LUND UNIVERSITY

A Chemical Plant Model in Omola

The code

Nilsson, Bernt

1993

Document Version:
Publisher's PDF, also known as Version of record

Link to publication

Citation for published version (APA):
Nilsson, B. (1993). *A Chemical Plant Model in Omola: The code*. (Technical Reports TFRT-7507). Department of Automatic Control, Lund Institute of Technology (LTH).

Total number of authors:
1

General rights
Unless other specific re-use rights are stated the following general rights apply:
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.
• Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
• You may not further distribute the material or use it for any profit-making activity or commercial gain
• You may freely distribute the URL identifying the publication in the public portal

Read more about Creative commons licenses: https://creativecommons.org/licenses/

Take down policy
If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

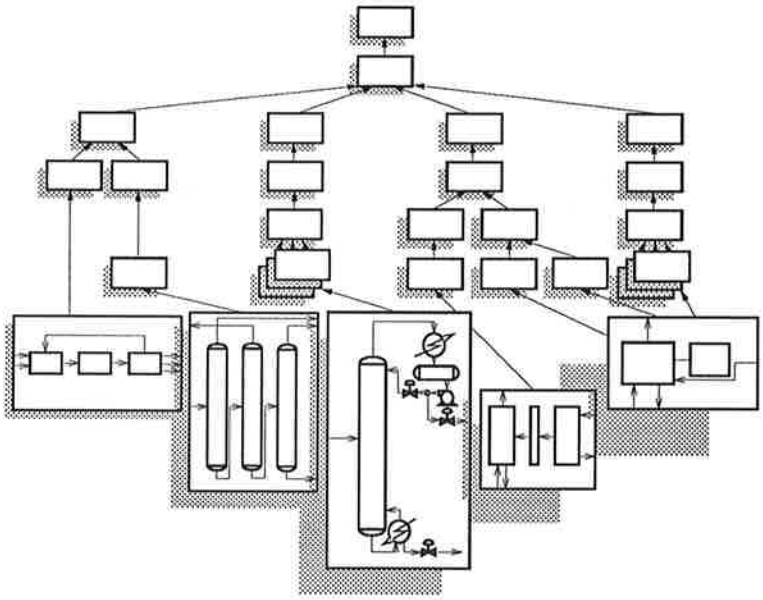
LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

ISSN 0280–5316
ISRN LUTFD2/TFRT--7507--SE

A Chemical Plant Model in Omola — the code

Bernt Nilsson



Department of Automatic Control
Lund Institute of Technology
June 1993

Department of Automatic Control
Lund Institute of Technology
P.O. Box 118
S-221 00 Lund Sweden

Document name
INTERNAL REPORT

Date of issue
June 1993

Document Number
ISRN LUTFD2/TFRT--7507--SE

Author(s)
Bernt Nilsson

Supervisor

Sponsoring organisation

Title and subtitle
A Chemical Plant Model in Omola

Abstract

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.

Key words

Classification system and/or index terms (if any)

Supplementary bibliographical information

ISSN and key title
0280–5316

ISBN
0280–5316

Language
English

Number of pages
70

Recipient's notes

Security classification

The report may be ordered from the Department of Automatic Control or borrowed through the University Library 2, Box 1010, S-221 03 Lund, Sweden, Fax +46 46 110019, Telex: 33248 lubbis lund.

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.

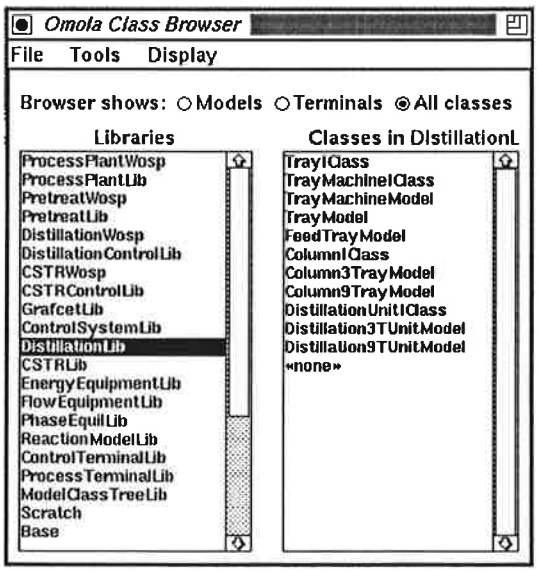


Figure 1. The Omola browser with the plant libraries.

```
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 procwess
%% 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 plow 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;
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

Reaction1OrderIClass 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;

Reaction1oiModel ISA Reaction1OrderIClass WITH
%% First order kinetics of a simple
%% irreverabel reaction, A -> B.
parameters:
  K0, R, Ea, Hreac ISA Parameter;
variable:
  rr TYPE Real;
equations:
  %% reaction rate
  %% temp in celcius
  rr = -K0*exp(-Ea/(R*(MMT.Temp+273)))*MMT.Conc[1];
  MMT.ReactionRate = [rr; -rr; 0];
  %% energy production
  MMT.EnergyProd = Hreac*rr;
END;


Reaction1orModel ISA Reaction1OrderIClass WITH
%% First order kinetics of a simple
%% reverabel reaction, A <-> B.
parameters:
  K0, R, Ea, Hreac, alfa ISA Parameter;
variables:
  Kreaction, rr ISA Variable;
equations:
  %% reaction rate
  Kreaction  = -K0*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 Reaction1oiModel WITH
%% A irreversabel 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
  K0.default := 6.99E10;
  R.default := 0.00833;
  Ea.default := 69.418;
  Hreac.default := -69.9e+3;
END;

ZeroReactionModel ISA Reaction1oiModel WITH
%% A irreversabel 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
  %% no reaction.
  K0.default := 0;
  R.default := 0.00833;
  Ea.default := 69.418;
  Hreac.default := -69.9e+3;
END;

AeqBReactionModel ISA Reaction1orModel WITH
%% A reversabel 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;
  K0      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;
END;

%-------------------------------------------------
```

```
LIBRARY PhaseEquilLib;
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 volality.
%% A and B are components and
%% S is solvent.
structure_parameter:
  NumberOfComponents := 3;
parameter:
  %% alfa koefficients 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 volality
  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
  %% Aceton-Ethanol-Water
  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;
```

```
LIBRARY FlowEquipmentLib;
USES ModelClassTreeLib, ProcessTerminalLib, PhaseEquilLib;
%% This a library containing classes for
%% process flow equipment in the Process Example.
%% Flow equipment are valves, mixers, vessels etc.
%%
%% Design: Bernt Nilsson, 4 march 1993.

%%-------------------------------------
%% valve classes

ControlValveIClass ISA FlowEquipClass WITH
%% A control valve interface class.
%% Uses the "pipe"-terminals.
icon:
  Graphic ISA Layout WITH
    bitmap TYPE String := "iconvalve";
  END;
terminals:
  In ISA PipeInTerminal WITH
  attributes:
    Graphic ISA Base::Layout WITH
    attributes:
      x_pos := 0;
      y_pos := 75;
      invisible := 1;
    END;
  END;
  Out ISA PipeOutTerminal WITH
  attributes:
    Graphic ISA Base::Layout WITH
    attributes:
      x_pos := 400;
      y_pos := 75;
      invisible := 1;
    END;
  END;
  Control ISA SimpleInput WITH
  attributes:
    Graphic ISA Base::Layout WITH
    attributes:
      x_pos := 200;
      y_pos := 299;
      invisible := 1;
    END;
  END;
END;

ControlValveModel ISA ControlValveIClass WITH
%% A control valve model.  The flow  through
%% the valve is proportional to the control signal.
%% Used in the nonmatrix based reactor example and
%% the "pipe"-terminals.
parameters:
  Qmax ISA Parameter;
variables:
  valveposition ISA Variable;
equations:
  %% static mass and energy balances
  In.Flow  = Out.Flow;
  In.AConc = Out.AConc;
  In.BConc = Out.BConc;
  In.Temp  = Out.Temp;
  In.Pres  = Out.Pres;
  %% constraints on the valve position
  valveposition= IF Control>1 THEN 1 ELSE IF Control<0 THEN 0 ELSE
    Control;
  %% flow expression
  In.Flow = Qmax*valveposition;
END;

CoolControlValveModel ISA ControlValveIClass WITH
%% A control valve model.  The flow  through
%% the valve is propotional to the max-flow
%% and the control signal.
%% Used in heating/cooling flows using the
%% "flow"-terminals.
  In ISA FlowInTerminal WITH
  attributes:
    Graphic ISA Base::Layout WITH
    attributes:
      x_pos := 0;
      y_pos := 75;
      invisible := 1;
    END;
  END;
  Out ISA FlowOutTerminal WITH
  attributes:
    Graphic ISA Base::Layout WITH
    attributes:
      x_pos := 400;
      y_pos := 75;
      invisible := 1;
    END;
  END;
parameters:
  Qmax ISA Parameter;
variables:
  valveposition ISA Variable;
equations:
  %% static mass and energy balances
  In.Flow  = Out.Flow;
  In.Temp  = Out.Temp;
  In.Pres  = Out.Pres;
  %% constraints on the valve position
  valveposition= IF Control>1 THEN 1 ELSE IF Control<0 THEN 0 ELSE
    Control;
  %% flow expression
  In.Flow = Qmax*valveposition;
END;

ControlValveModelV ISA ControlValveIClass WITH
%% A control valve model with vector notation.
%% The flow  through the valve is proportional
%% to the max-flow and the control signal.
%% Used in the distillation column and using
%% the "liquid/vapor"-terminals.
structure_parameter:
  ChemDim TYPE Integer;
terminals:
  In ISA ProcessTerminalLib::LiquidInTerminal WITH
  attributes:
    Graphic ISA Base::Layout WITH
    attributes:
      x_pos := 0;
      y_pos := 75;
```

```
      invisible := 1;
    END;
    Comp.n := ChemDim;
  END;
  Out ISA ProcessTerminalLib::LiquidOutTerminal WITH
  attributes:
    Graphic ISA Base::Layout WITH
    attributes:
      x_pos := 400;
      y_pos := 75;
      invisible := 1;
    END;
    Comp.n := ChemDim;
  END;
parameters:
  Qmax ISA Parameter;
variables:
  valveposition ISA Variable;
equations:
  %% static mass and energy balances
  In.Flow  = Out.Flow;
  In.Comp  = Out.Comp;
  In.Pressure  = Out.Pressure;
  In.MoleEnergy = Out.MoleEnergy;
  %% constraints on the valve position
  valveposition= IF Control>1 THEN 1 ELSE IF Control<0 THEN 0 ELSE
    Control;
  %% flow expression
  In.Flow = Qmax*valveposition;
END;


%%-------------------------------------------------------------
%% mixer models

Mixer ISA FlowEquipClass WITH
%% A static mixer model with two liquid
%% inflow and one liquid outflow.
%% Uses the "liquid"-terminals.
%% Example: in a feed tray model.
icon:
  Graphic ISA Base::Layout WITH bitmap TYPE String := "iconmixer"; END;
parameter:
  ChemDim TYPE Integer;
terminals:
  LIn1 ISA LiquidInTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 101;
      y_pos := 300;
      invisible := 1;
    END;
    Comp.n := ChemDim;
  END;
  LIn2 ISA LiquidInTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 301;
      y_pos := 300;
      invisible := 1;
    END;
    Comp.n := ChemDim;
  END;
  LOut ISA LiquidOutTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 200;
      y_pos := 1;
      invisible := 1;
    END;
    Comp.n := ChemDim;
  END;
parameter:
  Pressure ISA Base::Parameter;
variable:
  eps TYPE Real := 0.0001;
  Flow ISA Variable;
  q TYPE DISCRETE Integer;
event:
  Init ISAN Event;
equations:
  %% static mass blance
  LOut.Flow = LIn1.Flow + LIn2.Flow;
  %% Test if flow is zero then it is set to one
%  ONEVENT Init  DO new(q):= if LOut.Flow>eps then 1 else 0; END;
%  ONEVENT LOut.Flow<eps  DO new(q):=0; END;
%  ONEVENT LOut.Flow>eps  DO new(q):=1; END;
%  Flow = q*LOut.Flow + (1-q)*eps;
%  Flow = LOut.Flow + eps;
  Flow := if LOut.Flow>eps then LOut.Flow else eps;
  %% static component balance
  LOut.Comp = (LIn1.Flow*LIn1.Comp + LIn2.Flow*LIn2.Comp)/Flow;
  LOut.MoleEnergy = (LIn1.Flow*LIn1.MoleEnergy +
                     LIn2.Flow*LIn2.MoleEnergy)/Flow;
  LOut.Pressure = Pressure;
END;

MixerModel ISA FlowEquipClass WITH
%% A static mixer model with three liquid
%% inflow and one liquid outflow.
%% Uses the "liquid"-terminals.
icon:
  Graphic ISA Base::Layout WITH bitmap TYPE String := "iconmixer"; 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 ISA Base::Parameter;
variable:
  Flow ISA Variable;
  q TYPE DISCRETE Real;
event:
  Init ISAN Event;
equations:
  %% static mass blance
  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 equlibrium 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,
     PhaseEquilLib, 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;
END;

HeatTransferModel ISA EnergyEquipmentLib::HeatTransferIClass WITH
%% A static heat transfer model.
parameters:
  Kappa ISA Base::Parameter;
  TransArea ISA Base::Parameter;
realization:
  HTStatic ISA Base::SetOfDAE WITH
  equations:
    HTOut.Qtrans = Kappa*TransArea*(HTIn.Temp - HTOut.Temp);
    HTIn.Qtrans = HTOut.Qtrans;
  END;
END;

%%-------------------------------------------------------
%% heat/cool volume models

HEXPartIClass ISA ModelClassTreeLib::SubEnergyEquipClass WITH
%% An interface class of a volume for
%% heat/cool medium.
icon:
  Graphic ISA Base::Layout WITH
    bitmap TYPE String := "iconhexpart";
  END;
terminals:
  HTIn ISA ProcessTerminalLib::HeatTransferInTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 400;
      y_pos := 175;
      invisible := 1;
    END;
  END;
  In ISA ProcessTerminalLib::FlowInTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 0;
      y_pos := 200;
      invisible := 1;
    END;
  END;
  Out ISA ProcessTerminalLib::FlowOutTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 0;
      y_pos := 100;
      invisible := 1;
    END;
  END;
END;

HEXPartModel 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;

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:
  LIn ISA ProcessTerminalLib::LiquidInTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 220;
      y_pos := 0;
      invisible := 1;
    END;
    Comp.n := ChemDim;
  END;
```

```
  LOut 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;
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;
  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; END;
  Comp ISA ProcessTerminalLib::ColumnVectorClass WITH n := ChemDim; END;
equations:
  %% mole component balances
  Xmole' = LIn.Flow*LIn.Comp - LOut.Flow*LOut.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 equlibrium 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;
  END;
  HeatTrans ISA EnergyEquipmentLib::HeatTransferModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 150.0;
      y_pos := 150.0;
    END;
  END;
  HeatSide ISA EnergyEquipmentLib::HEXPartModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 75.0;
      y_pos := 150.0;
    END;
  END;
  MediumModel ISA PhaseEquilLib::DistMediumModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 325.0;
      y_pos := 150.0;
    END;
  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,$
                                                                          ^ 170.0];
  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;
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 := [58, 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;
terminals:
  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;
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 PhaseEquilLib::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 PhaseEquilLib::ABSPhaseEquilData;
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 225.0;
    END;
  END;
  Drum ISA FlowEquipmentLib::RefluxDrumModel WITH
    MediumModel ISA PhaseEquilLib::ABSPhaseEquilData;
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 150.0;
    END;
  END;
  RefluxValve ISA FlowEquipmentLib::ControlValveModelV WITH
    Graphic ISA super::Graphic WITH
      x_pos := 100.0;
      y_pos := 75.0;
    END;
    ChemDim := outer::ChemDim;
  END;
  TopValve ISA FlowEquipmentLib::ControlValveModelV 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 PhaseEquilLib::ABSPhaseEquilData;
    CondSide.Pressure.default := 671;
  END;
  Drum ISA FlowEquipmentLib::RefluxDrumModel WITH
    MediumModel ISA PhaseEquilLib::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 ModelClassTreeLib, 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

TankReactorMachineIClass 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;
END;

TankReactorMachineModel ISA TankReactorMachineIClass 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;
  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, 149.0; 250.0, 153.0; 299.0, 153.0];
  END;
END;
```

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

TankReactorIClass ISA CSTRLib::TankReactorClass 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;
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;
```

```
      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;
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;
    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, PhaseEquilLib,$
                                    ^ 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;
END;

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

TrayMachineModel ISA DistillationLib::TrayMachineIClass WITH
  %% A tray machine model.
  %% can be connected to a distillation
  %% medium model from the PhaseEquilLib.
parameters:
  TrayArea ISA Base::Parameter;
  WeirLenght 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 equlibrium description in medium model
  MMT.LComp = Comp;
  MMT.Pressure = VIn.Pressure - PressureDrop;
  %% liquid outflow
  OutFlow = if height < WeirHeight then 0 else WeirLenght/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;
  MediumModel ISA PhaseEquilLib::ABSPhaseEquilData WITH
    Graphic ISA super::Graphic WITH
      x_pos := 301;
      y_pos := 151;
    END;
  END;
connections:
  C1 ISA Base::Connection WITH
    VOut AT MachineModel.VOut;
    bpoints TYPE Matrix [4, 2] := [176.0, 300.0; 176.0, 225.0; 154.0, 225.0; 154.0,$
                                                                          ^ 186.0];
  END;
  C2 ISA Base::Connection WITH
    MachineModel.VIn AT VIn;
    bpoints TYPE Matrix [4, 2] := [154.0, 112.0; 154.0, 56.0; 176.0, 56.0; 176.0, 1.0];
  END;
  C3 ISA Base::Connection WITH
    MachineModel.MMT AT MediumModel.MMT;
    bpoints TYPE Matrix [4, 2] := [183.0, 149.0; 214.0, 149.0; 214.0, 156.0; 244.0,$
                                                                          ^ 156.0];
  END;
  C4 ISA Base::Connection WITH
    LIn AT MachineModel.LIn;
    bpoints TYPE Matrix [4, 2] := [101.0, 300.0; 101.0, 240.0; 95.0, 240.0; 95.0,$
                                                                        ^ 186.0];
  END;
  C5 ISA Base::Connection WITH
    MachineModel.LOut AT LOut;
    bpoints TYPE Matrix [4, 2] := [95.0, 112.0; 95.0, 47.0; 101.0, 42.0; 101.0, 1.0];
  END;
END;

FeedTrayModel ISA DistillationLib::TrayIClass WITH
  %% Composite model of a feed tray.
icon:
  Graphic ISA super::Graphic;
structure_parameters:
  ChemDim := MediumModel.NumberOfComponents;
  MachineModel.ChemDim := MediumModel.NumberOfComponents;
  Mixer.ChemDim := MediumModel.NumberOfComponents;
terminal:
  Feed ISA ProcessTerminalLib::LiquidInTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 0.0;
      y_pos := 150.0;
      invisible := 1;
    END;
    Comp.n := ChemDim;
  END;
submodels:
  MachineModel ISA DistillationLib::TrayMachineModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 125.0;
      y_pos := 100.0;
    END;
  END;
  MediumModel ISA PhaseEquilLib::ABSPhaseEquilData WITH
    Graphic ISA super::Graphic WITH
      x_pos := 275.0;
      y_pos := 100.0;
    END;
  END;
  Mixer ISA FlowEquipmentLib::Mixer WITH
    Graphic ISA super::Graphic WITH
      x_pos := 100.0;
      y_pos := 200.0;
    END;
  END;
connections:
  C1 ISA Base::Connection WITH
    Feed AT Mixer.LIn1;
    bpoints TYPE Matrix [5, 2] := [0, 150; 50, 174; 50, 238; 89, 238; 89, 219];
  END;
  C2 ISA Base::Connection WITH
    LIn AT Mixer.LIn2;
    bpoints TYPE Matrix [5, 2] := [99, 299; 99, 271; 99, 252; 109, 245; 109, 219];
  END;
  C3 ISA Base::Connection WITH
    Mixer.LOut AT MachineModel.LIn;
    bpoints TYPE Matrix [4, 2] := [99, 180; 99, 145; 109, 145; 109, 114];
  END;
  C4 ISA Base::Connection WITH
    VOut AT MachineModel.VOut;
    bpoints TYPE Matrix [4, 2] := [299, 299; 299, 160; 139, 160; 139, 114];
  END;
  C5 ISA Base::Connection WITH
    LOut AT MachineModel.LOut;
    bpoints TYPE Matrix [4, 2] := [109, 85; 109, 50; 99, 50; 99, 0];
  END;
  C6 ISA Base::Connection WITH
    VIn AT MachineModel.VIn;
    bpoints TYPE Matrix [4, 2] := [139, 85; 139, 51; 299, 51; 299, 0];
  END;
  C7 ISA Base::Connection WITH
    MachineModel.MMT AT MediumModel.MMT;
    bpoints TYPE Matrix [2, 2] := [154, 99; 245, 99];
  END;
END;

%%-------------------------------------------------------
%% column models

ColumnIClass ISA ModelClassTreeLib::SubSeparatorClass WITH
  %% A distillation column interface class.
icon:
  Graphic ISA Base::Layout WITH bitmap TYPE String := "iconcolumn"; END;
structure_parameter:
  ChemDim TYPE Integer;
terminals:
  Feed ISA ProcessTerminalLib::LiquidInTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 0.0;
      y_pos := 150.0;
      invisible := 1;
    END;
    Comp.n := ChemDim;
  END;
  Reflux ISA ProcessTerminalLib::LiquidInTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 400.0;
      y_pos := 275.0;
      invisible := 1;
    END;
    Comp.n := ChemDim;
  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;
  LOut 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;
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 PhaseEquilLib::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;
  END;
  Tray3 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 := 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;
  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.LOut AT FeedTray2.LIn;
    bpoints TYPE Matrix [2, 2] := [184.0, 210.0; 184.0, 163.0];
  END;
  C4 ISA Base::Connection WITH
    FeedTray2.LOut 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.LIn;
    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
    LOut 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;

Column9TrayModel 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;
  END;
  VOut ISA ProcessTerminalLib::VaporOutTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 500.0;
      invisible := 1;
    END;
    Comp.n := ChemDim;
  END;
abstract_submodel:
  MediumModel ISA PhaseEquilLib::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;
  END;
  Tray1 ISA DistillationLib::TrayModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 50.0;
    END;
  END;
  Tray2 ISA DistillationLib::TrayModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 100.0;
    END;
  END;
  Tray3 ISA DistillationLib::TrayModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 150.0;
    END;
  END;
  Tray4 ISA DistillationLib::TrayModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 200.0;
    END;
  END;
  Tray5 ISA DistillationLib::TrayModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 250.0;
    END;
  END;
  Tray8 ISA DistillationLib::TrayModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 400.0;
    END;
  END;
  Tray7 ISA DistillationLib::TrayModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 350.0;
    END;
  END;
  Tray9 ISA DistillationLib::TrayModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 450.0;
    END;
  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;
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 PhaseEquilLib::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:
  TrayColumn ISA DistillationLib::Column3TrayModel WITH
```

```
    MediumModel ISA outer::MediumModel WITH
      Graphic ISA super::Graphic WITH
        x_pos := 50.0;
        y_pos := 340;
      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;
    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::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 := 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[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.LOut AT RefluxDrum.LIn;
    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, 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.LOut 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.LOut 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;

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 PhaseEquilLib::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:
  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::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 := 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.LOut AT RefluxDrum.LIn;
    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, 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.LOut 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.LOut 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

PIDIClass 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;
  END;
  Control ISA ControlTerminalLib::ControlTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 400;
      y_pos := 150;
      invisible := 1;
    END;
  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::PIDIClass 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::PIDIClass 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*new(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;
```

```
      invisible := 1;
    END;
  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;
%variabels:
%  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;
  In0 ISA ControlTerminalLib::ReferenceTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 0;
      y_pos := 100;
      invisible := 1;
    END;
  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 := "iconcontantsignal";
  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;
    END;
    Control ISA Base::SimpleOutput WITH
      Graphic ISA Base::Layout WITH
        x_pos := 400;
        y_pos := 150;
        invisible := 1;
      END;
    END;
    AutoMan ISA ControlTerminalLib::ManualControlInTerminal WITH
      Graphic ISA Base::Layout WITH
        x_pos := 200;
        y_pos := 300;
        invisible := 1;
      END;
    END;
    SetPoint ISA Base::SimpleInput WITH
      Graphic ISA Base::Layout WITH
        x_pos := 1.0;
        y_pos := 226.0;
        invisible := 1;
      END;
    END;
  submodels:
    PID_Module ISA ControlSystemLib::PIDanalogalgorithm WITH
      Graphic ISA super::Graphic WITH
        x_pos := 125.0;
        y_pos := 150.0;
      END;
    END;
    Limiter ISA ControlSystemLib::Limiter WITH
      Graphic ISA super::Graphic WITH
        x_pos := 325.0;
        y_pos := 150.0;
      END;
    END;
    Switch ISA ControlSystemLib::Switch WITH
      Graphic ISA super::Graphic WITH
        x_pos := 250.0;
        y_pos := 150.0;
      END;
    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.In1.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, 143; 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;
    END;
  submodels:
    PID_Module ISA ControlSystemLib::PIDanalogalgorithm WITH
      Graphic ISA super::Graphic WITH
        x_pos := 125.0;
        y_pos := 150.0;
      END;
    END;
    Switch ISA ControlSystemLib::Switch WITH
      Graphic ISA super::Graphic WITH
        x_pos := 250.0;
        y_pos := 150.0;
      END;
    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.In1.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 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 MISOControllerClass 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 := 100.0;
    END;
  END;
  Control ISA Base::SimpleOutput WITH
    Graphic ISA Base::Layout WITH
      x_pos := 400.0;
      y_pos := 150.0;
    END;
  END;
  Manual1 ISA ControlTerminalLib::ManualControlInTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 175.0;
      y_pos := 300.0;
    END;
  END;
  Manual2 ISA ControlTerminalLib::ManualControlInTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 250.0;
      y_pos := 300.0;
    END;
  END;
submodels:
  PIDouter ISA ControlSystemLib::PIDModule WITH
    Graphic ISA super::Graphic WITH
      x_pos := 125.0;
      y_pos := 150.0;
    END;
  END;
  PIDinner ISA ControlSystemLib::PIDModule WITH
    Graphic ISA super::Graphic WITH
      x_pos := 250.0;
      y_pos := 150.0;
    END;
  END;
  Limiter ISA ControlSystemLib::Limiter WITH
    Graphic ISA super::Graphic WITH
      x_pos := 325.0;
      y_pos := 150.0;
    END;
  END;
connections:
  C1 ISA Base::Connection WITH
    SetPoint AT PIDouter.SetPoint.Ref;
    bpoints TYPE Matrix [4, 2] := [0, 249; 48, 249; 48, 157; 107, 157];
  END;
  C2 ISA Base::Connection WITH
    Measure1 AT PIDouter.Measure;
    bpoints TYPE Matrix [4, 2] := [0, 174; 39, 174; 39, 149; 107, 149];
  END;
  C6 ISA Base::Connection WITH
    PIDinner.Control AT Limiter.In;
    bpoints TYPE Matrix [3, 2] := [266, 149; 291, 149; 307, 149];
  END;
  C8 ISA Base::Connection WITH
    Limiter.Out AT Control;
    bpoints TYPE Matrix [2, 2] := [341, 149; 399, 149];
  END;
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
```

```
    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;
  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;

TransLTerm ISA RecordTerminal WITH
  Trigg ISAN EventOutput;
END;

GrafcetInTerminal 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 TransLTerm 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 Grafcets.
terminals:
  Upper ISA StepUTerm 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;
      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;
END;

Step ISA StepIClass WITH
%% The basic step object in Grafcets.
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 Grafcets.
%% 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;

%-------------------------------------------------------------------------
% 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;
  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;
  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;
```

```
      y_pos := 0;
      invisible := 1;
    END;
  END;
behaviour:
  Lower.State:=min(min(Upper_1.State, Upper_2.State), Upper_3.State);
  OnEvent Lower.Trigg CAUSE Upper_1.Trigg, Upper_2.Trigg, Upper_3.Trigg;
graphics:
  Graphic ISA Layout WITH
    bitmap TYPE String := "iconsync3";
  END;
END;

Fork_2 ISA ParallelSubGrafcetClass WITH
terminals:
  Upper ISA StepUTerm WITH
    Graphic ISA Base::Layout WITH
      x_pos := 200;
      y_pos := 300;
      invisible := 1;
    END;
  END;
  Lower_1 ISA TransLTerm WITH
    Graphic ISA Base::Layout WITH
      x_pos := 37;
      y_pos := 0;
      invisible := 1;
    END;
  END;
  Lower_2 ISA TransLTerm WITH
    Graphic ISA Base::Layout WITH
      x_pos := 365;
      y_pos := 0;
      invisible := 1;
    END;
  END;
behaviour:
  OnEvent Upper.Trigg CAUSE Lower_1.Trigg, Lower_2.Trigg;
graphics:
  Graphic ISA Layout WITH
    bitmap TYPE String := "iconfork2";
  END;
END;

Fork_3 ISA ParallelSubGrafcetClass WITH
terminals:
  Upper ISA StepUTerm WITH
    Graphic ISA Base::Layout WITH
      x_pos := 200;
      y_pos := 300;
      invisible := 1;
    END;
  END;
  Lower_1 ISA TransLTerm WITH
    Graphic ISA Base::Layout WITH
      x_pos := 37;
      y_pos := 0;
      invisible := 1;
    END;
  END;
  Lower_2 ISA TransLTerm WITH
    Graphic ISA Base::Layout WITH
      x_pos := 200;
      y_pos := 0;
      invisible := 1;
    END;
  END;
  Lower_3 ISA TransLTerm WITH
    Graphic ISA Base::Layout WITH
      x_pos := 365;
      y_pos := 0;
      invisible := 1;
    END;
  END;
behaviour:
  OnEvent Upper.Trigg CAUSE Lower_1.Trigg, Lower_2.Trigg;
graphics:
  Graphic ISA Layout WITH
    bitmap TYPE String := "iconfork3";
  END;
END;

%-------------------------------------------------------------------------------
% Extra things

Delay ISA SubGrafcetClass WITH
terminals:
  In ISA DiscBooleanTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 0;
      y_pos := 150;
    END;
  END;
  Out ISA DiscBooleanTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 400;
      y_pos := 150;
    END;
  END;
  Reset ISA DiscBooleanTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 200;
      y_pos := 0;
    END;
  END;
parameter:
  DelayTime ISA Parameter WITH default := 1.0; END;
events:
  Start, Timeout ISAN Event;
behaviour:
  OnEvent In > 0.5 CAUSE Start;
  OnEvent Reset > 0.5 DO new(Out) := 0.0; END;
  OnEvent Start DO schedule(Timeout,DelayTime); END;
  OnEvent Timeout DO new(Out) := 1.0; END;
graphics:
  Graphic ISA Layout WITH
    bitmap TYPE String := "icontimer";
  END;
END;

Pulse ISA SubGrafcetClass WITH
terminals:
  In ISA DiscBooleanTerminal WITH
    Graphic ISA Base::Layout WITH
      x_pos := 0;
      y_pos := 150;
```

```
    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;
  END;
  Control ISA ControlTerminalLib::CSTROutControl WITH
    Graphic ISA super::Graphic WITH
      x_pos := 400.0;
      y_pos := 150.0;
    END;
  END;
submodels:
  LevelPID ISA ControlSystemLib::PIDControllerModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 250.0;
      y_pos := 75.0;
    END;
  END;
  TempPID ISA ControlSystemLib::PIDControllerModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 150.0;
    END;
  END;
  FlowPID ISA ControlSystemLib::PIDControllerModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 150.0;
      y_pos := 225.0;
    END;
  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;
    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;
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;
  END;
  Controller ISA CSTRControlLib::CSTRCController 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; 196, 129];
  END;
END;

%%-------------------------------------------------------
```

```
%%sequence and continuous control

CSTRGrafcet ISA GrafcetLib::GrafcetClass WITH
  Graphic ISA super::Graphic;
terminals:
  OutFlow ISA ControlTerminalLib::ManualControlOutDiscreteTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 400.0;
      y_pos := 225.0;
      invisible := 1;
    END;
  END;
  InFlow ISA ControlTerminalLib::ManualControlOutDiscreteTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 400.0;
      y_pos := 525.0;
      invisible := 1;
    END;
  END;
  CoolFlow 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;
    Tref ISA Base::SimpleOutput WITH value TYPE DISCRETE Real; END;
    Fref 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;
  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;
  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.Fref := 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.Lref) := 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.Lref) := 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;

CSTRIController ISA ModelClassTreeLib::UnitController WITH
  %% An integrated CSTR unit controller with
  %% start up and shot down sequence and
  %% continuous controllers.
icon:
  Graphic ISA super::Graphic;
parameter:
  Lref ISA Base::Parameter;
  Tref ISA Base::Parameter;
  Fref ISA Base::Parameter;
equation:
  Grafcet.LevelRef := Lref;
  Grafcet.TempRef := Tref;
  Grafcet.FlowRef := Fref;
terminals:
  Measure ISA ControlTerminalLib::CSTRInMeasure WITH
    Graphic ISA super::Graphic WITH
      x_pos := 0.0;
      y_pos := 150.0;
      invisible := 1;
    END;
  END;
  Control ISA ControlTerminalLib::CSTROutControl 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;
submodels:
  Grafcet ISA CSTRControlLib::CSTRGrafcet 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;
  END;
  TempPID ISA ControlSystemLib::PIDControllerModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 250.0;
      y_pos := 100.0;
    END;
  END;
  FlowPID ISA ControlSystemLib::PIDControllerModel WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 150.0;
    END;
  END;
invisible_connections:
  LevelPID.SetPoint := Grafcet.Ref.Lref;
  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; 196, 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;
```

```
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];
        energy.initial := 114000;
      END;
    END;
  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
      PID_Module ISA super::PID_Module 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
      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 := 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;
    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;
      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, PhaseEquilLib,$
                        ^ 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;

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::Distillation9TUnitModel 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;

%%-----------------------------------------------------------
%% distillation sequential controller

DistGrafcet ISA GrafcetLib::GrafcetClass WITH
  %% A Grafcet sequencial 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;
  END;
  BottomCompPID ISA ControlTerminalLib::ManualControlOutDiscreteTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 400.0;
      y_pos := 325.0;
      invisible := 1;
    END;
  END;
  DrumLevelPID ISA ControlTerminalLib::ManualControlOutDiscreteTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 400.0;
      y_pos := 425.0;
      invisible := 1;
    END;
  END;
  TopCompPID ISA ControlTerminalLib::ManualControlOutDiscreteTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 400.0;
      y_pos := 525.0;
      invisible := 1;
    END;
  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;
```

```
      y_pos := 400.0;
    END;
    Condition := Measure.LD - LDmax;
  END;
  Production ISA GrafcetLib::Step WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 350.0;
    END;
    WHEN Action DO
      new(DrumLevelPID.Manual) := 0;
      new(TopCompPID.Manual) := 0;
    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(BoilerLevelPID.Manual) := 1;
      new(BottomCompPID.Manual) := 1;
      new(DrumLevelPID.Manual) := 1;
      new(DrumLevelPID.UMan) := 0.5;
      new(TopCompPID.Manual) := 1;
    END;
  END;
  WaitTransition ISA GrafcetLib::TransitionC WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 200.0;
    END;
    Condition := LDmin - Measure.LD;
  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;

%%-------------------------------------------------------------
%% distillation sequential and continuous controller

DistIController ISA ModelClassTreeLib::UnitController WITH
icon:
  Graphic ISA super::Graphic;
parameter:
  BLref ISA Base::Parameter;
  DLref ISA Base::Parameter;
  TCref ISA Base::Parameter;
  BCref ISA Base::Parameter;
terminals:
  Measure ISA ControlTerminalLib::DistInMeasure WITH
    Graphic ISA super::Graphic WITH
      x_pos := 0.0;
      y_pos := 150.0;
      invisible := 1;
    END;
  END;
  Control ISA ControlTerminalLib::DistOutControl 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 := 200.0;
      y_pos := 300.0;
      invisible := 1;
    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;
  Grafcet ISA DistillationControlLib::DistGrafcet WITH
    Graphic ISA super::Graphic WITH
      x_pos := 75.0;
      y_pos := 250.0;
    END;
  END;
equations:
  BoilerLevelPID.SetPoint := BLref;
  DrumLevelPID.SetPoint := DLref;
  BottomCompPID.SetPoint := BCref;
  TopCompPID.SetPoint := TCref;
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.LD;
    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;
  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;
  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;

IControlDist9TModel 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::Distillation9TUnitModel 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;

USES ModelClassTreeLib, ProcessTerminalLib, ControlTerminalLib, PhaseEquilLib,$
                          ^ FlowEquipmentLib, EnergyEquipmentLib, GrafcetLib,$
                  ^ ControlSystemLib, 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.WeirLenght.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.Aab.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.WeirLenght.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.Aab.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:
  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.WeirLenght.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.WeirLenght.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;

ColumnSimProblem 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;
      TrayModel2 ISA TrayData;
    END;
    Feed.Flow := 20;
    Feed.Comp := [0.33; 0.33; 0.34];
    Feed.MoleEnergy := 1000;
    Feed.Pressure := 1000;
    Control.Reflux := 0.5;
    Control.Heat   := 0.5;
    Control.Top    := 0.5;
    Control.Bottom := 0.5;
    RefluxValve.Qmax.default := 50;
    TopValve.Qmax.default := 50;
    BottomValve.Qmax.default := 50;
    HeatValve.Qmax.default := 10;
    HeatValve.In.Temp := 390;
    HeatValve.In.Pres := 0;
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;
    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;
    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:= 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;
  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.WeirLenght.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.WeirLenght.default := 1;
        MachineModel.WeirHeight.default := 0.02;
        MachineModel.GravConst.default := 9.81;
        MachineModel.PressureDrop.default := 671;
        MachineModel.Xmole.initial := [5; 5; 5];
      END;
    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;
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.WeirLenght.default := 1;
    Tray8.MachineModel.WeirLenght.default := 1;
    Tray7.MachineModel.WeirLenght.default := 1;
    FeedTray6.MachineModel.WeirLenght.default := 1;
    Tray5.MachineModel.WeirLenght.default := 1;
    Tray4.MachineModel.WeirLenght.default := 1;
    Tray3.MachineModel.WeirLenght.default := 1;
    Tray2.MachineModel.WeirLenght.default := 1;
    Tray1.MachineModel.WeirLenght.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:=[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;

IControlDist9TSimProblem ISA IControlDist9TModel WITH
%% A integrated control of a distillation unit
%% with parameter settings for a dynamic simulation.
  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;
      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;
    Grafcet ISA super::Grafcet WITH
      StartTime.default := 0.5;
      StopTime.default  := 45;
      LBmin.default     := 0.5;
      LDmax.default     := 6.5;
      LDmin.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;16.8;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.WeirLenght.default := 1;
      Tray8.MachineModel.WeirLenght.default := 1;
      Tray7.MachineModel.WeirLenght.default := 1;
      FeedTray6.MachineModel.WeirLenght.default := 1;
      Tray5.MachineModel.WeirLenght.default := 1;
      Tray4.MachineModel.WeirLenght.default := 1;
      Tray3.MachineModel.WeirLenght.default := 1;
      Tray2.MachineModel.WeirLenght.default := 1;
      Tray1.MachineModel.WeirLenght.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;0.560;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]];
  END;
END;

%%-------------------------------------------------------
%% unit data configuration
```

```
LIBRARY PretreatLib;

USES ModelClassTreeLib, ProcessTerminalLib, ControlTerminalLib, ReactionModelLib,$
                                ^ FlowEquipmentLib, EnergyEquipmentLib, CSTRLib,$
                                                    ^ ControlSystemLib, GrafcetLib;
%% 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;
  LOut 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;
END;

PretreatSectionModel ISA PretreatLib::PretreatSectionIClass WITH
  Graphic ISA super::Graphic;
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   := LOut.Comp[1];
    Level   := RecycleTank.ReactorMachine.Level;
    Outflow := LOut.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:
  C1 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; 132.0, 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;

%%-------------------------------------------------------
%% 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;
  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;
  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 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 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;

PtsIController ISA ModelClassTreeLib::UnitController WITH
  %% An integrated pretreatment section controller with
  %% start up and shot 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;
  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:
  Lref ISA Base::Parameter;
  Aref ISA Base::Parameter;
equation:
  Grafcet.LevelRef := Lref;
  Grafcet.Aref := Aref;
submodels:
  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;
  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;
  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
    Graphic ISA super::Graphic 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
    LOut AT Pretreat.LOut;
    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, 199; 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, PhaseEquilLib,
     FlowEquipmentLib, EnergyEquipmentLib,
     CSTRLib,
     ControlSystemLib, GrafcetLib,
     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
    Grafcet ISA super::Grafcet 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;
    Lref.default := 1.30;
    Aref.default := 0.3;
  END;
  Graphic ISA super::Graphic;
END;
```

```
LIBRARY ProcessPlantLib;

USES ModelClassTreeLib, ProcessTerminalLib, ControlTerminalLib, ReactionModelLib,$
                  ^ PhaseEquilLib, 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;
  END;
  ROut ISA GrafcetLib::GrafcetOutTerminal WITH
    Graphic ISA super::Graphic WITH
      x_pos := 200.0;
      y_pos := 0.0;
      invisible := 1;
    END;
  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;
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 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;

%%-----------------------------------
%% 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;
    END;
  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,$
                                                  ^ 285.0; 324.0, 285.0; 324.0, 274.0];
    END;
  END;
```

```
LIBRARY ProcessPlantWosp;

USES ModelClassTreeLib, ProcessTerminalLib, ControlTerminalLib, ReactionModelLib,$
                  ^ PhaseEquilLib, FlowEquipmentLib, EnergyEquipmentLib, CSTRLib,$
                 ^ DistillationLib, ControlSystemLib, GrafcetLib, 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;
        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 := 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;
          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;
        Graphic ISA super::Graphic;
      END;
      Lref.default := 1.3;
      Tref.default := 67;
      Fref.default := 0.5;
    END;
    Cool.Pres := 0;
    Cool.Temp := 21;
    Feed.MoleEnergy := 2380;
    Feed.Comp := [0.375; 0; 0.625];
    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;
```

```
    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;
  Grafcet ISA super::Grafcet WITH
    StartTime.default := 1;
    StopTime.default := 45;
    LBmin.default := 0.5;
    LDmax.default := 6.5;
    LDmin.default := 4;
  END;
END;
DistUnit ISA super::DistUnit WITH
  MediumModel ISA PhaseEquilLib::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.WeirLenght.default := 1;
    Tray8.MachineModel.WeirLenght.default := 1;
    Tray7.MachineModel.WeirLenght.default := 1;
    FeedTray6.MachineModel.WeirLenght.default := 1;
    Tray5.MachineModel.WeirLenght.default := 1;
    Tray4.MachineModel.WeirLenght.default := 1;
    Tray3.MachineModel.WeirLenght.default := 1;
    Tray2.MachineModel.WeirLenght.default := 1;
    Tray1.MachineModel.WeirLenght.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]$
```

```
          ^; 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;

%%-------------------------------------------------------
%%-------------------------------------------------------
%%-------------------------------------------------------

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
      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;
      MixerVessel.LOut.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;
      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.Xmole.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;
        Graphic ISA super::Graphic;
      END;
      Graphic ISA super::Graphic;
    END;
    Lref.default := 1.3;
    Tref.default := 67;
    Fref.default := 0.5;
  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.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;
    Grafcet ISA super::Grafcet WITH
      StartTime.default := 1;
      StopTime.default := 450;
      LBmin.default := 0.5;
      LDmax.default := 6.5;
      LDmin.default := 6;
    END;
  END;
  DistUnit ISA super::DistUnit WITH
    MediumModel ISA PhaseEquilLib::ABSPhaseEquilData;
    ReBoiler ISA super::ReBoiler WITH
      BoilerSide.BoilerArea.default := 3.14;
      BoilerSide.Pressure.default := 671;
      BoilerSide.Xmole.initial := [11.9; 17.0; 70.8];
      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; 268; 87.8];
    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.WeirLenght.default := 1;
    Tray8.MachineModel.WeirLenght.default := 1;
    Tray7.MachineModel.WeirLenght.default := 1;
    FeedTray6.MachineModel.WeirLenght.default := 1;
    Tray5.MachineModel.WeirLenght.default := 1;
    Tray4.MachineModel.WeirLenght.default := 1;
    Tray3.MachineModel.WeirLenght.default := 1;
    Tray2.MachineModel.WeirLenght.default := 1;
    Tray1.MachineModel.WeirLenght.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]$
      ^; 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;
```