 0.02;
    Tray2.MachineModel.WeirHeight.default := 0.02;
    Tray1.MachineModel.WeirHeight.default := 0.02;
    Tray9.MachineModel.GravConst.default := 9.81;
    Tray8.MachineModel.GravConst.default := 9.81;
    Tray7.MachineModel.GravConst.default := 9.81;
    FeedTray6.MachineModel.GravConst.default := 9.81;
    Tray5.MachineModel.GravConst.default := 9.81;
    Tray4.MachineModel.GravConst.default := 9.81;
    Tray3.MachineModel.GravConst.default := 9.81;
    Tray2.MachineModel.GravConst.default := 9.81;

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Tray1.MachineModel.GravConst.default := 9.81;
Tray9.MachineModel.PressureDrop.default := 671;
Tray8.MachineModel.PressureDrop.default := 671;
Tray7.MachineModel.PressureDrop.default := 671;
FeedTray6.MachineModel.PressureDrop.default := 671;
Tray5.MachineModel.PressureDrop.default := 671;
Tray4.MachineModel.PressureDrop.default := 671;
Tray3.MachineModel.PressureDrop.default := 671;
Tray2.MachineModel.PressureDrop.default := 671;
Tray1.MachineModel.PressureDrop.default := 671;
Tray9.MachineModel.Xmole.initial := [0.188;0.674;0.646];
Tray8.MachineModel.Xmole.initial := [0.202;0.605;0.893];
Tray7.MachineModel.Xmole.initial := [0.199;0.575;1.04];
FeedTray6.MachineModel.Xmole.initial := [0.191;0.569;1.12];
Tray5.MachineModel.Xmole.initial := [0.193;0.566;1.12];
Tray4.MachineModel.Xmole.initial := [0.195;0.560;1.14];
Tray3.MachineModel.Xmole.initial := [0.120;0.545;1.17];
Tray2.MachineModel.Xmole.initial := [0.210;0.514;1.23];
Tray1.MachineModel.Xmole.initial := [0.231;0.454;1.33];
END;

terminal_definition:
Feed.Flow :=
IF (time () < Controller.Grafcet.StartTime) THEN 0 ELSE
IF (time () < Controller.Grafcet.StopTime) THEN 20 ELSE
0;

variable:
feedflow TYPE DISCRETE Real;
event:
Init,dstart,dstop ISAN Event;
ONEVENT Init DO
new(feedflow) := 0;
schedule(dstart,Controller.Grafcet.StartTime);
schedule(dstop,Controller.Grafcet.StopTime);
END;
ONEVENT dstart DO new(feedflow) := 20; END;
ONEVENT dstop DO new(feedflow) := 0; END;
Feed.Flow = feedflow;
Feed.Comp := [0.106; 0.269; 0.625];
Feed.MoleEnergy := 6980;
Feed.Pressure := 1000;
Bottom.Pressure := 1000;
RefluxValve.Qmax.default := 50;
TopValve.Qmax.default := 50;
BottomValve.Qmax.default := 50;
HeatValve.Qmax.default := 10;
HeatValve.In.Temp := 177;
HeatValve.In.Pres := 0;

plot_vectors:
AC_BC, SC TYPE column[9];
AC := [TrayColumn.Tray9.Lout.Comp[1];TrayColumn.Tray8.Lout.Comp[1];
TrayColumn.Tray7.Lout.Comp[1];TrayColumn.FeedTray6.Lout.Comp[1];
TrayColumn.Tray5.Lout.Comp[1];TrayColumn.Tray4.Lout.Comp[1];
TrayColumn.Tray3.Lout.Comp[1];TrayColumn.Tray2.Lout.Comp[1];
TrayColumn.Tray1.Lout.Comp[1]];
BC := [TrayColumn.Tray9.Lout.Comp[2];TrayColumn.Tray8.Lout.Comp[2];
TrayColumn.Tray7.Lout.Comp[2];TrayColumn.FeedTray6.Lout.Comp[2];
TrayColumn.Tray5.Lout.Comp[2];TrayColumn.Tray4.Lout.Comp[2];
TrayColumn.Tray3.Lout.Comp[2];TrayColumn.Tray2.Lout.Comp[2];
TrayColumn.Tray1.Lout.Comp[2]];
SC := [TrayColumn.Tray9.Lout.Comp[3];TrayColumn.Tray8.Lout.Comp[3];
TrayColumn.Tray7.Lout.Comp[3];TrayColumn.FeedTray6.Lout.Comp[3];
TrayColumn.Tray5.Lout.Comp[3];TrayColumn.Tray4.Lout.Comp[3];
TrayColumn.Tray3.Lout.Comp[3];TrayColumn.Tray2.Lout.Comp[3];
TrayColumn.Tray1.Lout.Comp[3]];
TrayColumn.Tray1.Lout.Comp[3]];
END;
END;
%%-----
%% unit data configuration

```

```

LIBRARY PretreatLib;

USES ModelClassTreeLib, ProcessTerminalLib, ControlTerminalLib, ReactionModelLib, $
    ^ FlowEquipmentLib, EnergyEquipmentLib, CSTRLib, $
    ^ ControlSystemLib, GrafacetLib;

## The pretreatment plant section library.
##
## Design: Bernt Nilsson, 3 June 1993.
##-----
## pretreatment section

PretreatSectionIClass ISA ModelClassTreeLib::PlantSectionClass WITH
icon:
    Graphic ISA Base::Layout WITH bitmap TYPE String := "iconpretreat"; END;
structure parameter:
    ChemDim TYPE Integer;
terminals:
    Afeed ISA ProcessTerminalLib::LiquidInTerminal WITH
        Graphic ISA super::Graphic WITH
            x_pos := 0.0;
            y_pos := 250.0;
            invisible := 1;
    END;
    Comp.n := ChemDim;
    defaults:
        Comp.default := [1; 0; 0];
        MoleEnergy.default := 2700;
        Pressure.default := 0;
    END;
    Sfeed ISA ProcessTerminalLib::LiquidInTerminal WITH
        Graphic ISA super::Graphic WITH
            x_pos := 0.0;
            y_pos := 175.0;
            invisible := 1;
    END;
    Comp.n := ChemDim;
    defaults:
        Comp.default := [0; 0; 1];
        MoleEnergy.default := 1600;
        Pressure.default := 0;
    END;
    Recycle ISA ProcessTerminalLib::LiquidInTerminal WITH
        Graphic ISA super::Graphic WITH
            x_pos := 200.0;
            y_pos := 0.0;
            invisible := 1;
    END;
    Comp.n := ChemDim;
    defaults:
        Flow.default := 10;
        Comp.default := [0; 0; 1];
        MoleEnergy.default := 1600;
    END;
    Out ISA ProcessTerminalLib::LiquidOutTerminal WITH
        Graphic ISA super::Graphic WITH
            x_pos := 400.0;
            y_pos := 175.0;
            invisible := 1;
    END;
    Comp.n := ChemDim;
    default:
        Flow.default := 24;

Pressure.default := 0;
END;

PretreatSectionModel ISA PretreatLib::PretreatSectionIClass WITH
structure parameter:
    ChemDim := RecycleTank.ChemDim;
terminals:
    Measure ISA ControlTerminalLib::PtsOutMeasure WITH
        Graphic ISA super::Graphic WITH
            x_pos := 150.0;
            y_pos := 300.0;
            invisible := 1;
    END;
    AComp := Out.Comp[1];
    Level := RecycleTank.ReactorMachine.Level;
    Outflow := Out.Flow;
    Afeed := AfeedValve.out.Flow;
END;
Control ISA ControlTerminalLib::PtsInControl WITH
    Graphic ISA super::Graphic WITH
        x_pos := 350.0;
        y_pos := 300.0;
        invisible := 1;
    END;
END;

submodels:
    AfeedValve ISA FlowEquipmentLib::ControlValveModelV WITH
        Graphic ISA super::Graphic WITH
            x_pos := 150.0;
            y_pos := 250.0;
    END;
    ChemDim := outer::ChemDim;
END;
RecycleValve ISA FlowEquipmentLib::ControlValveModelV WITH
    Graphic ISA super::Graphic WITH
        x_pos := 300.0;
        y_pos := 50.0;
    END;
    ChemDim := outer::ChemDim;
END;
MixerVessel ISA FlowEquipmentLib::MixerVesselModel WITH
    Graphic ISA super::Graphic WITH
        x_pos := 350.0;
        y_pos := 175.0;
    END;
    ChemDim := outer::ChemDim;
END;
RecycleTank ISA CSTRLib::BufferTankModel WITH
    Graphic ISA super::Graphic WITH
        x_pos := 250.0;
        y_pos := 100.0;
    END;
END;
invisible connections:
    AfeedValve.Control := Control.Afeed;
    RecycleValve.Control := Control.Recycle;
connections:
    Cl ISA Base::Connection WITH
        Afeed AT AfeedValve.in;
    bpoints TYPE Matrix [4, 2] := [0.0, 249.0; 74.0, 249.0; 74.0, 241.0; 241.0];
END;

```

```

C2 ISA Base::Connection WITH
  Sfeed AT MixerVessel.LIn2;
  bpoints TYPE Matrix [2, 2] := [0.0, 174.0; 332.0, 174.0];
END;
C3 ISA Base::Connection WITH
  AfeedValve.out AT MixerVessel.LIn1;
  bpoints TYPE Matrix [3, 2] := [166.0, 241.0; 349.0, 241.0; 349.0, 191.0];
END;
C5 ISA Base::Connection WITH
  RecycleValve.out AT MixerVessel.LIn3;
  bpoints TYPE Matrix [3, 2] := [316.0, 41.0; 349.0, 41.0; 349.0, 157.0];
END;
C6 ISA Base::Connection WITH
  lout AT MixerVessel.lout;
  bpoints TYPE Matrix [2, 2] := [366.0, 173.0; 399.0, 174.0];
END;
C7 ISA Base::Connection WITH
  RecycleTank.out AT RecycleValve.in;
  bpoints TYPE Matrix [3, 2] := [249.0, 70.0; 249.0, 41.0; 282.0, 41.0];
END;
C8 ISA Base::Connection WITH
  Recycle AT RecycleTank.in;
  bpoints TYPE Matrix [4, 2] := [199.0, 0.0; 199.0, 144.0; 234.0, 144.0; 234.0, 128.0];
END;
END;
END;
%%-----
%% pretreatment section control system
PtsGrafcet ISA GrafcetLib::GrafcetClass WITH
  icon;
  Graphic ISA super::Graphic;
  terminals;
  AComp ISA ControlTerminalLib::ManualControlOutDiscreteTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 400.0;
      y_pos := 525.0;
      invisible := 1;
    END;
  END;
END;
Recycle ISA ControlTerminalLib::ManualControlOutDiscreteTerminal WITH
  Graphic ISA super::Graphic WITH
    x_pos := 400.0;
    y_pos := 375.0;
    invisible := 1;
  END;
END;
Ref ISA Base::RecordTerminal WITH
  Graphic ISA super::Graphic WITH
    x_pos := 200.0;
    y_pos := 0.0;
    invisible := 1;
  END;
lref ISA Base::SimpleOutput WITH value TYPE DISCRETE Real; END;
Aref ISA Base::SimpleOutput WITH value TYPE DISCRETE Real; END;
END;
Level ISA Base::SimpleInput WITH
  Graphic ISA super::Graphic WITH
    x_pos := 0.0;
    y_pos := 400.0;
    invisible := 1;
  END;
END;
State ISA Base::Variable;

```

```

END;
SuperControl ISA GrafcetLib::GrafcetInTerminal WITH
  Graphic ISA super::Graphic WITH
    x_pos := 275.0;
    y_pos := 600.0;
    invisible := 1;
  END;
END;
% ONEVENT SuperControl.Start CAUSE StartTransition.Condition;
% ONEVENT SuperControl.Stop CAUSE StopTransition.Condition;
parameters;
StartTime ISA Base::Parameter;
StopTime ISA Base::Parameter;
LevelRef ISA Base::Parameter;
Aref ISA Base::Parameter;
events;
Init ISA Base::Event;
Local ISA Base::Event;
%% At local control add following in subclass
ONEVENT Init CAUSE Local;
ONEVENT Local DO
  schedule(StartTransition.Condition, StartTime);
  schedule(StopTransition.Condition, StopTime);
END;
submodels;
Wait ISA GrafcetLib::InitStep WITH
  Graphic ISA super::Graphic WITH
    x_pos := 200.0;
    y_pos := 550.0;
  END;
ONEVENT Action DO
  new(AComp.Manual) := 1;
  new(AComp.UMan) := 0;
  new(Recycle.Manual) := 1;
  new(Recycle.UMan) := 0;
END;
END;
StartTransition ISA GrafcetLib::TransitionE WITH
  Graphic ISA super::Graphic WITH
    x_pos := 200.0;
    y_pos := 500.0;
  END;
END;
Start ISA GrafcetLib::Step WITH
  Graphic ISA super::Graphic WITH
    x_pos := 200.0;
    y_pos := 450.0;
  END;
ONEVENT Action DO
  new(AComp.Manual) := 0;
  new(Ref.Aref) := Aref;
  new(Recycle.Manual) := 0;
  new(Ref.Lref) := LevelRef;
END;
END;
StopTransition ISA GrafcetLib::TransitionE WITH
  Graphic ISA super::Graphic WITH
    x_pos := 200.0;
    y_pos := 400.0;
  END;
END;
state;

```

```

State = Wait.State + 2*Start.State;
connections:
C1 ISA Base::Connection WITH
  Wait.Lower AT StartTransition.Upper;
  bpoints TYPE Matrix [2, 2] := [199, 532; 199, 507];
END;
C2 ISA Base::Connection WITH
  StartTransition.Lower AT Start.Upper;
  bpoints TYPE Matrix [2, 2] := [199, 491; 199, 466];
END;
C3 ISA Base::Connection WITH
  Start.Lower AT StopTransition.Upper;
  bpoints TYPE Matrix [2, 2] := [199, 432; 199, 407];
END;
C10 ISA Base::Connection WITH
  StopTransition.Lower AT Wait.Upper;
  bpoints TYPE Matrix [6, 2] := [199, 391; 199, 374; 150, 374; 150, 586; 199, 586; $
    ^ 199, 566];
END;
END;
END;
PtsIController ISA ModelClassTreeLib::UnitController WITH
  %% An integrated pretreatment section controller with
  %% start up and shut down sequence and
  %% continuous controllers.
C1 ISA Base::Connection WITH
  SuperControl AT Grafcet.SuperControl;
  bpoints TYPE Matrix [2, 2] := [149.0, 299.0; 145.0, 266.0];
END;
icon:
  Graphic ISA super::Graphic;
terminals:
  Measure ISA ControlTerminalLib::PtsInMeasure WITH
    Graphic ISA super::Graphic WITH
      x_pos := 0.0;
      y_pos := 150.0;
      invisible := 1;
  END;
  Control ISA ControlTerminalLib::PtsOutControl WITH
    Graphic ISA super::Graphic WITH
      x_pos := 400.0;
      y_pos := 150.0;
      invisible := 1;
  END;
END;
SuperControl ISA GrafcetLib::GrafcetInTerminal WITH
  Graphic ISA super::Graphic WITH
    x_pos := 150.0;
    y_pos := 300.0;
    invisible := 1;
  END;
END;
parameter:
  Iref ISA Base::Parameter;
  Aref ISA Base::Parameter;
equation:
  Grafcet.LevelRef := Iref;
  Grafcet.Aref := Aref;
submodel:
  Grafcet ISA PretreatLib::PtsGrafcet WITH
    Graphic ISA super::Graphic WITH
      x_pos := 150.0;

```

```

      y_pos := 250.0;
    END;
  END;
  LevelPID ISA ControlSystemLib::PIDControllerModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 300.0;
      y_pos := 50.0;
  END;
  Control2 ISA SimpleOutput WITH
    Graphic ISA Base::Layout WITH
      x_pos := 400;
      y_pos := 150;
      invisible := 1;
  END;
  END;
  LevelPID.Control2 := min(LevelPID.Control,
    (Measure.Outflow - Measure.Afeed)/50);
  APID ISA ControlSystemLib::PIDControllerModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 250.0;
      y_pos := 100.0;
  END;
  Control2 ISA SimpleOutput WITH
    Graphic ISA Base::Layout WITH
      x_pos := 400;
      y_pos := 150;
      invisible := 1;
  END;
  END;
  APID.Control2 := min(APID.Control, Measure.Outflow/50);
  Invisible connections:
  LevelPID.SetPoint := Grafcet.Ref.Lref;
  APID.SetPoint := Grafcet.Ref.Aref;
connections:
  C3 ISA Base::Connection WITH
    Measure.AComp AT APID.Measure;
    bpoints TYPE Matrix [3, 2] := [0, 149; 66, 99; 232, 99];
  END;
  C5 ISA Base::Connection WITH
    Measure.Level AT LevelPID.Measure;
    bpoints TYPE Matrix [4, 2] := [0, 149; 23, 100; 23, 49; 282, 49];
  END;
  C7 ISA Base::Connection WITH
    Control.Recycle AT LevelPID.Control2;
    bpoints TYPE Matrix [4, 2] := [399, 149; 372, 119; 372, 49; 316, 49];
  END;
  C8 ISA Base::Connection WITH
    Control.Afeed AT APID.Control2;
    bpoints TYPE Matrix [4, 2] := [399, 149; 347, 124; 347, 99; 266, 99];
  END;
  C9 ISA Base::Connection WITH
    Measure.Level AT Grafcet.Level;
    bpoints TYPE Matrix [5, 2] := [0, 149; 21, 165; 33, 180; 33, 254; 132, 254];
  END;
  C17 ISA Base::Connection WITH
    Grafcet.AComp AT APID.AutoMan;
    bpoints TYPE Matrix [3, 2] := [166, 253; 249, 253; 249, 116];
  END;
  C18 ISA Base::Connection WITH
    Grafcet.Recycle AT LevelPID.AutoMan;
    bpoints TYPE Matrix [3, 2] := [166, 262; 299, 262; 299, 66];

```

```

END;
END;

%%-----
%% control pretreatment section

IControlPtsModel ISA PretreatLib::PretreatSectionIClass WITH
%% Pretreatment section with an integrated control system.
%% Sequence with start up and shot down and
%% three continuous controllers.
C5 ISA Base::Connection WITH
    SuperControl AT Controller.SuperControl;
    bpoints TYPE Matrix [4, 2] := [149.0, 299.0; 149.0, 254.0; 217.0, 254.0; 217.0,$
    ^ 219.0];
END;

icon:
    Graphic ISA super::Graphic;
structure_parameter:
    ChemDim := Pretreat.ChemDim;
terminals:
    SuperControl ISA GrafcetLib::GrafcetInTerminal WITH
        x_pos := 150.0;
        y_pos := 300.0;
        invisible := 1;
    END;
END;

submodels:
    Pretreat ISA PretreatLib::PretreatSectionModel WITH
        Graphic ISA super::Graphic WITH
            x_pos := 175.0;
            y_pos := 100.0;
        END;
    END;
    Controller ISA PretreatLib::PtsIController WITH
        Graphic ISA super::Graphic WITH
            x_pos := 225.0;
            y_pos := 200.0;
        END;
    END;
connections:
    C1 ISA Base::Connection WITH
        Afeed AT Pretreat.Afeed;
        bpoints TYPE Matrix [4, 2] := [0.0, 249.0; 100.0, 249.0; 100.0, 124.0; 125.0,$
        ^ 124.0];
    END;
    C2 ISA Base::Connection WITH
        Sfeed AT Pretreat.Sfeed;
        bpoints TYPE Matrix [4, 2] := [0.0, 174.0; 75.0, 174.0; 75.0, 105.0; 125.0, 105.0];
    END;
    C3 ISA Base::Connection WITH
        IOut AT Pretreat.IOut;
        bpoints TYPE Matrix [4, 2] := [224.0, 105.0; 350.0, 174.0; 350.0, 105.0; 399.0,$
        ^ 174.0];
    END;
    C4 ISA Base::Connection WITH
        Recycle AT Pretreat.Recycle;
        bpoints TYPE Matrix [4, 2] := [174.0, 62.0; 199.0, 33.0; 174.0, 33.0; 199.0, 0.0];
    END;
    C15 ISA Base::Connection WITH
        Pretreat.Measure AT Controller.Measure;
        bpoints TYPE Matrix [3, 2] := [159, 129; 159, 194, 199];
    END;

```

```

C16 ISA Base::Connection WITH
    Controller.Control AT Pretreat.Control;
    bpoints TYPE Matrix [5, 2] := [253, 199; 285, 199; 285, 149; 196, 149; 196, 129];
END;
END;

```

```

%%-----

```

```

LIBRARY PretreatWosp;
USES ModelClassTreeLib, ProcessTerminalLib, ControlTerminalLib,
    ReactionModelLib, PhaseEquilibLib,
    FlowEquipmentLib, EnergyEquipmentLib,
    CSTRLib,
    ControlSystemLib, GrafacetLib,
    PretreatLib;
** The process plant from Process Plant Lib
** is turned into a simulation problem.
**
** Design: Bernt Nilsson, 3 June 1993.

```

```

**-----
**sequence and continuous control

```

```

IControlPtsSimProblem ISA PretreatLib::IControlPtsModel WITH
Pretreat ISA super::Pretreat WITH
RecycleTank ISA super::RecycleTank WITH
    CrossArea.default := 1;
ReactorMachine.Xmole.initial := [0;0;7.2];
ReactorMachine.energy.initial := 11400;
Graphic ISA super::Graphic;
END;
MixerVessel.Pressure := 0;
MixerVessel.TotMole.default := 20;
AfeedValve.Qmax.default := 50;
RecycleValve.Qmax.default := 50;
Graphic ISA super::Graphic;
END;
Controller ISA super::Controller WITH
Grafacet ISA super::Grafacet WITH
    StartTime.default := 1;
    StopTime.default := 45;
ONEVENT Init CAUSE Local;
END;
LevelPID ISA super::LevelPID WITH
PID_Module ISA super::PID_Module WITH
    uHigh := 1;
    uReverse := 1;
    Don := 0;
    Ion.default := 0;
    N := 5;
    tr.default := 10;
    b := 1;
    Td := 5;
    Ti.default := 1;
    K.default := 3;
END;
Graphic ISA super::Graphic;
END;
APID ISA super::APID WITH
PID_Module ISA super::PID_Module WITH
    uHigh := 1;
    uReverse.default := 0;
    Don := 0;
    Ion.default := 0;
    N := 5;
    tr.default := 10;
    b := 1;
    Td := 5;
    Ti.default := 5;

```

```

    K.default := 5;
END;
Graphic ISA super::Graphic;
END;
Iref.default := 1.30;
Aref.default := 0.3;
END;
Graphic ISA super::Graphic;
END;

```



```

LIBRARY ProcessPlantLib;

USES ModelClassTreeLib, ProcessTerminalLib, ControlTerminalLib, ReactionModelLib, $
    ^ PhaseEquilibLib, FlowEquipmentLib, EnergyEquipmentLib, CSTRLib, $
    ^ DistillationLib, ControlSystemLib, GrafcetLib, CSTRControlLib, $
    ^ DistillationControlLib, PretreatLib;

%% A process plant is described in this library.
%%
%% Design: Bernt Nilsson, 3 June 1993.

APlantModel ISA ModelClassTreeLib::PlantClass WITH
    Graphic ISA super::Graphic;
    CSTR ISA CSTRControlLib::IControlCSTRModel WITH
        Graphic ISA super::Graphic WITH
            x_pos := 125.0;
            y_pos := 150.0;
        END;
    END;
    DistUnit ISA DistillationControlLib::IControlDist9TModel WITH
        Graphic ISA super::Graphic WITH
            x_pos := 275.0;
            y_pos := 150.0;
        END;
    END;
    C2 ISA Base::Connection WITH
        CSTR.out AT DistUnit.Feed;
        bpoints TYPE Matrix [4, 2] := [154.0, 134.0; 188.0, 134.0; 188.0, 149.0; 250.0, $
            ^ 149.0];
    END;
    END;
%% Bplant control system
%%
PlantGrafcet ISA GrafcetLib::GrafcetClass WITH
    icon:
        Graphic ISA super::Graphic;
    terminal:
        Pout ISA GrafcetLib::GrafcetOutTerminal WITH
            Graphic ISA super::Graphic WITH
                x_pos := 100.0;
                y_pos := 0.0;
                invisible := 1;
            END;
        Rout ISA GrafcetLib::GrafcetOutTerminal WITH
            Graphic ISA super::Graphic WITH
                x_pos := 200.0;
                y_pos := 0.0;
                invisible := 1;
            END;
        Dout ISA GrafcetLib::GrafcetOutTerminal WITH
            Graphic ISA super::Graphic WITH
                x_pos := 300.0;
                y_pos := 0.0;
                invisible := 1;
            END;
    END;
    parameters:
        StartTime ISA Base::Parameter;
        StopTime ISA Base::Parameter;
    END;

events:
    Init ISA Base::Event;
    Local ISA Base::Event;
    WHEN Init CAUSE Local;
    WHEN Local DO
        schedule(StartTransition.Condition, StartTime);
        schedule(StopTransition.Condition, StopTime);
    END;
    ONEVENT Start.Action CAUSE Pout.Start, Rout.Start, Dout.Start;
    ONEVENT Wait.Action CAUSE Pout.Stop, Rout.Stop, Dout.Stop;
    submodels:
        Wait ISA GrafcetLib::InitStep WITH
            Graphic ISA super::Graphic WITH
                x_pos := 200.0;
                y_pos := 550.0;
            END;
        END;
        StartTransition ISA GrafcetLib::TransitionE WITH
            Graphic ISA super::Graphic WITH
                x_pos := 200.0;
                y_pos := 500.0;
            END;
        END;
        Start ISA GrafcetLib::Step WITH
            Graphic ISA super::Graphic WITH
                x_pos := 200.0;
                y_pos := 450.0;
            END;
        END;
        StopTransition ISA GrafcetLib::TransitionE WITH
            Graphic ISA super::Graphic WITH
                x_pos := 200.0;
                y_pos := 400.0;
            END;
        END;
    state:
        State ISA Base::Variable;
        State = Wait.State + 2*Start.State;
    connections:
        C1 ISA Base::Connection WITH
            Wait.Lower AT StartTransition.Upper;
            bpoints TYPE Matrix [2, 2] := [199, 532; 199, 507];
        END;
        C2 ISA Base::Connection WITH
            StartTransition.Lower AT Wait.Upper;
            bpoints TYPE Matrix [2, 2] := [199, 491; 199, 466];
        END;
        C3 ISA Base::Connection WITH
            Start.Lower AT StopTransition.Upper;
            bpoints TYPE Matrix [2, 2] := [199, 432; 199, 407];
        END;
        C10 ISA Base::Connection WITH
            StopTransition.Lower AT Wait.Upper;
            bpoints TYPE Matrix [6, 2] := [199, 391; 199, 374; 150, 374; 150, 586; 199, 586; $
                ^ 199, 566];
        END;
    END;
    END;
%%-----
%% A Bplant model
BPlantModel ISA ModelClassTreeLib::PlantClass WITH
    icon:

```

```

Graphic ISA Base::Layout WITH bitmap TYPE String := "iconprocess"; END;
structure_parameter:
  ChemDim TYPE Integer;
  ChemDim := CSTR.ChemDim;
terminals:
  Afeed ISA ProcessTerminalLib::LiquidInTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 0.0;
      y_pos := 199.0;
      invisible := 1;
  END;
  Comp.n := ChemDim;
  defaults:
    Comp.default := [1; 0; 0];
    MoleEnergy.default := 2700;
    Pressure.default := 0;
  END;
  Sfeed ISA ProcessTerminalLib::LiquidInTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 0.0;
      y_pos := 149.0;
      invisible := 1;
  END;
  Comp.n := ChemDim;
  defaults:
    Comp.default := [0; 0; 1];
    MoleEnergy.default := 1600;
    Pressure.default := 0;
  END;
  BProduct ISA ProcessTerminalLib::LiquidOutTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 400.0;
      y_pos := 175.0;
      invisible := 1;
  END;
  Comp.n := ChemDim;
  submodels:
    Controller ISA ProcessPlantLib::PlantGrafcet WITH
      Graphic ISA super::Graphic WITH
        x_pos := 200.0;
        y_pos := 250.0;
      END;
  END;
  CSTR ISA CSTRControlLib::IControlCSTRModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 150.0;
    END;
  END;
  DistUnit ISA DistillationControlLib::IControlDist9TModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 325.0;
      y_pos := 175.0;
    END;
  END;
  Pretreat ISA PretreatLib::IControlPtsModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 75.0;
      y_pos := 150.0;
    END;
  END;
connections:

```

```

C1 ISA Base::Connection WITH
  Sfeed AT Pretreat.Sfeed;
  bpoints TYPE Matrix [4, 2] := [0.0, 149.0; 29.0, 149.0; 29.0, 154.0; 45.0, 154.0];
END;
C3 ISA Base::Connection WITH
  Afeed AT Pretreat.Afeed;
  bpoints TYPE Matrix [4, 2] := [0.0, 199.0; 31.0, 199.0; 31.0, 169.0; 45.0, 169.0];
END;
C9 ISA Base::Connection WITH
  BProduct AT DistUnit.Distillate;
  bpoints TYPE Matrix [4, 2] := [399.0, 174.0; 358.0, 174.0; 358.0, 257.0; 339.0, 257.0];
END;
C2 ISA Base::Connection WITH
  CSTR.out AT DistUnit.Feed;
  bpoints TYPE Matrix [4, 2] := [228.0, 134.0; 272.0, 134.0; 272.0, 174.0; 309.0, 174.0];
END;
C4 ISA Base::Connection WITH
  DistUnit.Bottom AT Pretreat.Recycle;
  bpoints TYPE Matrix [5, 2] := [338.0, 91.0; 363.0, 91.0; 363.0, 48.0; 74.0, 48.0; 74.0, 119.0];
END;
C6 ISA Base::Connection WITH
  Pretreat.LOut AT CSTR.Feed;
  bpoints TYPE Matrix [4, 2] := [103.0, 153.0; 140.0, 153.0; 140.0, 158.0; 169.0, 158.0];
END;
C7 ISA Base::Connection WITH
  Controller.Pout AT Pretreat.SuperControl;
  bpoints TYPE Matrix [4, 2] := [191.0, 232.0; 191.0, 215.0; 67.0, 215.0; 67.0, 179.0];
END;
C8 ISA Base::Connection WITH
  Controller.Rout AT CSTR.SuperControl;
  bpoints TYPE Matrix [4, 2] := [199.0, 232.0; 199.0, 198.0; 203.0, 198.0; 203.0, 179.0];
END;
C21 ISA Base::Connection WITH
  Controller.Dout AT DistUnit.SuperControl;
  bpoints TYPE Matrix [6, 2] := [208.0, 232.0; 208.0, 213.0; 272.0, 213.0; 272.0, 272.0; 272.0, 324.0; 272.0, 324.0];
END;
END;

```

```

LIBRARY ProcessPlantWosp;

USES ModelClassTreeLib, ProcessTerminalLib, ControlTerminalLib, ReactionModelLib, $
    ^ PhaseEquilibLib, FlowEquipmentLib, EnergyEquipmentLib, CSTRLib, $
    ^ DistillationLib, ControlSystemLib, GrafacetLib, CSTRControlLib, $
    ^ DistillationControlLib, PretreatLib, ProcessPlantLib;

%% The process plant from Process Plant Lib
%% is turned into a simulation problem.
%%
%% Design: Bernt Nilsson, 3 June 1993.

APlantSimProblem ISA ProcessPlantLib::APlantModel WITH
%% Simulation problem formulation for
%% a process plant with one CSTR and
%% one distillation unit.
CSTR ISA super::CSTR WITH
    CSTRUnit ISA super::CSTRUnit WITH
        CSTR ISA super::CSTR WITH
            Wall.Kappa.default := 3070;
            Wall.TransArea.default := 23;
            Jacket.Cp.default := 4.19;
            Jacket.Volume.default := 0.11;
            Jacket.Density.default := 1000;
            Jacket.Temp.initial := 21;
            ReactorVessel ISA super::ReactorVessel WITH
                CrossArea.default := 1;
                ReactorMachine.Xmole.initial := [0; 0; 7.2];
                ReactorMachine.energy.initial := 11400;
            END;
        END;
        Graphic ISA super::Graphic;
    END;
    CoolValve.Qmax.default := 2.8;
    FeedValve.Qmax.default := 50;
    OutValve.Qmax.default := 50;
    Graphic ISA super::Graphic;
END;

Controller ISA super::Controller WITH
    Grafacet ISA super::Grafacet WITH
        StartTime.default := 1;
        StopTime.default := 45;
        TempRefLow := 21;
    END;
    LevelPID ISA super::LevelPID WITH
        PID Module ISA super::PID_Module WITH
            uHigh := 1;
            uReverse := 0;
            Don := 0;
            Ion.default := 1;
            n := 5;
            tr.default := 10;
            b := 1;
            Td := 5;
            Ti.default := 1;
            K.default := 3;
        END;
        Graphic ISA super::Graphic;
    END;
    TempPID ISA super::TempPID WITH
        PID Module ISA super::PID_Module WITH
            uHigh := 1;
            uReverse.default := 1;
            Don := 0;
        END;
    END;

```

```

            Ion.default := 1;
            n := 5;
            tr.default := 10;
            b := 1;
            Td := 5;
            Ti.default := 5;
            K.default := 5;
        END;
        Graphic ISA super::Graphic;
    END;
    FlowPID ISA super::FlowPID WITH
        PID Module ISA super::PID_Module WITH
            uHigh := 1;
            uReverse.default := 0;
            Don := 0;
            Ion.default := 0;
            n := 5;
            tr.default := 10;
            b := 1;
            Td := 5;
            Ti.default := 10;
            K.default := 1;
        END;
        Graphic ISA super::Graphic;
    END;
    DistUnit ISA super::DistUnit WITH
        Controller ISA super::Controller WITH
            BLref.default := 1;
            DLref.default := 6;
            BCref.default := 0.2;
            TCref.default := 0.7;
            BoilerLevelPID ISA super::BoilerLevelPID WITH
                %% y = boiler level, u = bottom valve
                PID Module.K.default := 10;
                PID Module.Ti.default := 10;
                PID Module.Td := 0;
                PID Module.b := 1;
                PID Module.tr.default := 50;
                PID Module.n := 5;
                PID Module.Ion.default := 0;
                PID Module.Don := 0;
                PID Module.uReverse := 1;
                PID Module.uHigh := 1;
            END;
            DrumLevelPID ISA super::DrumLevelPID WITH
                %% y = drum level, u = top valve
                PID Module.K.default := 10;
                PID Module.Ti.default := 10;
                PID Module.Td := 0;
                PID Module.b := 1;
                PID Module.tr.default := 50;
                PID Module.n := 5;
            END;
        END;
    END;

```

```

PID Module.Ion.default := 0;
PID Module.Don := 0;
PID Module.uReverse := 1;
PID Module.uHigh := 1;
END;

TopCompPID ISA super::TopCompPID WITH
%% y = top composition, u = reflux valve
PID Module.K.default := 30;
PID Module.Ti.default := 10;
PID Module.Td := 0;
PID Module.b := 1;
PID Module.tr.default := 50;
PID Module.n := 5;
PID Module.Ion.default := 0;
PID Module.Don := 0;
PID Module.uReverse := 0;
PID Module.uHigh := 1;
END;

BottomCompPID ISA super::BottomCompPID WITH
%% y = bottom composition, u = heat valve
PID Module.K.default := 30;
PID Module.Ti.default := 10;
PID Module.Td := 0;
PID Module.b := 1;
PID Module.tr.default := 50;
PID Module.n := 5;
PID Module.Ion.default := 0;
PID Module.Don := 0;
PID Module.uReverse := 1;
PID Module.uHigh := 1;
END;

Grafset ISA super::Grafset WITH
StartTime.default := 1;
StopTime.default := 45;
Lbmin.default := 0.5;
Ldmax.default := 6.5;
Ldmin.default := 4;
END;

DistUnit ISA super::DistUnit WITH
MediumModel ISA PhaseEquilib::ABSPHASEEquilData;
ReBoiler ISA super::ReBoiler WITH
BoilerSide.BoilerArea.default := 3.14;
BoilerSide.Pressure.default := 671;
BoilerSide.Xmole.initial := [12.4; 16.8; 68.8];
HeatTrans.TransArea.default := 15;
HeatTrans.Kappa.default := 5000;
HeatSide.Cp := 4.18;
HeatSide.Volume.default := 1;
HeatSide.Density := 1000;
HeatSide.Temp.initial := 450;
END;

Condenser.CondSide.Pressure.default := 671;
RefluxDrum ISA super::RefluxDrum WITH
Drum.DrumArea.default := 3.14;
Drum.Pressure.default := 671;
Drum.Xmole.initial := [28.2; 172.8; 46.9];
END;

TrayColumn ISA super::TrayColumn WITH
Tray9.MachineModel.TrayArea.default := 3.14;
Tray8.MachineModel.TrayArea.default := 3.14;
Tray7.MachineModel.TrayArea.default := 3.14;
FeedTray6.MachineModel.TrayArea.default := 3.14;
Tray5.MachineModel.TrayArea.default := 3.14;
Tray4.MachineModel.TrayArea.default := 3.14;
Tray3.MachineModel.TrayArea.default := 3.14;
Tray2.MachineModel.TrayArea.default := 3.14;
Tray1.MachineModel.TrayArea.default := 3.14;
Tray9.MachineModel.WeirLength.default := 1;
Tray8.MachineModel.WeirLength.default := 1;
Tray7.MachineModel.WeirLength.default := 1;
FeedTray6.MachineModel.WeirLength.default := 1;
Tray5.MachineModel.WeirLength.default := 1;
Tray4.MachineModel.WeirLength.default := 1;
Tray3.MachineModel.WeirLength.default := 1;
Tray2.MachineModel.WeirLength.default := 1;
Tray1.MachineModel.WeirLength.default := 1;
Tray9.MachineModel.WeirHeight.default := 0.02;
Tray8.MachineModel.WeirHeight.default := 0.02;
Tray7.MachineModel.WeirHeight.default := 0.02;
FeedTray6.MachineModel.WeirHeight.default := 0.02;
Tray5.MachineModel.WeirHeight.default := 0.02;
Tray4.MachineModel.WeirHeight.default := 0.02;
Tray3.MachineModel.WeirHeight.default := 0.02;
Tray2.MachineModel.WeirHeight.default := 0.02;
Tray1.MachineModel.WeirHeight.default := 0.02;
Tray9.MachineModel.GravConst.default := 9.81;
Tray8.MachineModel.GravConst.default := 9.81;
Tray7.MachineModel.GravConst.default := 9.81;
FeedTray6.MachineModel.GravConst.default := 9.81;
Tray5.MachineModel.GravConst.default := 9.81;
Tray4.MachineModel.GravConst.default := 9.81;
Tray3.MachineModel.GravConst.default := 9.81;
Tray2.MachineModel.GravConst.default := 9.81;
Tray1.MachineModel.GravConst.default := 9.81;
Tray9.MachineModel.PressureDrop.default := 671;
Tray8.MachineModel.PressureDrop.default := 671;
Tray7.MachineModel.PressureDrop.default := 671;
FeedTray6.MachineModel.PressureDrop.default := 671;
Tray5.MachineModel.PressureDrop.default := 671;
Tray4.MachineModel.PressureDrop.default := 671;
Tray3.MachineModel.PressureDrop.default := 671;
Tray2.MachineModel.PressureDrop.default := 671;
Tray1.MachineModel.PressureDrop.default := 671;
Tray9.MachineModel.Xmole.initial := [0.188; 0.674; 0.646];
Tray8.MachineModel.Xmole.initial := [0.202; 0.605; 0.893];
Tray7.MachineModel.Xmole.initial := [0.199; 0.575; 1.04];
FeedTray6.MachineModel.Xmole.initial := [0.191; 0.569; 1.12];
Tray5.MachineModel.Xmole.initial := [0.193; 0.566; 1.12];
Tray4.MachineModel.Xmole.initial := [0.195; 0.56; 1.14];
Tray3.MachineModel.Xmole.initial := [0.12; 0.545; 1.17];
Tray2.MachineModel.Xmole.initial := [0.21; 0.514; 1.23];
Tray1.MachineModel.Xmole.initial := [0.231; 0.454; 1.33];
END;

RefluxValve.Qmax.default := 50;
TopValve.Qmax.default := 50;
BottomValve.Qmax.default := 50;
HeatValve.Qmax.default := 10;
HeatValve.in.Temp := 450;
HeatValve.in.Pres := 0;
plot_vectors;
AC TYPE Matrix [9, 1];
BC TYPE Matrix [9, 1];
SC TYPE Matrix [9, 1];
AC := [TrayColumn.Tray9.LOut.Comp[1]; TrayColumn.Tray8.LOut.Comp[1]; $
^ TrayColumn.Tray7.LOut.Comp[1]; TrayColumn.FeedTray6.LOut.Comp[1]; $

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```

^; TrayColumnn.Tray5.IOut.Comp[1]; TrayColumnn.Tray4.IOut.Comp[1];$
^ TrayColumnn.Tray3.IOut.Comp[1]; TrayColumnn.Tray2.IOut.Comp[1];$
^ TrayColumnn.Tray1.IOut.Comp[1];$
BC := [TrayColumnn.Tray9.IOut.Comp[2]; TrayColumnn.Tray8.IOut.Comp[2];$
^ TrayColumnn.Tray7.IOut.Comp[2]; TrayColumnn.Tray6.IOut.Comp[2];$
^ TrayColumnn.Tray5.IOut.Comp[2]; TrayColumnn.Tray4.IOut.Comp[2];$
^ TrayColumnn.Tray3.IOut.Comp[2]; TrayColumnn.Tray2.IOut.Comp[2];$
^ TrayColumnn.Tray1.IOut.Comp[2];$
SC := [TrayColumnn.Tray9.IOut.Comp[3]; TrayColumnn.Tray8.IOut.Comp[3];$
^ TrayColumnn.Tray7.IOut.Comp[3]; TrayColumnn.Tray6.IOut.Comp[3];$
^ TrayColumnn.Tray5.IOut.Comp[3]; TrayColumnn.Tray4.IOut.Comp[3];$
^ TrayColumnn.Tray3.IOut.Comp[3]; TrayColumnn.Tray2.IOut.Comp[3];$
^ TrayColumnn.Tray1.IOut.Comp[3];$
END;
END;
END;
%%-----
%%-----
%%-----
BPlantSimProblem ISA ProcessPlantLib::BPlantModel WITH
%% Simulation problem formulation for
%% a process plant with one CSTR and
%% one distillation unit.
Controller ISA super::Controller WITH
StartTime.default := 0.1;
StopTime.default := 100;
END;
Pretreat ISA super::Pretreat WITH
Pretreat ISA super::Pretreat WITH
RecycleRANK ISA super::RecycleRANK WITH
CrossArea.default := 1;
ReactorMachine.Mole.initial := [0; 0; 7.2];
ReactorMachine.energy.initial := 11400;
Graphic ISA super::Graphic;
END;
MixerVessel.Pressure := 0;
MixerVessel.TotMole.default := 20;
MixerVessel.IOut.Comp.default := [0;0;1];
AfeedValve.Qmax.default := 50;
RecycleValve.Qmax.default := 50;
Graphic ISA super::Graphic;
END;
Controller ISA super::Controller WITH
Grafcet ISA super::Grafcet WITH
StartTime.default := 0.5;
StopTime.default := 100;
END;
LevelPID ISA super::LevelPID WITH
PID Module ISA super::PID Module WITH
uHigh := 1;
uReverse := 1;
Don := 0;
Ion.default := 0;
n := 5;
tr.default := 10;
b := 1;
Td := 5;
Ti.default := 1;
K.default := 3;
END;
Graphic ISA super::Graphic;

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```

END;
APID ISA super::APID WITH
PID Module ISA super::PID Module WITH
uHigh := 1;
uReverse.default := 0;
Don := 0;
Ion.default := 0;
n := 5;
tr.default := 10;
b := 1;
Td := 5;
Ti.default := 5;
K.default := 5;
END;
Graphic ISA super::Graphic;
END;
Lref.default := 1.3;
Aref.default := 0.3;
END;
Graphic ISA super::Graphic;
END;
CSTR ISA super::CSTR WITH
CSTRUnit ISA super::CSTRUnit WITH
CSTR ISA super::CSTR WITH
Wall.Kappa.default := 3070;
Wall.TransArea.default := 23;
Jacket.Cp.default := 4.19;
Jacket.Volume.default := 0.11;
Jacket.Density.default := 1000;
Jacket.Temp.initial := 21;
ReactorVessel ISA super::ReactorVessel WITH
CrossArea.default := 1;
ReactorMachine.Mole.initial := [0; 0; 7.2];
ReactorMachine.energy.initial := 11400;
END;
Graphic ISA super::Graphic;
END;
CoolValve.Qmax.default := 2.8;
FeedValve.Qmax.default := 50;
OutValve.Qmax.default := 50;
Graphic ISA super::Graphic;
END;
Controller ISA super::Controller WITH
Grafcet ISA super::Grafcet WITH
StartTime.default := 0.7;
StopTime.default := 100;
TempReflow := 21;
END;
LevelPID ISA super::LevelPID WITH
PID Module ISA super::PID Module WITH
uHigh := 1;
uReverse := 0;
Don := 0;
Ion.default := 1;
n := 5;
tr.default := 10;
b := 1;
Td := 5;
Ti.default := 1;
K.default := 3;
END;
Graphic ISA super::Graphic;
END;

```

```

TempPID ISA super::TempPID WITH
  PID Module ISA super::PID Module WITH
    uHigh := 1;
    uReverse.default := 1;
    Don := 0;
    Ion.default := 1;
    n := 5;
    tr.default := 10;
    b := 1;
    Td := 5;
    Ti.default := 5;
    K.default := 5;
  END;
  Graphic ISA super::Graphic;
END;

FlowPID ISA super::FlowPID WITH
  PID Module ISA super::PID Module WITH
    uHigh := 1;
    uReverse.default := 0;
    Don := 0;
    Ion.default := 0;
    n := 5;
    tr.default := 10;
    b := 1;
    Td := 5;
    Ti.default := 10;
    K.default := 1;
  END;
  Graphic ISA super::Graphic;
END;
  Graphic ISA super::Graphic;
END;

Cool.Pres := 0;
Cool.Temp := 21;
  Graphic ISA super::Graphic;
END;

DistUnit ISA super::DistUnit WITH
  Controller ISA super::Controller WITH
    BLref.default := 1;
    DLref.default := 6;
    BCref.default := 0.1;
    TCref.default := 0.75;
    BoilerLevelPID ISA super::BoilerLevelPID WITH
      %% y = boiler level, u = bottom valve
      PID Module.K.default := 10;
      PID Module.Ti.default := 10;
      PID Module.Td := 0;
      PID Module.b := 1;
      PID Module.tr.default := 50;
      PID Module.n := 5;
      PID Module.Ion.default := 0;
      PID Module.uReverse := 1;
      PID Module.uHigh := 1;
    END;
  DrumLevelPID ISA super::DrumLevelPID WITH
    %% y = drum level, u = top valve
    PID Module.K.default := 10;
    PID Module.Ti.default := 10;
    PID Module.Td := 0;
  END;
  Condenser.CondSide.Pressure.default := 671;
  RefluxDrum ISA super::RefluxDrum WITH
    Drum.DrumArea.default := 3.14;
    Drum.Pressure.default := 671;
    Drum.Xmole.initial := [28.2; 268; 87.8];
  END;
  TrayColumn ISA super::TrayColumn WITH
    Tray9.MachineModel.TrayArea.default := 3.14;

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```

Tray8.MachineModel.TrayArea.default := 3.14;
Tray7.MachineModel.TrayArea.default := 3.14;
FeedTray6.MachineModel.TrayArea.default := 3.14;
Tray5.MachineModel.TrayArea.default := 3.14;
Tray4.MachineModel.TrayArea.default := 3.14;
Tray3.MachineModel.TrayArea.default := 3.14;
Tray2.MachineModel.TrayArea.default := 3.14;
Tray1.MachineModel.TrayArea.default := 3.14;
Tray8.MachineModel.WeirLength.default := 1;
Tray7.MachineModel.WeirLength.default := 1;
FeedTray6.MachineModel.WeirLength.default := 1;
Tray5.MachineModel.WeirLength.default := 1;
Tray4.MachineModel.WeirLength.default := 1;
Tray3.MachineModel.WeirLength.default := 1;
Tray2.MachineModel.WeirLength.default := 1;
Tray1.MachineModel.WeirLength.default := 1;
Tray9.MachineModel.WeirHeight.default := 0.02;
Tray8.MachineModel.WeirHeight.default := 0.02;
Tray7.MachineModel.WeirHeight.default := 0.02;
FeedTray6.MachineModel.WeirHeight.default := 0.02;
Tray5.MachineModel.WeirHeight.default := 0.02;
Tray4.MachineModel.WeirHeight.default := 0.02;
Tray3.MachineModel.WeirHeight.default := 0.02;
Tray2.MachineModel.WeirHeight.default := 0.02;
Tray1.MachineModel.WeirHeight.default := 0.02;
Tray9.MachineModel.GravConst.default := 9.81;
Tray8.MachineModel.GravConst.default := 9.81;
Tray7.MachineModel.GravConst.default := 9.81;
FeedTray6.MachineModel.GravConst.default := 9.81;
Tray5.MachineModel.GravConst.default := 9.81;
Tray4.MachineModel.GravConst.default := 9.81;
Tray3.MachineModel.GravConst.default := 9.81;
Tray2.MachineModel.GravConst.default := 9.81;
Tray1.MachineModel.PressureDrop.default := 671;
Tray9.MachineModel.PressureDrop.default := 671;
Tray8.MachineModel.PressureDrop.default := 671;
Tray7.MachineModel.PressureDrop.default := 671;
FeedTray6.MachineModel.PressureDrop.default := 671;
Tray5.MachineModel.PressureDrop.default := 671;
Tray4.MachineModel.PressureDrop.default := 671;
Tray3.MachineModel.PressureDrop.default := 671;
Tray2.MachineModel.PressureDrop.default := 671;
Tray1.MachineModel.PressureDrop.default := 671;
Tray9.MachineModel.Xmole.initial := [0.188; 0.674; 0.646];
Tray8.MachineModel.Xmole.initial := [0.202; 0.605; 0.893];
Tray7.MachineModel.Xmole.initial := [0.199; 0.575; 1.04];
FeedTray6.MachineModel.Xmole.initial := [0.191; 0.569; 1.12];
Tray5.MachineModel.Xmole.initial := [0.193; 0.566; 1.12];
Tray4.MachineModel.Xmole.initial := [0.195; 0.56; 1.14];
Tray3.MachineModel.Xmole.initial := [0.12; 0.545; 1.17];
Tray2.MachineModel.Xmole.initial := [0.21; 0.514; 1.23];
Tray1.MachineModel.Xmole.initial := [0.231; 0.454; 1.33];
END;
RefluxValve.Qmax.default := 50;
TopValve.Qmax.default := 50;
BottomValve.Qmax.default := 50;
HeatValve.Qmax.default := 10;
HeatValve.in.Temp := 450;
HeatValve.in.Pres := 0;
plot_vectors;
AC TYPE Matrix [9, 1];
BC TYPE Matrix [9, 1];

```

```

SC TYPE Matrix [9, 1];
AC := [TrayColumn.Tray9.LOut.Comp[1]; TrayColumn.Tray8.LOut.Comp[1]; $
^ TrayColumn.Tray7.LOut.Comp[1]; TrayColumn.FeedTray6.LOut.Comp[1] $
^ TrayColumn.Tray5.LOut.Comp[1]; TrayColumn.Tray4.LOut.Comp[1] $
^ TrayColumn.Tray3.LOut.Comp[1]; TrayColumn.Tray2.LOut.Comp[1]; $
^ TrayColumn.Tray1.LOut.Comp[1];
BC := [TrayColumn.Tray9.LOut.Comp[2]; TrayColumn.Tray8.LOut.Comp[2]; $
^ TrayColumn.Tray7.LOut.Comp[2]; TrayColumn.FeedTray6.LOut.Comp[2] $
^ TrayColumn.Tray5.LOut.Comp[2]; TrayColumn.Tray4.LOut.Comp[2]; $
^ TrayColumn.Tray3.LOut.Comp[2]; TrayColumn.Tray2.LOut.Comp[2]; $
^ TrayColumn.Tray1.LOut.Comp[2];
SC := [TrayColumn.Tray9.LOut.Comp[3]; TrayColumn.Tray8.LOut.Comp[3]; $
^ TrayColumn.Tray7.LOut.Comp[3]; TrayColumn.FeedTray6.LOut.Comp[3] $
^ TrayColumn.Tray5.LOut.Comp[3]; TrayColumn.Tray4.LOut.Comp[3]; $
^ TrayColumn.Tray3.LOut.Comp[3]; TrayColumn.Tray2.LOut.Comp[3]; $
^ TrayColumn.Tray1.LOut.Comp[3];
END;
END;
END;
MyFactory ISA Base::Model WITH
AtoBPlant ISA ProcessPlantWosp::BPlantSimProblem WITH
Graphic ISA super::Graphic WITH
x_pos := 200.0;
y_pos := 175.0;
END;
END;
Graphic ISA super::Graphic;
END;

```