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FINAL TECHNICAL REPORT
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"A FUZZY EXPERT SYSTEM FOR FAULT MANAGEMENT OF WATER SUPPLY RECOVERY IN THE ALSS PROJECT "

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TABLE OF CONTENTS

OBJECTIVE:

- Model and simulate the Water Recovery System (WRS)-Phase III using a high-performance, object oriented software.
- Creation of software for automation of the physical model.

Modeling with conventional systems has its shortcomings. Some systems are not suited for evaluating conceptual designs from the beginning of a system life cycle or its starting cycle. Abstract designs use more conceptual design definition and evaluations. Discrete simulation is one type of abstract design. CONFIG uses discrete event and structure of components connections. It is developed to define and evaluate conceptual designs for several type of systems. CONFIG works with quantitative modeling, discrete event simulation and directed graphic analysis for use in the analysis of normal and faulty behavior of a system.

For modeling the WRS-phase III CONFIG Software is the best software. As mentioned above CONFIG supports integrated modeling, simulation and analysis of different systems. Moreover CONFIG has a graphical object oriented interface that permits the user to see the simulation and analysis of a system from the early stages of the systems' life cycle.

The model with CONFIG focuses on the operation of two sub-systems: Immobilized Cell Bioreactor (ICB) and the Trickling Filter Bioreactor (TFB). The simulation and analysis can be extended to modeling the whole water recovery system in the future for BIO-PLEX testing. This model will help the Water recovery team to analyze the physical model as well as to define performances and failures of the system's hardware.

WATER RECOVERY SYSTEM DESCRIPTION

The Hybrid Regenerative Water Recovery System (HRWRS) was founded to investigate the efficiency of a hybrid system to recover potable water from waste water. The WRS is design for a four-person crew and consists of a two-stage aerobic trickling filter bioreactor and a reverse osmosis system. The WRS is composed of six major sub-systems:

- Immobilized Cell Bioreactor -ICB
- Trickling filter bioreactor -TFB
- Reverse Osmosis System -ROS
- Air Evaporation System -AES
- Ammonia Removal System -NH4RS
- Post-processing / Potable Water

Fig 1. represent the WRS and its sub-systems.

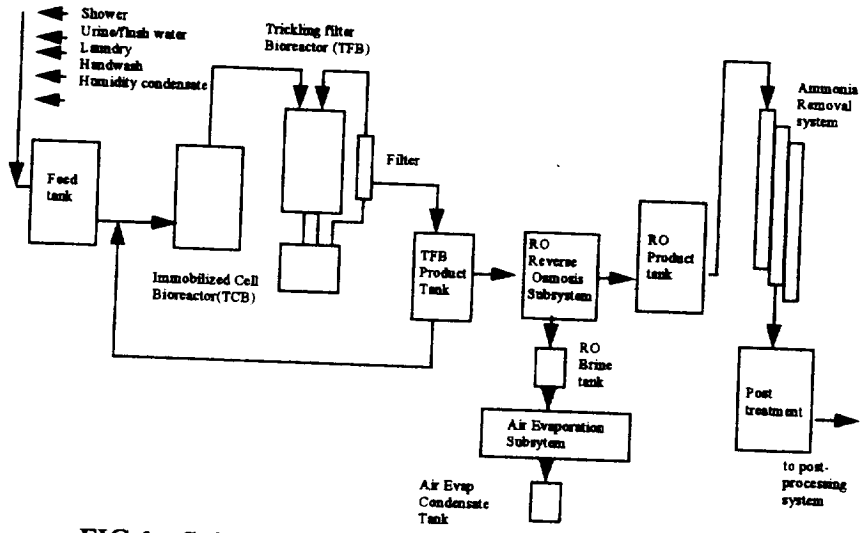


FIG 1. Sub-systems of the Water Recovery System

The HRWRS consist of two main processes:

1. Biological-Water Recovery performed by the ICB and TFB
2. Physico-Chemical Water Recovery-Performed by the ROS, AES and NH4RS.

The system is complimented with a vent system for recovery of gases and collection of excess of flows in the drain systems. For modeling purposes with CONFIG, we concentrated on the Biological Water Recovery performed by the ICB and TFB. These two subsystem interrelations are described in the following paragraph.

INTERCONNECTION BETWEEN SUB-SYSTEMS ICB AND TFB

A Brief description of how the ICB and TFB work are explained in this section. Water and air flow from the feed tank enter the bottom of the ICB until it fills up the ICB. The effluent exits from the ICB to a gas and liquid separator where a valve or a pump is opened to permit the fluid to pass to the TBF. The effluent from the TFB flows into a 75 liter aeration tank for processing of the water. In the product TFB tank, filtered water is collected to activate the ROS when the level of the filtered water is sufficient. A general schematic of the connection between of these two sub-systems is shown in Fig 2.

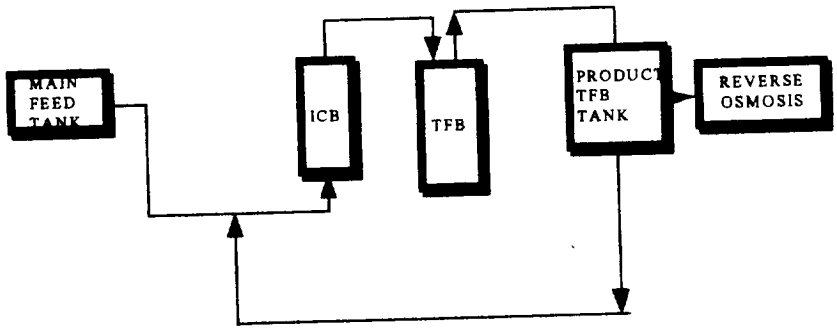


FIG 2. Interconnection of ICB and TFB systems

As stated before, the modeling with CONFIG will concentrate on the process from the main feed tank to the ICB and later to the TFB. The purpose of the modeling with CONFIG is to create scenarios of the failures that might occur to the hardware during testing on these two sub-systems. Once we have detected where the problems could be, the hardware can be fixed with ease.

Air and water are flowing through the whole system. On the model represented with CONFIG only water is included, air and other elements can be added to a later model.

ICB subsystem: The ICB is the site of primary deterioration of the waste water. Upflow operation is the characteristic of the ICB. Wastewater and air enter the bottom of the reactor, flow up to its length, and exit the reactor to enter to the gas and liquid separator. Valves can be configured with the purpose of draining or pump the flow to the TFB. The ICB group controls the amount of feed in the ICB. For mass flow rates the water and air are monitored through flow meters in the blue prints for WRS described as FF## (see Appendix 1). The ICB acts as a switch that enables the feed pump (pu-bio-05) when the water level in the starting tank is sufficient to be able to operate. The feed pump will be turned off when it senses that the tank is getting to a low level or empties. The pump will also turn off when the tank level is too high. In either case, alarms will occur if the water level raise to ± 10%. For modeling purpose, we assumed that the ICB has been initialized and is in ready level.

TFB subsystem: The TFB is used for biological nitrification of the ammonium found in the wastewater. The reactor is injected with microorganisms that are capable of converting ammonium ($NH4^+$) to nitrite ($NO2^-$)and nitrate ($NO3^-$). The TFB group control the amount of air into the TFB and aeration tank. It also controls the amount of feed out from the TFB. It controls the rate of recycle from the aeration tank to the TFB column. It controls the rate of recycle from the TFB product tank to the ICB. Alarms will sound at high temperatures because it controls the amount of heat in the aeration tank.
FIG 3 shows the CONFIG software modeling of this subsystem. It represents the sub-systems in discussion. At the moment the model is running manually. A creation of a control panel was necessary for monitoring the components that need to be opening or closing such as valves and pumps. A printout of the control panel is presented in Fig 4.

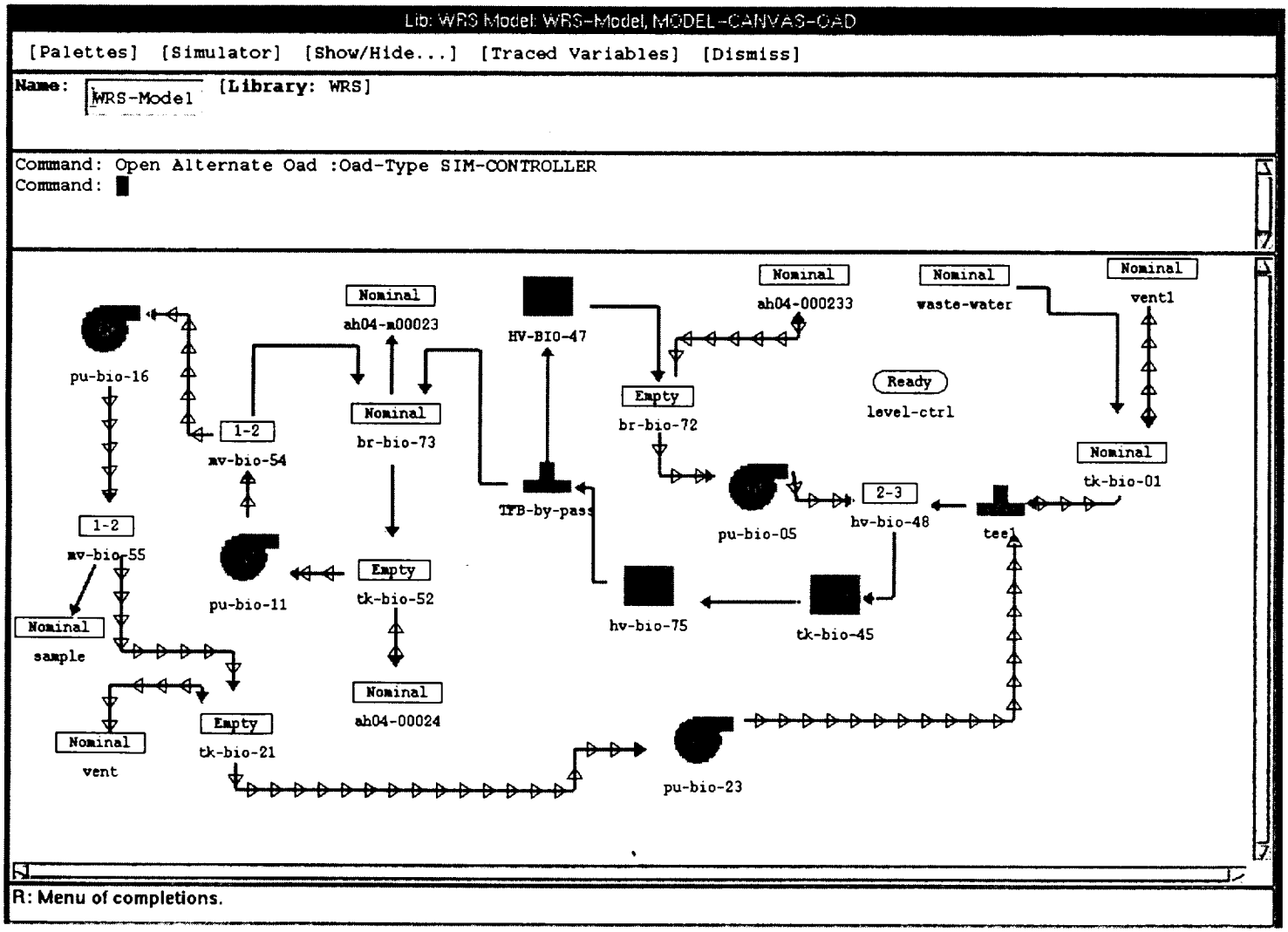


Figure 3. CONFIG model for TFB and ICB of WRS

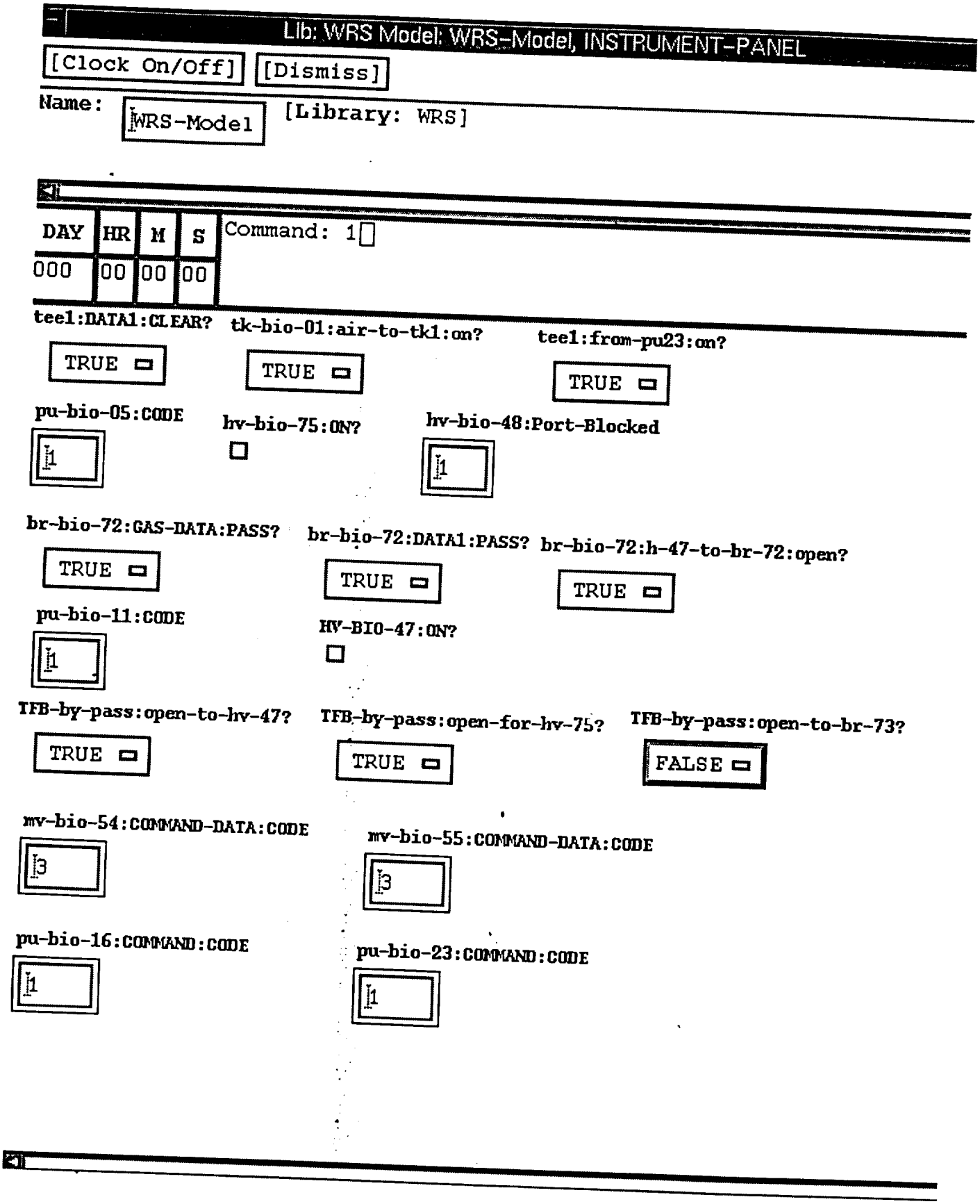


Figure 4 . Instrument panel for ICB and TFB

There are requirements specified for testing listed in the JSG-388862 document; the air evaporation and ammonia removal should be operated to produce 115 Liters (253 lb) of finish water daily. This however applies to the whole WRS. For describing activities for the subsystems in discussion only the flow of wastewater is necessary that is taken to be 80 ml/min.

WRS HARDWARE FAILURES

- There are some problems encounter in the WRS system. From the test of Phase II it was found that WRS would work with fuzzy logic and the tank's weight to determine the configuration of the valves.

  The current system has flow meters (FM##) these have been somewhat unreliable. For instance the TFB was observed to have :
  flow problem : three pumps with flow meter but low, sporadic (pulse) flow does not work well with flow meters.
- current system has very few valves but it is controlled by adjusting pump speed.
- ICB feeds into the TFB so part of it may have to be modeled. Common failures: Inaccurate flow meters, level sensors that stick, some flow problems.

  screen problems: problems similar to treatment system.
- Tank weight using fuzzy logic sensors are failing.
- Hardware need an indirect measure to measure the flow.

Further notification of the hardware failures can be obtained from the WRS team when testing for Phase III with applications to BIO-Plex concludes. The modeling with CONFIG can be updated to work with new requirements for BIO-Plex.

The code for CONFIG WRS is presented in Appendix 2. Notice that activities for this model are not clearly defined. More information is needed from the WRS team to be able to model failures in the system.

CONFIG CONSIDERATIONS:

- Not very easy to Load
- Time to Load into a remote is too slow
- Needs to be user friendly
- Operator needs to be familiar with Lisp code
- Libraries need to be focus on Bio-plex

DESCRIBING ACTIVITIES WITH CONFIG

The activities and activity-relations in CONFIG are yet to be determined. Fig 5 shows the sequence planned to define for the activities, and FIG 6. for the ICB and TFB respectively.

- ICB Activities:
  - The ICB controls the amount of feed
  - Checks for an adequate level of water on the feed tank
  - Activate the feed pump (pu-bio-05)
  - Disables the feed pump when water levels are full or empty

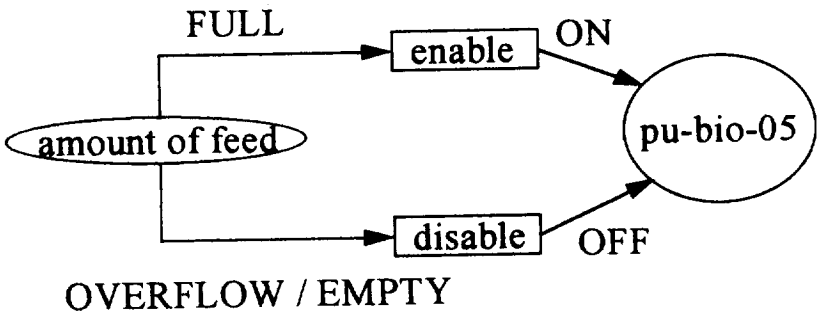


FIG 5. ICB activity chart

- TFB Activities
  - TFB controls amount of air into TFB and aeration tank
  - Controls amount of feed out of TFB
  - Controls rate-recycle from aeration tank to TFB
  - Controls rate-recycle from TFB product tank to ICB
  - Controls amount of heat in aeration tank
  - Activate pumps 16, 11, and 13.
  - Disable pumps and controls when the tank level is empty or full.

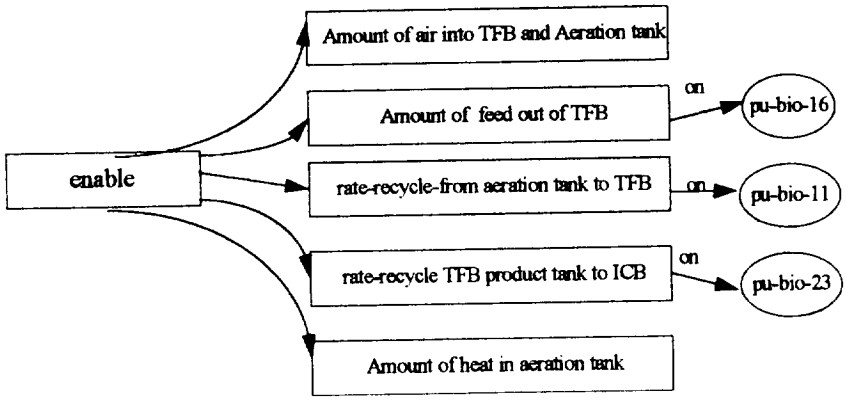


FIG 6. Activities for TFB

CONCLUSION

Modeling with a new software is a challenge. CONFIG is a challenge and is design to work with many types of systems in which discrete and continuous processes occur. The CONFIG software was used to model the two subsystem of the Water Recovery system: ICB and TFB. The model worked manually only for water flows with further implementation to be done in the future. Activities in the models are still need to be implemented based on testing of the hardware for phase III. More improvements to CONFIG are in progress to make it a more user friendly software.

ACKNOWLEDGMENTS

I would like to thank the many individuals who have influenced this work. Jane Malin for support in Intelligent modeling and for counting me as part of the CONFIG team. Thanks to Land Flemming for help with the CONFIG modeling. Thanks to David Prentice for sharing knowledge on water recovery system operation. Thank to Karen Pickering for counting me as part of WRS team and for sharing information on water recovery system schedules and hardware operation. Thanks to Tom for helping with the set up of the system. Thanks to Dr. Jian Li for the opportunity to work with this system.

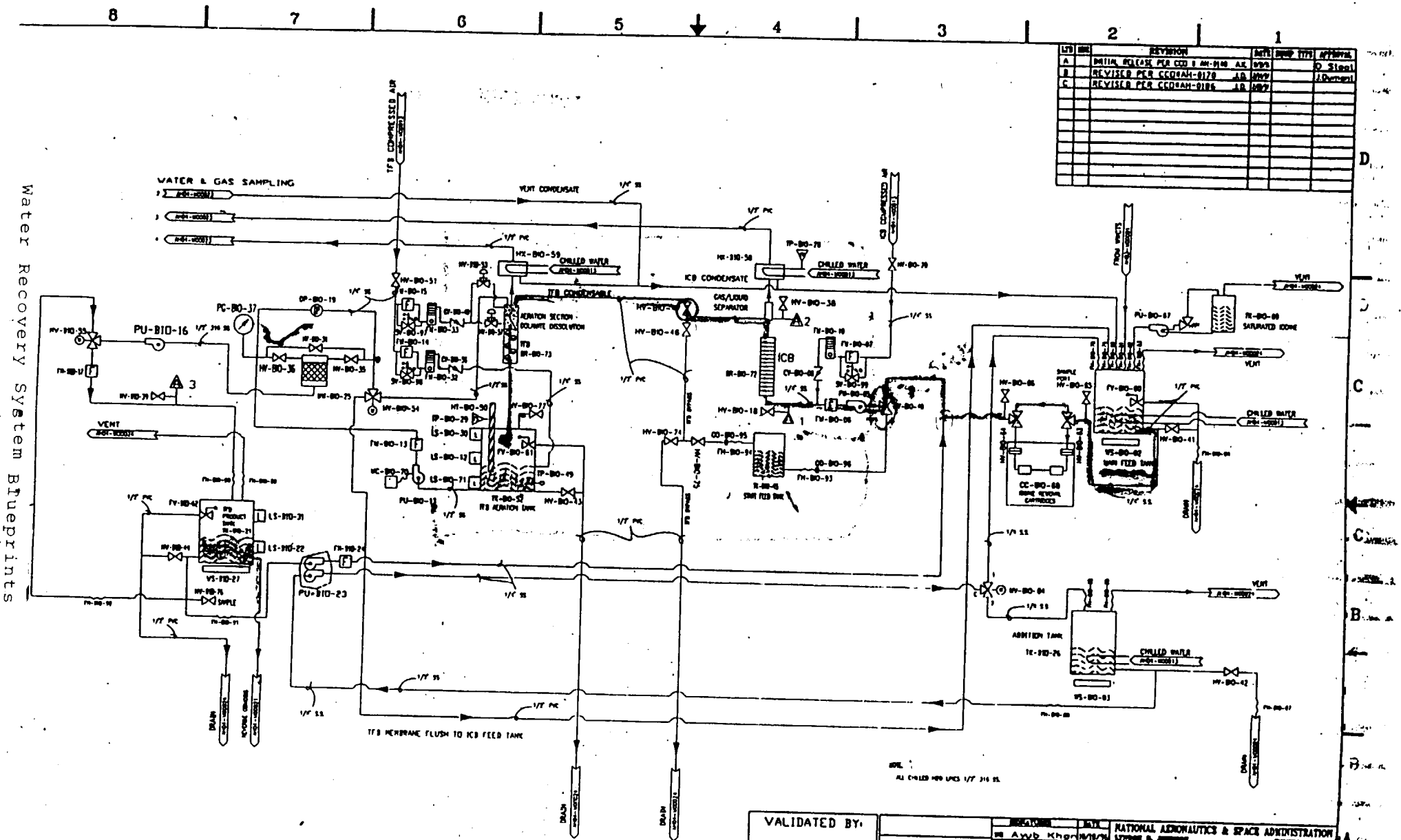
REFERENCES

"config4 brief users manual" 1996.
"crew and thermal systems division" JSG-38862
"Qualitative Simulation"

APPENDIX 1.

BLUE PRINTS OF THE WATER RECOVERY SYSTEM

Water Recovery System Blueprints



LTR	REVISION	DATE	DWG TYPE	APPROVAL
A	INITIAL RELEASE PER CCD # AH-0100	9/95		D. Steel
B	REVISED PER CCD#AH-0170	1/97		J.Dumont
C	REVISED PER CCD#AH-0186	1/97		

VALIDATED BY:

INITIAL RELEASE CCD SIGNED	
HISTORY CARD/NO OPEN BOI'S	

ORIGINATOR	Awb Khan	10/18/96
QUALITY ASSURANCE	Byron Ayanmade	1/15/96
CIS		
ART	David Steel	11/14/96
SE		
PATH		
PTHERM		
ARTS		
PRESSURE SYSTEMS	Cory Sandhubl	11/14/96

NATIONAL AERONAUTICS & SPACE ADMINISTRATION
LYNDON B. JOHNSON SPACE CENTER, HOUSTON, TEXAS

EHT PHASE III
WRS DEMO TEST
BIOREACTORS

CAGE SHEET NO.	SIZE	DWG NO.	REV
21356	D	AH04-M00020	C
		CD4584	SHEET 1 OF 2

"EO REQUIRED FOR DRAWING CHANGE"

APPENDIX 2.

CONFIG CODE GENERATED

```
"Date Saved(Y-M-D): 1997-9-26, Time(H:M:S) 17:44:52"

;; Listing for Library WRS

;; Report Options: (DOC)


(:LIBRARY-NAME "WRS" :SUPER-LIBRARIES
 (("FLUID-DEVICE-LIB"
   "/net/data1/config_src/config4/CONFIG-User/libraries/Numeric-Fluid-Lib/Numeric-Fluid-Lib.
lisp"))
 :LIBRARY-DOCUMENTATION "")
;;*****************************************************************************

;;;;;;;;;;;;;;;;;;;;;;;;; QUALITATIVE TYPES ;;;;;;;;;;;;;;;;;;;;;;;;;
;;*****************************************************************************



;;;;;;;;;;;;;;;;;;;; END QUALITATIVE TYPES LISTING ;;;;;;;;;;;;;;;;;;;



;;*****************************************************************************

;;;;;;;;;;;;;;;;;;;;;;;; DIMENSIONS AND UNITS ;;;;;;;;;;;;;;;;;;;;;;;;
;;*****************************************************************************



;;;;;;;;;;;;;;;;;;;;; <END> DIMENSIONS AND UNITS ;;;;;;;;;;;;;;;;;;;;;



;;*****************************************************************************

;;;;;;;;;;;;;;;;;;;;;;; OPERATORS AND OPERATIONS ;;;;;;;;;;;;;;;;;;;;;;;
;;*****************************************************************************



;;;;;;;;;;;;;;;;;;; <END> OPERATORS AND OPERATIONS ;;;;;;;;;;;;;;;;;;;



;;*****************************************************************************

;;;;;;;;;;;;;;;;;; FOREIGN FUNCTION INTERFACE OBJECTS ;;;;;;;;;;;;;;;;;;
;;*****************************************************************************



;;;;;;;;;;;;;;; <END> FOREIGN FUNCTION INTERFACE OBJECTS ;;;;;;;;;;;;;;;



;;*****************************************************************************

;;;;;;;;;;;;;;;;;;;;;;; VARIABLE CLUSTER CLASSES ;;;;;;;;;;;;;;;;;;;;;;;
;;*****************************************************************************


(DEFINE-CLASS VC-CLASS :NAME "LIQ-CONTAINER.VC" :SUPERCLASSES
 ("FLUID-CONTAINER.VC") :ABSTRACT? NIL :FLOW-DOMAIN "NFLUID-DOMAIN" :VARIABLES
```

```
((:VAR-NAME "PASS?" :DEFAULT-VALUE TRUE :DEFAULT-UNIT "BOOLEAN" :EVENT-ARITY
  :ONE :EVENT-RESCHEDULING? NIL)
 (:VAR-NAME "O-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir" :EVENT-ARITY
  :ONE :EVENT-RESCHEDULING? NIL)
 (:VAR-NAME "DELTA-P" :DEFAULT-VALUE 0 :DEFAULT-UNIT "NPressure" :EVENT-ARITY
  :ONE :EVENT-RESCHEDULING? NIL)
 (:VAR-NAME "F-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir" :EVENT-ARITY
  :ONE :EVENT-RESCHEDULING? NIL)
 (:VAR-NAME "CAPACITY" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "LITER" :EVENT-ARITY
  :ONE :EVENT-RESCHEDULING? NIL)
 (:VAR-NAME "SAMPLE-INTERVAL" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "SECOND"
  :EVENT-ARITY :ONE :EVENT-RESCHEDULING? NIL)
 (:VAR-NAME "FLOW-RESISTANCE" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS"
  :EVENT-ARITY :ONE :EVENT-RESCHEDULING? NIL)
 (:VAR-NAME "AREA" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS" :EVENT-ARITY
  :ONE :EVENT-RESCHEDULING? NIL)
 (:VAR-NAME "FLOW-RATE" :DEFAULT-VALUE 0.0 :DEFAULT-UNIT "UNITLESS"
  :EVENT-ARITY :ONE :EVENT-RESCHEDULING? NIL)
 (:VAR-NAME "LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "LITER" :EVENT-ARITY :ONE
  :EVENT-RESCHEDULING? NIL)
 (:VAR-NAME "ON-LEVEL" :SLOT-SOURCE :SELF :DEFAULT-VALUE 0 :DEFAULT-UNIT
  "UNITLESS" :EVENT-ARITY :ONE :EVENT-RESCHEDULING? NIL)
 (:VAR-NAME "OFF-LEVEL" :SLOT-SOURCE :SELF :DEFAULT-VALUE 0 :DEFAULT-UNIT
  "UNITLESS" :EVENT-ARITY :ONE :EVENT-RESCHEDULING? NIL)))


;;;;;;;;;;;;;;;;;;; <END> VARIABLE CLUSTER CLASSES ;;;;;;;;;;;;;;;;;;;


;;*********************************************************************

;;;;;;;;;;;;;;;;;;;;;;;;;; DEVICE CLASSES ;;;;;;;;;;;;;;;;;;;;;;;;;;
;;*********************************************************************


(DEFINE-CLASS DEVICE-CLASS :NAME "WATER-TANK" :SUPERCLASSES
 ("CLOSED-CONTAINER") :ABSTRACT? NIL :VC-SPECS
 ((:VC-NAME "LIQ-PORT" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARIABLES
   ((:VAR-NAME "PHASE" :DEFAULT-VALUE UNKNOWN :DEFAULT-UNIT "FLUID-PHASE")))
  (:VC-NAME "DATA" :SLOT-SOURCE "CONTAINER" :VC-TYPE "LIQ-CONTAINER.VC"
   :VC-KIND :INTERNAL :VARIABLES
   ((:VAR-NAME "PASS?" :DEFAULT-VALUE TRUE :DEFAULT-UNIT "BOOLEAN")
    (:VAR-NAME "O-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "DELTA-P" :DEFAULT-VALUE 0 :DEFAULT-UNIT "NPressure")
    (:VAR-NAME "F-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "CAPACITY" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "LITER")
    (:VAR-NAME "SAMPLE-INTERVAL" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "SECOND")
    (:VAR-NAME "FLOW-RESISTANCE" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "AREA" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "FLOW-RATE" :DEFAULT-VALUE 0.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "LITER")
    (:VAR-NAME "ON-LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "OFF-LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "UNITLESS")))
  (:VC-NAME "GAS-DATA" :VC-TYPE "FLUID-EFFORT-STORAGE.VC" :VC-KIND :INTERNAL
   :VARIABLES
   ((:VAR-NAME "PASS?" :DEFAULT-VALUE TRUE :DEFAULT-UNIT "BOOLEAN")
    (:VAR-NAME "O-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "DELTA-P" :DEFAULT-VALUE 0 :DEFAULT-UNIT "NPressure")
    (:VAR-NAME "F-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "P-OUTPUT" :DEFAULT-VALUE 0 :DEFAULT-UNIT "NPressure")
    (:VAR-NAME "P-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "RESISTANCE" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")))
  (:VC-NAME "GAS-PORT" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARIABLES
   ((:VAR-NAME "PHASE" :DEFAULT-VALUE UNKNOWN :DEFAULT-UNIT "FLUID-PHASE"))))
```

```
 :FLOW-MAPS
 ((:FLOW-DOMAIN "NFLUID-DOMAIN" :MAP-NODES
   ((:MAPPED-VC-NAME "GAS-DATA" :FLOW-CONNECTIONS-FROM NIL
     :GRAPHICS-COORDINATES (57 131))
    (:MAPPED-VC-NAME "GAS-PORT" :FLOW-CONNECTIONS-FROM
     ((:FLOWS-TO "GAS-DATA" :GRAPHICS-COORDINATES
       ((64.03615 58.0) (57.963856 121.0))))
     :GRAPHICS-COORDINATES (65 48))
    (:MAPPED-VC-NAME "DATA" :FLOW-CONNECTIONS-FROM NIL :GRAPHICS-COORDINATES
     (49 183))
    (:MAPPED-VC-NAME "LIQ-PORT" :FLOW-CONNECTIONS-FROM
     ((:FLOWS-TO "DATA" :GRAPHICS-COORDINATES
       ((50.770115 260.0) (49.229885 193.0))))
      :GRAPHICS-COORDINATES (51 270)))))
 :INITIAL-MODE "Empty" :MIPS
 ((:PROCESS-NAME "gas-pressure-proc" :INVOCATIONS
   ((:STMT-ID "INVOCATION-157" :STATEMENT "liq-data:pass?")) :EFFECTS
   ((:STMT-ID "EFFECT-241" :STATEMENT "(<- gas-data:p-output
    (- (signed-unit liq-data:delta-p)))" :DELAY ("0.01:s")))
   :DOCUMENTATION "This process exerts an effort
in the opposite direction of the
liquid flow. The delay must be
shorter than the delay on the
gas-liq-flow-proc. It is nonzero
to prevent some stabilization to
occur in the flow-paths before it
is computed.")
  (:PROCESS-NAME "gas-liq-flow-proc" :INVOCATIONS NIL :EFFECTS
   ((:STMT-ID "EFFECT-242" :STATEMENT "(<- liq-data:pass?
    (or (not (zerop gas-data:delta-p))
        (and (zerop gas-data:p-output)
             (zerop liq-data:delta-p)
             (zerop gas-data:delta-p))))" :DELAY ("0.1:s")))
   :DOCUMENTATION "This process states that there
must be gas flow if there is also
liquid flow. NOTE: this
process is dependent on the
gas-pressure-proc, and therefore
has a longer time delay.
")
  (:PROCESS-NAME "Rate-Proc" :INVOCATIONS NIL :EFFECTS
   ((:STMT-ID "EFFECT-26" :STATEMENT "(<- data:flow-rate
     (/ data:delta-p
        data:flow-resistance))" :DELAY ("0.0:s")))
   :DOCUMENTATION "This process sets the rate variable
that in turn determines the
rate at which the Container's
Level variable is incremented
or decremented. In a basic
container, there is only one factor:
the pressure drop (Delta-P)
across the liquid port. In more
complex subclasses of container,
the rate may be the sum of several
other factors, such as rates of
leakage, condensation, or evaporation.
The effect statement for this
process should be modified for
those subclasses, and additional
variables should be added to a
subclass of the Fluid-Container.VC.")
  (:PROCESS-NAME "level-proc" :INVOCATIONS
   ((:STMT-ID "INVOCATION-152" :STATEMENT "(or
    (and (minusp data:delta-p)
         (> data:level 0))
```

```
    (and (plusp data:delta-p)
         (< data:level data:capacity)))"))
   :EFFECTS
   ((:STMT-ID "EFFECT-27" :STATEMENT "(<- data:level
    (min data:capacity
        (max 0
           (+ data:level
             (* data:flow-rate
                data:sample-interval)))))" :DELAY ("data:sample-interval")))))
 :MODES
 ((:MODE-NAME "Nominal" :MDPS NIL :MTPS-FROM
   ((:TO "Empty" :INVOCATIONS
     ((:STMT-ID "INVOCATION-27" :STATEMENT "(zerop data:level)"))
     :GRAPHICS-COORDINATES ((127 155) (127 226)))
    (:TO "Full" :INVOCATIONS
     ((:STMT-ID "INVOCATION-28" :STATEMENT "(= data:level data:capacity)"))
     :GRAPHICS-COORDINATES ((124 121) (124 56))))
   :GRAPHICS-COORDINATES (140 142))
  (:MODE-NAME "Empty" :MDPS ((:PROCESS-NAME "" :INVOCATIONS NIL :EFFECTS NIL))
   :MTPS-FROM
   ((:TO "Nominal" :INVOCATIONS
     ((:STMT-ID "INVOCATION-26" :STATEMENT "(not (zerop data:level))"))
     :GRAPHICS-COORDINATES ((151 228) (151 157))))
   :GRAPHICS-COORDINATES (140 241))
  (:MODE-NAME "Full" :MDPS NIL :MTPS-FROM
   ((:TO "Nominal" :INVOCATIONS
     ((:STMT-ID "INVOCATION-29" :STATEMENT "(< data:level data:capacity)"))
     :GRAPHICS-COORDINATES ((151 58) (151 124))))
   :GRAPHICS-COORDINATES (141 44))))

(DEFINE-CLASS DEVICE-CLASS :NAME "2-PORT-WATER-TANK" :SUPERCLASSES
 ("WATER-TANK") :ABSTRACT? NIL :VC-SPECS
 ((:VC-NAME "LIQ-PORT1" :SLOT-SOURCE "CONTAINER" :INHERITED-NAME "PORT"
   :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARIABLES
   ((:VAR-NAME "PHASE" :DEFAULT-VALUE UNKNOWN :DEFAULT-UNIT "FLUID-PHASE")))
  (:VC-NAME "DATA1" :SLOT-SOURCE "CONTAINER" :INHERITED-NAME "DATA" :VC-TYPE
   "LIQ-CONTAINER.VC" :VC-KIND :INTERNAL :VARIABLES
   ((:VAR-NAME "PASS?" :DEFAULT-VALUE TRUE :DEFAULT-UNIT "BOOLEAN")
    (:VAR-NAME "O-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "DELTA-P" :DEFAULT-VALUE 0 :DEFAULT-UNIT "NPressure")
    (:VAR-NAME "F-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "CAPACITY" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "LITER")
    (:VAR-NAME "SAMPLE-INTERVAL" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "SECOND")
    (:VAR-NAME "FLOW-RESISTANCE" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "AREA" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "FLOW-RATE" :DEFAULT-VALUE 0.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "LITER")
    (:VAR-NAME "ON-LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "OFF-LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "UNITLESS")))
  (:VC-NAME "GAS-DATA" :VC-TYPE "FLUID-EFFORT-STORAGE.VC" :VC-KIND :INTERNAL
   :VARIABLES
   ((:VAR-NAME "PASS?" :DEFAULT-VALUE TRUE :DEFAULT-UNIT "BOOLEAN")
    (:VAR-NAME "O-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "DELTA-P" :DEFAULT-VALUE 0 :DEFAULT-UNIT "NPressure")
    (:VAR-NAME "F-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "P-OUTPUT" :DEFAULT-VALUE 0 :DEFAULT-UNIT "NPressure")
    (:VAR-NAME "P-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "RESISTANCE" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")))
  (:VC-NAME "GAS-PORT" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARIABLES
   ((:VAR-NAME "PHASE" :DEFAULT-VALUE UNKNOWN :DEFAULT-UNIT "FLUID-PHASE")))
  (:VC-NAME "DATA2" :SLOT-SOURCE :SELF :VC-TYPE "LIQ-CONTAINER.VC" :VC-KIND
   :INTERNAL :VARIABLES
   ((:VAR-NAME "PASS?" :DEFAULT-VALUE TRUE :DEFAULT-UNIT "BOOLEAN")
    (:VAR-NAME "O-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "DELTA-P" :DEFAULT-VALUE 0 :DEFAULT-UNIT "NPressure")
```

```
    (:VAR-NAME "F-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "CAPACITY" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "LITER")
    (:VAR-NAME "SAMPLE-INTERVAL" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "SECOND")
    (:VAR-NAME "FLOW-RESISTANCE" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "AREA" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "FLOW-RATE" :DEFAULT-VALUE 0.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "LITER")
    (:VAR-NAME "ON-LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "OFF-LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "UNITLESS")))
  (:VC-NAME "LIQ-PORT2" :SLOT-SOURCE :SELF :VC-TYPE "FLUID-PORT.VC" :VC-KIND
   :PORT :VARIABLES
   ((:VAR-NAME "PHASE" :DEFAULT-VALUE UNKNOWN :DEFAULT-UNIT "FLUID-PHASE"))))
 :FLOW-MAPS
 ((:FLOW-DOMAIN "NFLUID-DOMAIN" :MAP-NODES
   ((:MAPPED-VC-NAME "DATA2" :FLOW-CONNECTIONS-FROM NIL :GRAPHICS-COORDINATES
     (182 192))
    (:MAPPED-VC-NAME "LIQ-PORT2" :FLOW-CONNECTIONS-FROM
     ((:FLOWS-TO "DATA2" :GRAPHICS-COORDINATES ((182 262.0) (182 201.0))))
     :GRAPHICS-COORDINATES (182 271))
    (:MAPPED-VC-NAME "GAS-DATA" :FLOW-CONNECTIONS-FROM NIL
     :GRAPHICS-COORDINATES (57 131))
    (:MAPPED-VC-NAME "GAS-PORT" :FLOW-CONNECTIONS-FROM
     ((:FLOWS-TO "GAS-DATA" :GRAPHICS-COORDINATES
       ((64.03615 58.0) (57.963856 121.0))))
     :GRAPHICS-COORDINATES (65 48))
    (:MAPPED-VC-NAME "DATA1" :FLOW-CONNECTIONS-FROM NIL :GRAPHICS-COORDINATES
     (54 192))
    (:MAPPED-VC-NAME "LIQ-PORT1" :FLOW-CONNECTIONS-FROM
     ((:FLOWS-TO "DATA1" :GRAPHICS-COORDINATES
       ((51.346153 261.0) (53.634617 201.5))))
     :GRAPHICS-COORDINATES (51 270)))))
 :INITIAL-MODE "Empty" :MIPS
 ((:PROCESS-NAME "gas-pressure-proc" :INVOCATIONS
   ((:STMT-ID "INVOCATION-157" :STATEMENT "(or data1:pass? data2:pass?)"
     :MODIFIED "2-PORT-WATER-TANK"))
   :EFFECTS
   ((:STMT-ID "EFFECT-241" :STATEMENT "(<- gas-data:p-output
    (- (signed-unit
        (+ data1:delta-p
           data2:delta-p))))" :MODIFIED "2-PORT-WATER-TANK" :DELAY ("0.01:s")))
   :DOCUMENTATION "This process exerts an effort
in the opposite direction of the
liquid flow. The delay must be
shorter than the delay on the
gas-liq-flow-proc. It is nonzero
to prevent some stabilization to
occur in the flow-paths before it
is computed.")
  (:PROCESS-NAME "gas-liq-flow-proc" :INVOCATIONS NIL :EFFECTS
   ((:STMT-ID "EFFECT-319" :STATEMENT "(<- data2:pass?
    (or (not (zerop gas-data:delta-p))
        (and (zerop gas-data:p-output)
             (zerop (+ data1:flow-rate
                       data2:flow-rate))
             (zerop gas-data:delta-p))))" :DELAY ("0.1:s"))
    (:STMT-ID "EFFECT-242" :STATEMENT "(<- data1:pass?
    (or (not (zerop gas-data:delta-p))
        (and (zerop gas-data:p-output)
             (zerop (+ data1:flow-rate
                       data2:flow-rate))
             (zerop gas-data:delta-p))))" :MODIFIED "2-PORT-WATER-TANK" :DELAY
     ("0.1:s")))
   :DOCUMENTATION "This process states that there
must be gas flow if there is also
liquid flow. NOTE: this
```

```
process is dependent on the
gas-pressure-proc, and therefore
has a longer time delay.
")
  (:PROCESS-NAME "Rate-Proc" :INVOCATIONS NIL :EFFECTS
   ((:STMT-ID "EFFECT-318" :STATEMENT "(<- data2:flow-rate
     (/ data2:delta-p
        data2:flow-resistance))" :DELAY ("0.0:s"))
    (:STMT-ID "EFFECT-26" :STATEMENT "(<- data1:flow-rate
     (/ data1:delta-p
        data1:flow-resistance))" :MODIFIED "2-PORT-WATER-TANK" :DELAY
     ("0.0:s")))
   :DOCUMENTATION "This process sets the rate variable
that in turn determines the
rate at which the Container's
Level variable is incremented
or decremented. In a basic
container, there is only one factor:
the pressure drop (Delta-P)
across the liquid port. In more
complex subclasses of container,
the rate may be the sum of several
other factors, such as rates of
leakage, condensation, or evaporation.
The effect statement for this
process should be modified for
those subclasses, and additional
variables should be added to a
subclass of the Fluid-Container.VC.")
  (:PROCESS-NAME "level-proc" :INVOCATIONS
   ((:STMT-ID "INVOCATION-152" :STATEMENT "(or
    (and (minusp (+ data1:flow-rate data2:flow-rate))
         (> data1:level 0))
    (and (plusp (+ data1:flow-rate data2:flow-rate))
         (< data1:level data1:capacity)))" :MODIFIED "2-PORT-WATER-TANK"))
   :EFFECTS
   ((:STMT-ID "EFFECT-27" :STATEMENT "(<- data1:level
    (min data1:capacity
        (max 0
           (+ data1:level
              (* (+ data1:flow-rate
                    data2:flow-rate)
                 data1:sample-interval)))))" :MODIFIED "2-PORT-WATER-TANK" :DELAY
    ("data:sample-interval")))))
:MODES
((:MODE-NAME "Nominal" :MDPS NIL :MTPS-FROM
  ((:TO "Empty" :INVOCATIONS
    ((:STMT-ID "INVOCATION-27" :STATEMENT "(zerop data:level)"))
    :GRAPHICS-COORDINATES ((127 155) (127 226)))
   (:TO "Full" :INVOCATIONS
    ((:STMT-ID "INVOCATION-28" :STATEMENT "(= data:level data:capacity)"))
    :GRAPHICS-COORDINATES ((124 121) (124 56))))
  :GRAPHICS-COORDINATES (140 142))
 (:MODE-NAME "Empty" :MDPS ((:PROCESS-NAME "" :INVOCATIONS NIL :EFFECTS NIL))
  :MTPS-FROM
  ((:TO "Nominal" :INVOCATIONS
    ((:STMT-ID "INVOCATION-26" :STATEMENT "(not (zerop data:level))"))
    :GRAPHICS-COORDINATES ((151 228) (151 157))))
  :GRAPHICS-COORDINATES (140 241))
 (:MODE-NAME "Full" :MDPS NIL :MTPS-FROM
  ((:TO "Nominal" :INVOCATIONS
    ((:STMT-ID "INVOCATION-29" :STATEMENT "(< data:level data:capacity)"))
    :GRAPHICS-COORDINATES ((151 58) (151 124))))
  :GRAPHICS-COORDINATES (141 44))))
```

```
(DEFINE-CLASS DEVICE-CLASS :NAME "3-PORT-WATER-TANK" :SUPERCLASSES
 ("2-PORT-WATER-TANK") :ABSTRACT? NIL :VC-SPECS
 ((:VC-NAME "LIQ-PORT1" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARIABLES
   ((:VAR-NAME "PHASE" :DEFAULT-VALUE UNKNOWN :DEFAULT-UNIT "FLUID-PHASE")))
  (:VC-NAME "DATA1" :VC-TYPE "LIQ-CONTAINER.VC" :VC-KIND :INTERNAL :VARIABLES
   ((:VAR-NAME "PASS?" :DEFAULT-VALUE TRUE :DEFAULT-UNIT "BOOLEAN")
    (:VAR-NAME "O-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "DELTA-P" :DEFAULT-VALUE 0 :DEFAULT-UNIT "NPressure")
    (:VAR-NAME "F-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "CAPACITY" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "LITER")
    (:VAR-NAME "SAMPLE-INTERVAL" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "SECOND")
    (:VAR-NAME "FLOW-RESISTANCE" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "AREA" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "FLOW-RATE" :DEFAULT-VALUE 0.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "LITER")
    (:VAR-NAME "ON-LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "OFF-LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "UNITLESS")))
  (:VC-NAME "GAS-DATA" :VC-TYPE "FLUID-EFFORT-STORAGE.VC" :VC-KIND :INTERNAL
   :VARIABLES
   ((:VAR-NAME "PASS?" :DEFAULT-VALUE TRUE :DEFAULT-UNIT "BOOLEAN")
    (:VAR-NAME "O-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "DELTA-P" :DEFAULT-VALUE 0 :DEFAULT-UNIT "NPressure")
    (:VAR-NAME "F-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "P-OUTPUT" :DEFAULT-VALUE 0 :DEFAULT-UNIT "NPressure")
    (:VAR-NAME "P-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "RESISTANCE" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")))
  (:VC-NAME "GAS-PORT" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARIABLES
   ((:VAR-NAME "PHASE" :DEFAULT-VALUE UNKNOWN :DEFAULT-UNIT "FLUID-PHASE")))
  (:VC-NAME "DATA2" :VC-TYPE "LIQ-CONTAINER.VC" :VC-KIND :INTERNAL :VARIABLES
   ((:VAR-NAME "PASS?" :DEFAULT-VALUE TRUE :DEFAULT-UNIT "BOOLEAN")
    (:VAR-NAME "O-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "DELTA-P" :DEFAULT-VALUE 0 :DEFAULT-UNIT "NPressure")
    (:VAR-NAME "F-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "CAPACITY" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "LITER")
    (:VAR-NAME "SAMPLE-INTERVAL" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "SECOND")
    (:VAR-NAME "FLOW-RESISTANCE" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "AREA" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "FLOW-RATE" :DEFAULT-VALUE 0.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "LITER")
    (:VAR-NAME "ON-LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "OFF-LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "UNITLESS")))
  (:VC-NAME "LIQ-PORT2" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARIABLES
   ((:VAR-NAME "PHASE" :DEFAULT-VALUE UNKNOWN :DEFAULT-UNIT "FLUID-PHASE")))
  (:VC-NAME "LIQ-PORT3" :SLOT-SOURCE :SELF :VC-TYPE "FLUID-PORT.VC" :VC-KIND
   :PORT :VARIABLES
   ((:VAR-NAME "PHASE" :DEFAULT-VALUE UNKNOWN :DEFAULT-UNIT "FLUID-PHASE")))
  (:VC-NAME "DATA3" :SLOT-SOURCE :SELF :VC-TYPE "LIQ-CONTAINER.VC" :VC-KIND
   :INTERNAL :VARIABLES
   ((:VAR-NAME "PASS?" :DEFAULT-VALUE TRUE :DEFAULT-UNIT "BOOLEAN")
    (:VAR-NAME "O-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "DELTA-P" :DEFAULT-VALUE 0 :DEFAULT-UNIT "NPressure")
    (:VAR-NAME "F-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "CAPACITY" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "LITER")
    (:VAR-NAME "SAMPLE-INTERVAL" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "SECOND")
    (:VAR-NAME "FLOW-RESISTANCE" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "AREA" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "FLOW-RATE" :DEFAULT-VALUE 0.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "LITER")
    (:VAR-NAME "ON-LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "OFF-LEVEL" :DEFAULT-VALUE 0 :DEFAULT-UNIT "UNITLESS"))))
:FLOW-MAPS
((:FLOW-DOMAIN "NFLUID-DOMAIN" :MAP-NODES
  ((:MAPPED-VC-NAME "LIQ-PORT3" :FLOW-CONNECTIONS-FROM
    ((:FLOWS-TO "DATA3" :GRAPHICS-COORDINATES
      ((275.41357 263.5) (271.58643 201.5))))
```

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    :GRAPHICS-COORDINATES (276.0 273.0))
   (:MAPPED-VC-NAME "DATA3" :FLOW-CONNECTIONS-FROM NIL :GRAPHICS-COORDINATES
    (271.0 192.0))
   (:MAPPED-VC-NAME "DATA2" :FLOW-CONNECTIONS-FROM NIL :GRAPHICS-COORDINATES
    (143.0 195.0))
   (:MAPPED-VC-NAME "LIQ-PORT2" :FLOW-CONNECTIONS-FROM
    ((:FLOWS-TO "DATA2" :GRAPHICS-COORDINATES
      ((141.27632 260.5) (142.73685 205.0))))
    :GRAPHICS-COORDINATES (141.0 271.0))
   (:MAPPED-VC-NAME "GAS-DATA" :FLOW-CONNECTIONS-FROM NIL
    :GRAPHICS-COORDINATES (57 131))
   (:MAPPED-VC-NAME "GAS-PORT" :FLOW-CONNECTIONS-FROM
    ((:FLOWS-TO "GAS-DATA" :GRAPHICS-COORDINATES
      ((64.03615 58.0) (57.963856 121.0))))
    :GRAPHICS-COORDINATES (65 48))
   (:MAPPED-VC-NAME "DATA1" :FLOW-CONNECTIONS-FROM NIL :GRAPHICS-COORDINATES
    (16.0 193.0))
   (:MAPPED-VC-NAME "LIQ-PORT1" :FLOW-CONNECTIONS-FROM
    ((:FLOWS-TO "DATA1" :GRAPHICS-COORDINATES
      ((11.681818 259.5) (15.350649 203.0))))
    :GRAPHICS-COORDINATES (11.0 270.0)))))
 :INITIAL-MODE "Empty" :MIPS
 ((:PROCESS-NAME "gas-pressure-proc" :INVOCATIONS
   ((:STMT-ID "INVOCATION-157" :STATEMENT "(or data1:pass? data2:pass?)"))
   :EFFECTS
   ((:STMT-ID "EFFECT-241" :STATEMENT "(<- gas-data:p-output
    (- (signed-unit (+ data1:delta-p
                       data2:delta-p
                       data3:delta-p)))" :MODIFIED "3-PORT-WATER-TANK" :DELAY ("0.01:s")))
   :DOCUMENTATION "This process exerts an effort
in the opposite direction of the
liquid flow. The delay must be
shorter than the delay on the
gas-liq-flow-proc. It is nonzero
to prevent some stabilization to
occur in the flow-paths before it
is computed.")
  (:PROCESS-NAME "gas-liq-flow-proc" :INVOCATIONS NIL :EFFECTS
   ((:STMT-ID "EFFECT-324" :STATEMENT "(<- data3:pass?
    (or (not (zerop gas-data:delta-p))
        (and (zerop gas-data:p-output)
             (zerop (+ data1:flow-rate
                       data2:flow-rate
                       data3:flow-rate))
             (zerop gas-data:delta-p)))" :DELAY ("0.1:s"))
    (:STMT-ID "EFFECT-319" :STATEMENT "(<- data2:pass?
    (or (not (zerop gas-data:delta-p))
        (and (zerop gas-data:p-output)
             (zerop (+ data1:flow-rate
                       data2:flow-rate
                       data3:flow-rate))
             (zerop gas-data:delta-p)))" :MODIFIED "3-PORT-WATER-TANK" :DELAY
     ("0.1:s"))
    (:STMT-ID "EFFECT-242" :STATEMENT "(<- data1:pass?
    (or (not (zerop gas-data:delta-p))
        (and (zerop gas-data:p-output)
             (zerop (+ data1:flow-rate
                       data2:flow-rate
                       data3:flow-rate)))
             (zerop gas-data:delta-p)))" :MODIFIED "3-PORT-WATER-TANK" :DELAY
     ("0.1:s")))
   :DOCUMENTATION "This process states that there
must be gas flow if there is also
liquid flow. NOTE: this
process is dependent on the
```

```
gas-pressure-proc, and therefore
has a longer time delay.
")
  (:PROCESS-NAME "Rate-Proc" :INVOCATIONS NIL :EFFECTS
   ((:STMT-ID "EFFECT-323" :STATEMENT "(<- data3:flow-rate
     (/ data3:delta-p
        data3:flow-resistance))" :DELAY ("0.0:s"))
    (:STMT-ID "EFFECT-318" :STATEMENT "(<- data2:flow-rate
     (/ data2:delta-p
        data2:flow-resistance))" :DELAY ("0.0:s"))
    (:STMT-ID "EFFECT-26" :STATEMENT "(<- data1:flow-rate
     (/ data1:delta-p
        data1:flow-resistance))" :DELAY ("0.0:s")))
   :DOCUMENTATION "This process sets the rate variable
that in turn determines the
rate at which the Container's
Level variable is incremented
or decremented. In a basic
container, there is only one factor:
the pressure drop (Delta-P)
across the liquid port. In more
complex subclasses of container,
the rate may be the sum of several
other factors, such as rates of
leakage, condensation, or evaporation.
The effect statement for this
process should be modified for
those subclasses, and additional
variables should be added to a
subclass of the Fluid-Container.VC.")
  (:PROCESS-NAME "level-proc" :INVOCATIONS
   ((:STMT-ID "INVOCATION-152" :STATEMENT "(or
    (and (minusp (+ data1:flow-rate
                    data2:flow-rate data3:flow-rate))
         (> data1:level 0))
    (and (plusp (+ data1:flow-rate
                   data2:flow-rate data3:flow-rate))
         (< data1:level data1:capacity)))" :MODIFIED "3-PORT-WATER-TANK"))
   :EFFECTS
   ((:STMT-ID "EFFECT-27" :STATEMENT "(<- data1:level
    (min data1:capacity
        (max 0
           (+ data1:level
              (* (+ data1:flow-rate
                    data2:flow-rate
                    data3:flow-rate)
                 data1:sample-interval)))))" :MODIFIED "3-PORT-WATER-TANK" :DELAY
     ("data:sample-interval")))))
 :MODES
 ((:MODE-NAME "Nominal" :MDPS NIL :MTPS-FROM
   ((:TO "Empty" :INVOCATIONS
     ((:STMT-ID "INVOCATION-27" :STATEMENT "(zerop data:level)"))
     :GRAPHICS-COORDINATES ((127 155) (127 226)))
    (:TO "Full" :INVOCATIONS
     ((:STMT-ID "INVOCATION-28" :STATEMENT "(= data:level data:capacity)"))
     :GRAPHICS-COORDINATES ((124 121) (124 56))))
   :GRAPHICS-COORDINATES (140 142))
  (:MODE-NAME "Empty" :MDPS ((:PROCESS-NAME "" :INVOCATIONS NIL :EFFECTS NIL))
   :MTPS-FROM
   ((:TO "Nominal" :INVOCATIONS
     ((:STMT-ID "INVOCATION-26" :STATEMENT "(not (zerop data:level))"))
     :GRAPHICS-COORDINATES ((151 228) (151 157))))
   :GRAPHICS-COORDINATES (140 241))
  (:MODE-NAME "Full" :MDPS NIL :MTPS-FROM
   ((:TO "Nominal" :INVOCATIONS
```

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     ((:STMT-ID "INVOCATION-29" :STATEMENT "(< data:level data:capacity)"))
     :GRAPHICS-COORDINATES ((151 58) (151 124))))
   :GRAPHICS-COORDINATES (141 44))))


;;;;;;;;;;;;;;;;;;;;;;;; <END> DEVICE CLASSES ;;;;;;;;;;;;;;;;;;;;;;;;


;;*****************************************************************************

;;;;;;;;;;;;;;;;;;;;;;;; DEVICE-RELATION CLASSES ;;;;;;;;;;;;;;;;;;;;;;;;
;;*****************************************************************************


;;;;;;;;;;;;;;;;;;;;; <END DEVICE-RELATION CLASSES ;;;;;;;;;;;;;;;;;;;;;


;;*****************************************************************************

;;;;;;;;;;;;;;;;;;;;;;;;;; ACTIVITY CLASSES ;;;;;;;;;;;;;;;;;;;;;;;;;;
;;*****************************************************************************


(DEFINE-CLASS ACTIVITY-CLASS :NAME "TFB-CTRL-ACT" :SUPERCLASSES ("ACTIVITIES")
 :ABSTRACT? NIL :VC-SPECS NIL :INITIAL-PHASE "Ready" :PIPS NIL :PHASES
 ((:PHASE-NAME "Ready" :PTPS NIL :PDPS NIL :PTPS-FROM NIL
   :GRAPHICS-COORDINATES (0 0))))

(DEFINE-CLASS ACTIVITY-CLASS :NAME "LEVEL-BR-BIO-73" :SUPERCLASSES
 ("TFB-CTRL-ACT") :ABSTRACT? NIL :VC-SPECS NIL :INITIAL-PHASE "Ready" :PIPS
 NIL :PHASES
 ((:PHASE-NAME "Ready" :PTPS NIL :PDPS NIL :PTPS-FROM NIL
   :GRAPHICS-COORDINATES (0 0))))

(DEFINE-CLASS ACTIVITY-CLASS :NAME "PU-BIO-16-ON" :SUPERCLASSES
 ("LEVEL-BR-BIO-73") :ABSTRACT? NIL :VC-SPECS NIL :INITIAL-PHASE "Ready" :PIPS
 NIL :PHASES
 ((:PHASE-NAME "Ready" :PTPS NIL :PDPS NIL :PTPS-FROM NIL
   :GRAPHICS-COORDINATES (0 0))))

(DEFINE-CLASS ACTIVITY-CLASS :NAME "PU-BIO-23-ON" :SUPERCLASSES
 ("LEVEL-BR-BIO-73") :ABSTRACT? NIL :VC-SPECS NIL :INITIAL-PHASE "Ready" :PIPS
 NIL :PHASES
 ((:PHASE-NAME "Ready" :PTPS NIL :PDPS NIL :PTPS-FROM NIL
   :GRAPHICS-COORDINATES (0 0))))

(DEFINE-CLASS ACTIVITY-CLASS :NAME "PU-BIO-11-ON" :SUPERCLASSES
 ("LEVEL-BR-BIO-73") :ABSTRACT? NIL :VC-SPECS NIL :INITIAL-PHASE "Ready" :PIPS
 NIL :PHASES
 ((:PHASE-NAME "Ready" :PTPS NIL :PDPS NIL :PTPS-FROM NIL
   :GRAPHICS-COORDINATES (0 0))))

(DEFINE-CLASS ACTIVITY-CLASS :NAME "ICB-CTRL-ACT" :SUPERCLASSES ("ACTIVITIES")
 :ABSTRACT? NIL :VC-SPECS
 ((:VC-NAME "DATA1" :SLOT-SOURCE :SELF :VC-TYPE "LIQ-CONTAINER.VC" :VC-KIND
   :INTERNAL :VARIABLES
   ((:VAR-NAME "PASS?" :DEFAULT-VALUE TRUE :DEFAULT-UNIT "BOOLEAN")
    (:VAR-NAME "O-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "DELTA-P" :DEFAULT-VALUE 0 :DEFAULT-UNIT "NPressure")
    (:VAR-NAME "F-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "CAPACITY" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "LITER")
    (:VAR-NAME "SAMPLE-INTERVAL" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "SECOND")
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      (:VAR-NAME "FLOW-RESISTANCE" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
      (:VAR-NAME "AREA" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
      (:VAR-NAME "FLOW-RATE" :DEFAULT-VALUE 0.0 :DEFAULT-UNIT "UNITLESS")
      (:VAR-NAME "LEVEL" :DEFAULT-VALUE 3 :DEFAULT-UNIT "LITER")
      (:VAR-NAME "ON-LEVEL" :DEFAULT-VALUE 2 :DEFAULT-UNIT "UNITLESS")
      (:VAR-NAME "OFF-LEVEL" :DEFAULT-VALUE 4 :DEFAULT-UNIT "UNITLESS"))))
   :INITIAL-PHASE "Ready" :PIPS
   ((:PROCESS-NAME "level-control" :INVOCATIONS
     ((:STMT-ID "INVOCATION-82" :STATEMENT :NO-VALUE)) :EFFECTS NIL))
   :PHASES
   ((:PHASE-NAME "Ready" :PTPS NIL :PDPS NIL :PTPS-FROM NIL
     :GRAPHICS-COORDINATES (118 101)))
   :DOCUMENTATION "ICB-CTRL-ACT controls the activity of
the ICB. When the tank level of the
br-bio-72 is normal, pump pu-bio-05
will turn on.  If level is too,
high or too low alarms will occur.
It also controls levels on tk-bio-01
")

  (DEFINE-CLASS ACTIVITY-CLASS :NAME "TURN-ON-PU-BIO-05" :SUPERCLASSES
   ("ICB-CTRL-ACT") :ABSTRACT? NIL :VC-SPECS
   ((:VC-NAME "DATA1" :VC-TYPE "LIQ-CONTAINER.VC" :VC-KIND :INTERNAL :VARIABLES
     ((:VAR-NAME "PASS?" :DEFAULT-VALUE TRUE :DEFAULT-UNIT "BOOLEAN")
      (:VAR-NAME "O-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
      (:VAR-NAME "DELTA-P" :DEFAULT-VALUE 0 :DEFAULT-UNIT "NPressure")
      (:VAR-NAME "F-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
      (:VAR-NAME "CAPACITY" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "LITER")
      (:VAR-NAME "SAMPLE-INTERVAL" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "SECOND")
      (:VAR-NAME "FLOW-RESISTANCE" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
      (:VAR-NAME "AREA" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
      (:VAR-NAME "FLOW-RATE" :DEFAULT-VALUE 0.0 :DEFAULT-UNIT "UNITLESS")
      (:VAR-NAME "LEVEL" :DEFAULT-VALUE 3 :DEFAULT-UNIT "LITER")
      (:VAR-NAME "ON-LEVEL" :DEFAULT-VALUE 2 :DEFAULT-UNIT "UNITLESS")
      (:VAR-NAME "OFF-LEVEL" :DEFAULT-VALUE 4 :DEFAULT-UNIT "UNITLESS"))))
   :INITIAL-PHASE "Ready" :PIPS
   ((:PROCESS-NAME "level-control" :INVOCATIONS
     ((:STMT-ID "INVOCATION-82" :STATEMENT :NO-VALUE)) :EFFECTS NIL))
   :PHASES
   ((:PHASE-NAME "Ready" :PTPS NIL :PDPS NIL :PTPS-FROM NIL
     :GRAPHICS-COORDINATES (118 101))))

  (DEFINE-CLASS ACTIVITY-CLASS :NAME "LEVEL-BR-BIO-72" :SUPERCLASSES
   ("ICB-CTRL-ACT") :ABSTRACT? NIL :VC-SPECS
   ((:VC-NAME "DATA1" :VC-TYPE "LIQ-CONTAINER.VC" :VC-KIND :INTERNAL :VARIABLES
     ((:VAR-NAME "PASS?" :DEFAULT-VALUE TRUE :DEFAULT-UNIT "BOOLEAN")
      (:VAR-NAME "O-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
      (:VAR-NAME "DELTA-P" :DEFAULT-VALUE 0 :DEFAULT-UNIT "NPressure")
      (:VAR-NAME "F-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
      (:VAR-NAME "CAPACITY" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "LITER")
      (:VAR-NAME "SAMPLE-INTERVAL" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "SECOND")
      (:VAR-NAME "FLOW-RESISTANCE" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
      (:VAR-NAME "AREA" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
      (:VAR-NAME "FLOW-RATE" :DEFAULT-VALUE 0.0 :DEFAULT-UNIT "UNITLESS")
      (:VAR-NAME "LEVEL" :DEFAULT-VALUE 3 :DEFAULT-UNIT "LITER")
      (:VAR-NAME "ON-LEVEL" :DEFAULT-VALUE 2 :DEFAULT-UNIT "UNITLESS")
      (:VAR-NAME "OFF-LEVEL" :DEFAULT-VALUE 4 :DEFAULT-UNIT "UNITLESS"))))
   :INITIAL-PHASE "Ready" :PIPS
   ((:PROCESS-NAME "level-control" :INVOCATIONS
     ((:STMT-ID "INVOCATION-82" :STATEMENT :NO-VALUE)) :EFFECTS NIL))
   :PHASES
   ((:PHASE-NAME "Ready" :PTPS NIL :PDPS NIL :PTPS-FROM NIL
     :GRAPHICS-COORDINATES (118 101))))

(DEFINE-CLASS ACTIVITY-CLASS :NAME "LEVEL-TK-BIO-01" :SUPERCLASSES
```

```
("ICB-CTRL-ACT") :ABSTRACT? NIL :VC-SPECS
((:VC-NAME "DATA1" :VC-TYPE "LIQ-CONTAINER.VC" :VC-KIND :INTERNAL :VARIABLES
  ((:VAR-NAME "PASS?" :DEFAULT-VALUE TRUE :DEFAULT-UNIT "BOOLEAN")
   (:VAR-NAME "O-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
   (:VAR-NAME "DELTA-P" :DEFAULT-VALUE 0 :DEFAULT-UNIT "NPressure")
   (:VAR-NAME "F-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
   (:VAR-NAME "CAPACITY" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "LITER")
   (:VAR-NAME "SAMPLE-INTERVAL" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "SECOND")
   (:VAR-NAME "FLOW-RESISTANCE" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
   (:VAR-NAME "AREA" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
   (:VAR-NAME "FLOW-RATE" :DEFAULT-VALUE 0.0 :DEFAULT-UNIT "UNITLESS")
   (:VAR-NAME "LEVEL" :DEFAULT-VALUE 3 :DEFAULT-UNIT "LITER")
   (:VAR-NAME "ON-LEVEL" :DEFAULT-VALUE 2 :DEFAULT-UNIT "UNITLESS")
   (:VAR-NAME "OFF-LEVEL" :DEFAULT-VALUE 4 :DEFAULT-UNIT "UNITLESS"))))
 :INITIAL-PHASE "Ready" :PIPS
 ((:PROCESS-NAME "level-control" :INVOCATIONS
   ((:STMT-ID "INVOCATION-82" :STATEMENT :NO-VALUE)) :EFFECTS NIL))
 :PHASES
 ((:PHASE-NAME "Ready" :PTPS NIL :PDPS NIL :PTPS-FROM NIL
   :GRAPHICS-COORDINATES (118 101))))

(DEFINE-CLASS ACTIVITY-CLASS :NAME "ALARMS" :SUPERCLASSES ("ICB-CTRL-ACT")
 :ABSTRACT? NIL :VC-SPECS
 ((:VC-NAME "DATA1" :VC-TYPE "LIQ-CONTAINER.VC" :VC-KIND :INTERNAL :VARIABLES
   ((:VAR-NAME "PASS?" :DEFAULT-VALUE TRUE :DEFAULT-UNIT "BOOLEAN")
    (:VAR-NAME "O-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "DELTA-P" :DEFAULT-VALUE 0 :DEFAULT-UNIT "NPressure")
    (:VAR-NAME "F-DIR" :DEFAULT-VALUE NONE :DEFAULT-UNIT "Flow-Dir")
    (:VAR-NAME "CAPACITY" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "LITER")
    (:VAR-NAME "SAMPLE-INTERVAL" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "SECOND")
    (:VAR-NAME "FLOW-RESISTANCE" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "AREA" :DEFAULT-VALUE 1.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "FLOW-RATE" :DEFAULT-VALUE 0.0 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "LEVEL" :DEFAULT-VALUE 3 :DEFAULT-UNIT "LITER")
    (:VAR-NAME "ON-LEVEL" :DEFAULT-VALUE 2 :DEFAULT-UNIT "UNITLESS")
    (:VAR-NAME "OFF-LEVEL" :DEFAULT-VALUE 4 :DEFAULT-UNIT "UNITLESS"))))
 :INITIAL-PHASE "Ready" :PIPS
 ((:PROCESS-NAME "level-control" :INVOCATIONS
   ((:STMT-ID "INVOCATION-82" :STATEMENT :NO-VALUE)) :EFFECTS NIL))
 :PHASES
 ((:PHASE-NAME "Ready" :PTPS NIL :PDPS NIL :PTPS-FROM NIL
   :GRAPHICS-COORDINATES (118 101))))


;;;;;;;;;;;;;;;;;;;;;;; <END> ACTIVITY CLASSES ;;;;;;;;;;;;;;;;;;;;


;;*****************************************************************

;;;;;;;;;;;;;;;;;;;;;;;;; AD-RELATION CLASSES ;;;;;;;;;;;;;;;;;;;;;;;
;;*****************************************************************


(DEFINE-CLASS AD-RELATION-CLASS :NAME "ICB-ACTIVITY-RELATIONS" :SUPERCLASSES
 ("ACTIVITY-DEVICE-RELATIONS") :ABSTRACT? NIL :FROM-VC "LIQ-CONTAINER.VC"
 :TO-VC "LIQ-CONTAINER.VC" :MAPPINGS
 (("FLOW-RATE" * "FLOW-RATE") ("AREA" * "AREA")
  ("FLOW-RESISTANCE" * "FLOW-RESISTANCE")
  ("SAMPLE-INTERVAL" * "SAMPLE-INTERVAL") ("CAPACITY" * "CAPACITY")
  ("F-DIR" * "F-DIR") ("DELTA-P" * "DELTA-P") ("O-DIR" * "O-DIR")
  ("PASS?" * "PASS?")))

(DEFINE-CLASS AD-RELATION-CLASS :NAME "TFB-DEVICE-RELATIONS" :SUPERCLASSES
 ("ACTIVITY-DEVICE-RELATIONS") :ABSTRACT? NIL :FROM-VC "LIQ-CONTAINER.VC"
```

```
 :TO-VC "LIQ-CONTAINER.VC" :MAPPINGS
 (("FLOW-RATE" * "FLOW-RATE") ("AREA" * "AREA")
  ("FLOW-RESISTANCE" * "FLOW-RESISTANCE")
  ("SAMPLE-INTERVAL" * "SAMPLE-INTERVAL") ("CAPACITY" * "CAPACITY")
  ("F-DIR" * "F-DIR") ("DELTA-P" * "DELTA-P") ("O-DIR" * "O-DIR")
  ("PASS?" * "PASS?")))


;;;;;;;;;;;;;;;;;;;;; <END> AD-RELATION CLASSES ;;;;;;;;;;;;;;;;;;;;


;;*****************************************************************************

;;;;;;;;;;;;;;;;;;;;;;;;;;;;.SYSTEM MODELS ;;;;;;;;;;;;;;;;;;;;;;;;;;;;
;;*****************************************************************************


(:MODEL-NAME "WRS-Model" :SIMULATOR
 (:REAL-TIME-PROP (:SIM/REAL 40.0 :MAX-RTIME 2 :MIN-RTIME 0.1)) :DEVICES
 ((:DEVICE-NAME "waste-water" :CLASS "FLUID-SINK-SOURCE" :VCS
   ((:VC-NAME "PORT" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
     ((:VAR-NAME "PHASE" :VALUE LIQUID :INSTANCE-DEFAULT-VALUE LIQUID)))
    (:VC-NAME "DATA" :VC-TYPE "FLUID-SINK.VC" :VC-KIND :INTERNAL :VARS
     ((:VAR-NAME "PASS?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
      (:VAR-NAME "DELTA-P" :VALUE 0) (:VAR-NAME "F-DIR" :VALUE NONE)
      (:VAR-NAME "RESISTANCE" :VALUE 1.0))))
   :RELATIONS-FROM
   ((:RELATION-TYPE "FLUID" :FROM-VC "PORT" :TO-VC "LIQ-PORT1" :TO-DEVICE
     "tk-bio-01" :GRAPHICS-COORDINATES
     ((708.0 -197.0) (734.0 -197.0) (734.0 -176.0) (789.0 -176.0)
      (789.0 -94.0))))
   :GRAPHICS-COORDINATES (667.0 -196.0))
  (:DEVICE-NAME "vent1" :CLASS "FLUID-SINK-SOURCE" :VCS
   ((:VC-NAME "PORT" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
     ((:VAR-NAME "PHASE" :VALUE UNKNOWN :INSTANCE-DEFAULT-VALUE UNKNOWN)))
    (:VC-NAME "DATA" :VC-TYPE "FLUID-SINK.VC" :VC-KIND :INTERNAL :VARS
     ((:VAR-NAME "PASS?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
      (:VAR-NAME "DELTA-P" :VALUE 0) (:VAR-NAME "F-DIR" :VALUE NONE)
      (:VAR-NAME "RESISTANCE" :VALUE 1.0))))
   :RELATIONS-FROM
   ((:RELATION-TYPE "FLUID" :FROM-VC "PORT" :TO-VC "GAS-PORT" :TO-DEVICE
     "tk-bio-01" :GRAPHICS-COORDINATES ((813.8 -182.0) (814.0 -82.0))))
   :GRAPHICS-COORDINATES (817.0 -202.0))
  (:DEVICE-NAME "vent" :CLASS "FLUID-SINK-SOURCE" :VCS
   ((:VC-NAME "PORT" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
     ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
    (:VC-NAME "DATA" :VC-TYPE "FLUID-SINK.VC" :VC-KIND :INTERNAL :VARS
     ((:VAR-NAME "PASS?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
      (:VAR-NAME "DELTA-P" :VALUE 0) (:VAR-NAME "F-DIR" :VALUE NONE)
      (:VAR-NAME "RESISTANCE" :VALUE 1.0))))
   :RELATIONS-FROM
   ((:RELATION-TYPE "FLUID" :FROM-VC "PORT" :TO-VC "GAS-PORT" :TO-DEVICE
     "tk-bio-21" :GRAPHICS-COORDINATES
     ((-18.0 169.0) (-18.0 130.0) (56.0 130.0) (55.0 144.0))))
   :GRAPHICS-COORDINATES (-25.0 188.0))
  (:DEVICE-NAME "sample" :CLASS "FLUID-SINK-SOURCE" :VCS
   ((:VC-NAME "PORT" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
     ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
    (:VC-NAME "DATA" :VC-TYPE "FLUID-SINK.VC" :VC-KIND :INTERNAL :VARS
     ((:VAR-NAME "PASS?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
      (:VAR-NAME "DELTA-P" :VALUE 0) (:VAR-NAME "F-DIR" :VALUE NONE)
      (:VAR-NAME "RESISTANCE" :VALUE 1.0))))
   :RELATIONS-FROM NIL :GRAPHICS-COORDINATES (-58.0 94.0))
  (:DEVICE-NAME "ah04-00024" :CLASS "FLUID-SINK-SOURCE" :VCS
```

```
((:VC-NAME "PORT" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
  ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
 (:VC-NAME "DATA" :VC-TYPE "FLUID-SINK.VC" :VC-KIND :INTERNAL :VARS
  ((:VAR-NAME "PASS?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
   (:VAR-NAME "DELTA-P" :VALUE 0) (:VAR-NAME "F-DIR" :VALUE NONE)
   (:VAR-NAME "RESISTANCE" :VALUE 1.0))))
:RELATIONS-FROM NIL :GRAPHICS-COORDINATES (214.0 146.0))
(:DEVICE-NAME "br-bio-73" :CLASS "3-PORT-WATER-TANK" :VCS
 ((:VC-NAME "LIQ-PORT1" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
  ((:VAR-NAME "PHASE" :VALUE UNKNOWN :INSTANCE-DEFAULT-VALUE UNKNOWN)))
  (:VC-NAME "DATA1" :VC-TYPE "LIQ-CONTAINER.VC" :VC-KIND :INTERNAL :VARS
   ((:VAR-NAME "PASS?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
    (:VAR-NAME "DELTA-P" :VALUE 1.0) (:VAR-NAME "F-DIR" :VALUE RIGHT)
    (:VAR-NAME "CAPACITY" :VALUE 1.0)
    (:VAR-NAME "SAMPLE-INTERVAL" :VALUE 1.0)
    (:VAR-NAME "FLOW-RESISTANCE" :VALUE 1.0) (:VAR-NAME "AREA" :VALUE 1.0)
    (:VAR-NAME "FLOW-RATE" :VALUE 1.0)
    (:VAR-NAME "LEVEL" :VALUE 10.0 :INSTANCE-DEFAULT-VALUE 10.0)
    (:VAR-NAME "ON-LEVEL" :VALUE 0) (:VAR-NAME "OFF-LEVEL" :VALUE 0)))
  (:VC-NAME "GAS-DATA" :VC-TYPE "FLUID-EFFORT-STORAGE.VC" :VC-KIND :INTERNAL
   :VARS
   ((:VAR-NAME "PASS?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
    (:VAR-NAME "DELTA-P" :VALUE -1) (:VAR-NAME "F-DIR" :VALUE LEFT)
    (:VAR-NAME "P-OUTPUT" :VALUE -1) (:VAR-NAME "P-DIR" :VALUE LEFT)
    (:VAR-NAME "RESISTANCE" :VALUE 1.0)))
  (:VC-NAME "GAS-PORT" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
   ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
  (:VC-NAME "DATA2" :VC-TYPE "LIQ-CONTAINER.VC" :VC-KIND :INTERNAL :VARS
   ((:VAR-NAME "PASS?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
    (:VAR-NAME "DELTA-P" :VALUE 0) (:VAR-NAME "F-DIR" :VALUE NONE)
    (:VAR-NAME "CAPACITY" :VALUE 1.0)
    (:VAR-NAME "SAMPLE-INTERVAL" :VALUE 1.0)
    (:VAR-NAME "FLOW-RESISTANCE" :VALUE 1.0) (:VAR-NAME "AREA" :VALUE 1.0)
    (:VAR-NAME "FLOW-RATE" :VALUE 0.0)
    (:VAR-NAME "LEVEL" :VALUE 10.0 :INSTANCE-DEFAULT-VALUE 10.0)
    (:VAR-NAME "ON-LEVEL" :VALUE 0) (:VAR-NAME "OFF-LEVEL" :VALUE 0)))
  (:VC-NAME "LIQ-PORT2" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
   ((:VAR-NAME "PHASE" :VALUE UNKNOWN :INSTANCE-DEFAULT-VALUE UNKNOWN)))
  (:VC-NAME "LIQ-PORT3" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
   ((:VAR-NAME "PHASE" :VALUE UNKNOWN :INSTANCE-DEFAULT-VALUE UNKNOWN)))
  (:VC-NAME "DATA3" :VC-TYPE "LIQ-CONTAINER.VC" :VC-KIND :INTERNAL :VARS
   ((:VAR-NAME "PASS?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
    (:VAR-NAME "DELTA-P" :VALUE 0) (:VAR-NAME "F-DIR" :VALUE NONE)
    (:VAR-NAME "CAPACITY" :VALUE 1.0)
    (:VAR-NAME "SAMPLE-INTERVAL" :VALUE 1.0)
    (:VAR-NAME "FLOW-RESISTANCE" :VALUE 1.0) (:VAR-NAME "AREA" :VALUE 1.0)
    (:VAR-NAME "FLOW-RATE" :VALUE 0.0)
    (:VAR-NAME "LEVEL" :VALUE 10.0 :INSTANCE-DEFAULT-VALUE 10.0)
    (:VAR-NAME "ON-LEVEL" :VALUE 0) (:VAR-NAME "OFF-LEVEL" :VALUE 0))))
  :RELATIONS-FROM
  ((:RELATION-TYPE "FLUID" :FROM-VC "LIQ-PORT2" :TO-VC "LIQ-PORT2" :TO-DEVICE
    "tk-bio-52" :GRAPHICS-COORDINATES ((209.0 -51.0) (209.0 9.0)))
   (:RELATION-TYPE "FLUID" :FROM-VC "GAS-PORT" :TO-VC "PORT" :TO-DEVICE
    "ah04-m00023" :GRAPHICS-COORDINATES ((208.0 -108.0) (208.04169 -158.0))))
  :GRAPHICS-COORDINATES (212.0 -82.0))
 (:DEVICE-NAME "pu-bio-23" :CLASS "PUMP" :VCS
  ((:VC-NAME "IN" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
    ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
   (:VC-NAME "OUT" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
    ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
   (:VC-NAME "DATA" :VC-TYPE "PUMP.VC" :VC-KIND :INTERNAL :VARS
    ((:VAR-NAME "CLEAR?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
     (:VAR-NAME "DELTA-P" :VALUE 1) (:VAR-NAME "F-DIR" :VALUE RIGHT)
     (:VAR-NAME "P-OUTPUT" :VALUE 1) (:VAR-NAME "E-DIR" :VALUE RIGHT)
     (:VAR-NAME "RESISTANCE" :VALUE 1.0) (:VAR-NAME "DELTA-T" :VALUE 0)
```

```
      (:VAR-NAME "P-RATING" :VALUE 1) (:VAR-NAME "ON?" :VALUE TRUE)))
    (:VC-NAME "COMMAND" :VC-TYPE "STATE-CODE.VC" :VC-KIND :PORT :VARS
     ((:VAR-NAME "ENABLED?" :VALUE TRUE)
      (:VAR-NAME "COMMAND-RESPONSE-DELAY" :VALUE 1.0)
      (:VAR-NAME "CODE" :VALUE 1 :VAR-INSTRUMENTS
       ((:GADGET-TYPE TEXT-FIELD :GADGET-OPTIONS
         (:NCOLUMNS 4 :WIDTH 54 :LABEL "pu-bio-23:COMMAND:CODE" :EDITABLE-P T)
         :POSITION (231 416)))))))
  :RELATIONS-FROM
  ((:RELATION-TYPE "FLUID" :FROM-VC "OUT" :TO-VC "PORT3" :TO-DEVICE "tee1"
    :GRAPHICS-COORDINATES ((490.5 156.94937) (707.0 157.0) (707.0 3.0))))
  :GRAPHICS-COORDINATES (459.0 183.0))
 (:DEVICE-NAME "tee1" :CLASS "TEE-PIPE" :VCS
  ((:VC-NAME "PORT1" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
    ((:VAR-NAME "PHASE" :VALUE LIQUID :INSTANCE-DEFAULT-VALUE LIQUID)))
   (:VC-NAME "PORT2" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
    ((:VAR-NAME "PHASE" :VALUE LIQUID :INSTANCE-DEFAULT-VALUE LIQUID)))
   (:VC-NAME "PORT3" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
    ((:VAR-NAME "PHASE" :VALUE LIQUID :INSTANCE-DEFAULT-VALUE LIQUID)))
   (:VC-NAME "DATA1" :VC-TYPE "FLUID-STATE.VC" :VC-KIND :INTERNAL :VARS
    ((:VAR-NAME "CLEAR?" :VALUE TRUE :VAR-INSTRUMENTS
      ((:GADGET-TYPE OPTION-PANE :GADGET-OPTIONS
        (:MODE :EXCLUSIVE :LABEL "tee1:DATA1:CLEAR?" :EDITABLE-P T) :POSITION
        (1 1))))
     (:VAR-NAME "O-DIR" :VALUE NONE) (:VAR-NAME "DELTA-P" :VALUE -1)
     (:VAR-NAME "F-DIR" :VALUE LEFT) (:VAR-NAME "RESISTANCE" :VALUE 1.0)
     (:VAR-NAME "DELTA-T" :VALUE 0)))
   (:VC-NAME "DATA2" :VC-TYPE "FLUID-STATE.VC" :VC-KIND :INTERNAL :VARS
    ((:VAR-NAME "CLEAR?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
     (:VAR-NAME "DELTA-P" :VALUE 0) (:VAR-NAME "F-DIR" :VALUE NONE)
     (:VAR-NAME "RESISTANCE" :VALUE 1.0) (:VAR-NAME "DELTA-T" :VALUE 0)))
   (:VC-NAME "DATA3" :VC-TYPE "FLUID-STATE.VC" :VC-KIND :INTERNAL :VARS
    ((:VAR-NAME "CLEAR?" :VALUE TRUE :VAR-INSTRUMENTS
      ((:GADGET-TYPE OPTION-PANE :GADGET-OPTIONS
        (:MODE :EXCLUSIVE :LABEL "tee1:from-pu23:on?" :EDITABLE-P T)
        :POSITION (336 2))))
     (:VAR-NAME "O-DIR" :VALUE NONE) (:VAR-NAME "DELTA-P" :VALUE 1)
     (:VAR-NAME "F-DIR" :VALUE RIGHT) (:VAR-NAME "RESISTANCE" :VALUE 1.0)
     (:VAR-NAME "DELTA-T" :VALUE 0))))
  :RELATIONS-FROM
  ((:RELATION-TYPE "FLUID" :FROM-VC "PORT2" :TO-VC "PORT1" :TO-DEVICE
    "hv-bio-48" :GRAPHICS-COORDINATES ((669.0 -19.0) (639.0 -19.0))))
  :GRAPHICS-COORDINATES (696.0 -13.0))
 (:DEVICE-NAME "pu-bio-16" :CLASS "PUMP" :VCS
  ((:VC-NAME "IN" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
    ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
   (:VC-NAME "OUT" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
    ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
   (:VC-NAME "DATA" :VC-TYPE "PUMP.VC" :VC-KIND :INTERNAL :VARS
    ((:VAR-NAME "CLEAR?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
     (:VAR-NAME "DELTA-P" :VALUE 2) (:VAR-NAME "F-DIR" :VALUE RIGHT)
     (:VAR-NAME "P-OUTPUT" :VALUE 1) (:VAR-NAME "E-DIR" :VALUE RIGHT)
     (:VAR-NAME "RESISTANCE" :VALUE 1.0) (:VAR-NAME "DELTA-T" :VALUE 0)
     (:VAR-NAME "P-RATING" :VALUE 1) (:VAR-NAME "ON?" :VALUE TRUE)))
   (:VC-NAME "COMMAND" :VC-TYPE "STATE-CODE.VC" :VC-KIND :PORT :VARS
    ((:VAR-NAME "ENABLED?" :VALUE TRUE)
     (:VAR-NAME "COMMAND-RESPONSE-DELAY" :VALUE 1.0)
     (:VAR-NAME "CODE" :VALUE 1 :VAR-INSTRUMENTS
      ((:GADGET-TYPE TEXT-FIELD :GADGET-OPTIONS
        (:NCOLUMNS 4 :WIDTH 54 :LABEL "pu-bio-16:COMMAND:CODE" :EDITABLE-P T)
        :POSITION (5 416)))))))
 :RELATIONS-FROM
 ((:RELATION-TYPE "FLUID" :FROM-VC "OUT" :TO-VC "PORT1" :TO-DEVICE
   "mv-bio-55" :GRAPHICS-COORDINATES ((-19.438272 -115.5) (-19.0 -18.0))))
 :GRAPHICS-COORDINATES (-19.0 -151.0))
```

```
(:DEVICE-NAME "tk-bio-21" :CLASS "2-PORT-WATER-TANK" :VCS
 ((:VC-NAME "LIQ-PORT1" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
   ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
  (:VC-NAME "DATA1" :VC-TYPE "LIQ-CONTAINER.VC" :VC-KIND :INTERNAL :VARS
   ((:VAR-NAME "PASS?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
    (:VAR-NAME "DELTA-P" :VALUE 2) (:VAR-NAME "F-DIR" :VALUE RIGHT)
    (:VAR-NAME "CAPACITY" :VALUE 1.0)
    (:VAR-NAME "SAMPLE-INTERVAL" :VALUE 1.0)
    (:VAR-NAME "FLOW-RESISTANCE" :VALUE 1.0) (:VAR-NAME "AREA" :VALUE 1.0)
    (:VAR-NAME "FLOW-RATE" :VALUE 2.0) (:VAR-NAME "LEVEL" :VALUE 0)
    (:VAR-NAME "ON-LEVEL" :VALUE 0) (:VAR-NAME "OFF-LEVEL" :VALUE 0)))
  (:VC-NAME "GAS-DATA" :VC-TYPE "FLUID-EFFORT-STORAGE.VC" :VC-KIND :INTERNAL
   :VARS
   ((:VAR-NAME "PASS?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
    (:VAR-NAME "DELTA-P" :VALUE 0) (:VAR-NAME "F-DIR" :VALUE NONE)
    (:VAR-NAME "P-OUTPUT" :VALUE 0) (:VAR-NAME "P-DIR" :VALUE NONE)
    (:VAR-NAME "RESISTANCE" :VALUE 1.0)))
  (:VC-NAME "GAS-PORT" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
   ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
  (:VC-NAME "DATA2" :VC-TYPE "LIQ-CONTAINER.VC" :VC-KIND :INTERNAL :VARS
   ((:VAR-NAME "PASS?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
    (:VAR-NAME "DELTA-P" :VALUE -1) (:VAR-NAME "F-DIR" :VALUE LEFT)
    (:VAR-NAME "CAPACITY" :VALUE 1.0)
    (:VAR-NAME "SAMPLE-INTERVAL" :VALUE 1.0)
    (:VAR-NAME "FLOW-RESISTANCE" :VALUE 1.0) (:VAR-NAME "AREA" :VALUE 1.0)
    (:VAR-NAME "FLOW-RATE" :VALUE -1.0) (:VAR-NAME "LEVEL" :VALUE 0)
    (:VAR-NAME "ON-LEVEL" :VALUE 0) (:VAR-NAME "OFF-LEVEL" :VALUE 0)))
  (:VC-NAME "LIQ-PORT2" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
   ((:VAR-NAME "PHASE" :VALUE UNKNOWN))))
 :RELATIONS-FROM
 ((:RELATION-TYPE "FLUID" :FROM-VC "LIQ-PORT2" :TO-VC "IN" :TO-DEVICE
   "pu-bio-23" :GRAPHICS-COORDINATES
   ((83.0 193.0) (83.0 215.0) (356.0 215.0) (356.0 181.0) (414.0 181.0))))
 :GRAPHICS-COORDINATES (84.0 172.0))
(:DEVICE-NAME "mv-bio-55" :CLASS "3-WAY-MOTOR-VALVE" :VCS
 ((:VC-NAME "PORT1" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
   ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
  (:VC-NAME "PORT2" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
   ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
  (:VC-NAME "PORT3" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
   ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
  (:VC-NAME "DATA1" :VC-TYPE "FLUID-STATE.VC" :VC-KIND :INTERNAL :VARS
   ((:VAR-NAME "CLEAR?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
    (:VAR-NAME "DELTA-P" :VALUE 2) (:VAR-NAME "F-DIR" :VALUE RIGHT)
    (:VAR-NAME "RESISTANCE" :VALUE 1.0) (:VAR-NAME "DELTA-T" :VALUE 0)))
  (:VC-NAME "DATA2" :VC-TYPE "FLUID-STATE.VC" :VC-KIND :INTERNAL :VARS
   ((:VAR-NAME "CLEAR?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
    (:VAR-NAME "DELTA-P" :VALUE -2) (:VAR-NAME "F-DIR" :VALUE LEFT)
    (:VAR-NAME "RESISTANCE" :VALUE 1.0) (:VAR-NAME "DELTA-T" :VALUE 0)))
  (:VC-NAME "DATA3" :VC-TYPE "FLUID-STATE.VC" :VC-KIND :INTERNAL :VARS
   ((:VAR-NAME "CLEAR?" :VALUE FALSE) (:VAR-NAME "O-DIR" :VALUE NONE)
    (:VAR-NAME "DELTA-P" :VALUE 0) (:VAR-NAME "F-DIR" :VALUE NONE)
    (:VAR-NAME "RESISTANCE" :VALUE 1.0) (:VAR-NAME "DELTA-T" :VALUE 0)))
  (:VC-NAME "COMMAND-DATA" :VC-TYPE "VALVE-COMMAND.VC" :VC-KIND :PORT :VARS
   ((:VAR-NAME "ENABLED?" :VALUE TRUE)
    (:VAR-NAME "COMMAND-RESPONSE-DELAY" :VALUE 1.0)
    (:VAR-NAME "CODE" :VALUE 3 :VAR-INSTRUMENTS
     ((:GADGET-TYPE TEXT-FIELD :GADGET-OPTIONS
       (:NCOLUMNS 4 :WIDTH 54 :LABEL "mv-bio-55:COMMAND-DATA:CODE"
        :EDITABLE-P T)
       :POSITION (236 339))))
    (:VAR-NAME "ACTIVE?" :VALUE TRUE)
    (:VAR-NAME "RESPONSE-DELAY" :VALUE 0))))
 :RELATIONS-FROM
 ((:RELATION-TYPE "FLUID" :FROM-VC "PORT3" :TO-VC "PORT" :TO-DEVICE "sample"
```

```
    :GRAPHICS-COORDINATES ((-29.915665 31.0) (-49.084335 74.0)))
   (:RELATION-TYPE "FLUID" :FROM-VC "PORT2" :TO-VC "LIQ-PORT1" :TO-DEVICE
    "tk-bio-21" :GRAPHICS-COORDINATES
    ((-9.0 25.0) (-9.0 102.0) (81.0 102.0) (81.0 135.0))))
  :GRAPHICS-COORDINATES (-21.0 11.0))
 (:DEVICE-NAME "ah04-000233" :CLASS "FLUID-SINK-SOURCE" :VCS
  ((:VC-NAME "PORT" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
    ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
   (:VC-NAME "DATA" :VC-TYPE "FLUID-SINK.VC" :VC-KIND :INTERNAL :VARS
    ((:VAR-NAME "PASS?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
     (:VAR-NAME "DELTA-P" :VALUE -1) (:VAR-NAME "F-DIR" :VALUE LEFT)
     (:VAR-NAME "RESISTANCE" :VALUE 1.0))))
  :RELATIONS-FROM NIL :GRAPHICS-COORDINATES (539.0 -196.0))
 (:DEVICE-NAME "br-bio-72" :CLASS "2-PORT-WATER-TANK" :VCS
  ((:VC-NAME "LIQ-PORT1" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
    ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
   (:VC-NAME "DATA1" :VC-TYPE "LIQ-CONTAINER.VC" :VC-KIND :INTERNAL :VARS
    ((:VAR-NAME "PASS?" :VALUE TRUE :VAR-INSTRUMENTS
      ((:GADGET-TYPE OPTION-PANE :GADGET-OPTIONS
        (:MODE :EXCLUSIVE :LABEL "br-bio-72:DATA1:PASS?" :EDITABLE-P T)
        :POSITION (189 139))))
     (:VAR-NAME "O-DIR" :VALUE NONE) (:VAR-NAME "DELTA-P" :VALUE -1.0)
     (:VAR-NAME "F-DIR" :VALUE LEFT) (:VAR-NAME "CAPACITY" :VALUE 1.0)
     (:VAR-NAME "SAMPLE-INTERVAL" :VALUE 1.0)
     (:VAR-NAME "FLOW-RESISTANCE" :VALUE 1.0) (:VAR-NAME "AREA" :VALUE 1.0)
     (:VAR-NAME "FLOW-RATE" :VALUE -1.0) (:VAR-NAME "LEVEL" :VALUE 0)
     (:VAR-NAME "ON-LEVEL" :VALUE 0) (:VAR-NAME "OFF-LEVEL" :VALUE 0)))
   (:VC-NAME "GAS-DATA" :VC-TYPE "FLUID-EFFORT-STORAGE.VC" :VC-KIND :INTERNAL
    :VARS
    ((:VAR-NAME "PASS?" :VALUE TRUE :VAR-INSTRUMENTS
      ((:GADGET-TYPE OPTION-PANE :GADGET-OPTIONS
        (:MODE :EXCLUSIVE :LABEL "br-bio-72:GAS-DATA:PASS?" :EDITABLE-P T)
        :POSITION (2 138))))
     (:VAR-NAME "O-DIR" :VALUE NONE) (:VAR-NAME "DELTA-P" :VALUE 1)
     (:VAR-NAME "F-DIR" :VALUE RIGHT) (:VAR-NAME "P-OUTPUT" :VALUE 1)
     (:VAR-NAME "P-DIR" :VALUE RIGHT) (:VAR-NAME "RESISTANCE" :VALUE 1.0)))
   (:VC-NAME "GAS-PORT" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
    ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
   (:VC-NAME "DATA2" :VC-TYPE "LIQ-CONTAINER.VC" :VC-KIND :INTERNAL :VARS
    ((:VAR-NAME "PASS?" :VALUE TRUE :VAR-INSTRUMENTS
      ((:GADGET-TYPE OPTION-PANE :GADGET-OPTIONS
        (:MODE :EXCLUSIVE :LABEL "br-bio-72:h-47-to-br-72:open?" :EDITABLE-P
        T)
        :POSITION (344 140))))
     (:VAR-NAME "O-DIR" :VALUE NONE) (:VAR-NAME "DELTA-P" :VALUE 1.0)
     (:VAR-NAME "F-DIR" :VALUE RIGHT) (:VAR-NAME "CAPACITY" :VALUE 1.0)
     (:VAR-NAME "SAMPLE-INTERVAL" :VALUE 1.0)
     (:VAR-NAME "FLOW-RESISTANCE" :VALUE 1.0) (:VAR-NAME "AREA" :VALUE 1.0)
     (:VAR-NAME "FLOW-RATE" :VALUE 1.0) (:VAR-NAME "LEVEL" :VALUE 0)
     (:VAR-NAME "ON-LEVEL" :VALUE 0) (:VAR-NAME "OFF-LEVEL" :VALUE 0)))
   (:VC-NAME "LIQ-PORT2" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
    ((:VAR-NAME "PHASE" :VALUE UNKNOWN))))
  :RELATIONS-FROM
  ((:RELATION-TYPE "FLUID" :FROM-VC "GAS-PORT" :TO-VC "PORT" :TO-DEVICE
    "ah04-000233" :GRAPHICS-COORDINATES
    ((436.0 -123.0) (436.0 -155.0) (534.0 -155.0) (534.0 -178.0)))
   (:RELATION-TYPE "FLUID" :FROM-VC "LIQ-PORT1" :TO-VC "IN" :TO-DEVICE
    "pu-bio-05" :GRAPHICS-COORDINATES
    ((423.0 -78.0) (423.0 -43.0) (469.0 -43.0))))
  :GRAPHICS-COORDINATES (422.0 -97.0))
 (:DEVICE-NAME "ah04-m00023" :CLASS "FLUID-SINK-SOURCE" :VCS
  ((:VC-NAME "PORT" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
    ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
   (:VC-NAME "DATA" :VC-TYPE "FLUID-SINK.VC" :VC-KIND :INTERNAL :VARS
    ((:VAR-NAME "PASS?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
```

```
    (:VAR-NAME "DELTA-P" :VALUE 1) (:VAR-NAME "F-DIR" :VALUE RIGHT)
    (:VAR-NAME "RESISTANCE" :VALUE 1.0))))
 :RELATIONS-FROM NIL :GRAPHICS-COORDINATES (207.0 -178.0))
(:DEVICE-NAME "tk-bio-45" :CLASS "VALVE" :VCS
 ((:VC-NAME "IN" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
   ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
  (:VC-NAME "OUT" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
   ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
  (:VC-NAME "DATA" :VC-TYPE "FLUID-STATE.VC" :VC-KIND :INTERNAL :VARS
   ((:VAR-NAME "CLEAR?" :VALUE TRUE :INSTANCE-DEFAULT-VALUE TRUE)
    (:VAR-NAME "O-DIR" :VALUE NONE) (:VAR-NAME "DELTA-P" :VALUE 1.0)
    (:VAR-NAME "F-DIR" :VALUE RIGHT) (:VAR-NAME "RESISTANCE" :VALUE 1.0)
    (:VAR-NAME "DELTA-T" :VALUE 0))))
 :RELATIONS-FROM
 ((:RELATION-TYPE "FLUID" :FROM-VC "OUT" :TO-VC "IN" :TO-DEVICE "hv-bio-75"
   :GRAPHICS-COORDINATES ((537.0 60.0) (498.0 60.0) (455.5 59.902683))))
 :GRAPHICS-COORDINATES (564.0 65.0))
(:DEVICE-NAME "tk-bio-01" :CLASS "2-PORT-WATER-TANK" :VCS
 ((:VC-NAME "LIQ-PORT1" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
   ((:VAR-NAME "PHASE" :VALUE UNKNOWN :INSTANCE-DEFAULT-VALUE UNKNOWN)))
  (:VC-NAME "DATA1" :VC-TYPE "LIQ-CONTAINER.VC" :VC-KIND :INTERNAL :VARS
   ((:VAR-NAME "PASS?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
    (:VAR-NAME "DELTA-P" :VALUE 0) (:VAR-NAME "F-DIR" :VALUE NONE)
    (:VAR-NAME "CAPACITY" :VALUE 1.0)
    (:VAR-NAME "SAMPLE-INTERVAL" :VALUE 1.0)
    (:VAR-NAME "FLOW-RESISTANCE" :VALUE 1.0) (:VAR-NAME "AREA" :VALUE 1.0)
    (:VAR-NAME "FLOW-RATE" :VALUE 0.0)
    (:VAR-NAME "LEVEL" :VALUE 1.0 :INSTANCE-DEFAULT-VALUE 1.0)
    (:VAR-NAME "ON-LEVEL" :VALUE 0) (:VAR-NAME "OFF-LEVEL" :VALUE 0)))
  (:VC-NAME "GAS-DATA" :VC-TYPE "FLUID-EFFORT-STORAGE.VC" :VC-KIND :INTERNAL
   :VARS
   ((:VAR-NAME "PASS?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
    (:VAR-NAME "DELTA-P" :VALUE 0) (:VAR-NAME "F-DIR" :VALUE NONE)
    (:VAR-NAME "P-OUTPUT" :VALUE 0) (:VAR-NAME "P-DIR" :VALUE NONE)
    (:VAR-NAME "RESISTANCE" :VALUE 1.0)))
  (:VC-NAME "GAS-PORT" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
   ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
  (:VC-NAME "DATA2" :VC-TYPE "LIQ-CONTAINER.VC" :VC-KIND :INTERNAL :VARS
   ((:VAR-NAME "PASS?" :VALUE TRUE :VAR-INSTRUMENTS
     ((:GADGET-TYPE OPTION-PANE :GADGET-OPTIONS
       (:MODE :EXCLUSIVE :LABEL "tk-bio-01:air-to-tk1:on?" :EDITABLE-P T)
       :POSITION (132 2))))
    (:VAR-NAME "O-DIR" :VALUE NONE) (:VAR-NAME "DELTA-P" :VALUE 1)
    (:VAR-NAME "F-DIR" :VALUE RIGHT) (:VAR-NAME "CAPACITY" :VALUE 1.0)
    (:VAR-NAME "SAMPLE-INTERVAL" :VALUE 1.0)
    (:VAR-NAME "FLOW-RESISTANCE" :VALUE 1.0) (:VAR-NAME "AREA" :VALUE 1.0)
    (:VAR-NAME "FLOW-RATE" :VALUE 1.0)
    (:VAR-NAME "LEVEL" :VALUE 1.0 :INSTANCE-DEFAULT-VALUE 1.0)
    (:VAR-NAME "ON-LEVEL" :VALUE 0) (:VAR-NAME "OFF-LEVEL" :VALUE 0)))
  (:VC-NAME "LIQ-PORT2" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
   ((:VAR-NAME "PHASE" :VALUE UNKNOWN :INSTANCE-DEFAULT-VALUE UNKNOWN))))
 :RELATIONS-FROM
 ((:RELATION-TYPE "FLUID" :FROM-VC "LIQ-PORT2" :TO-VC "PORT1" :TO-DEVICE
   "tee1" :GRAPHICS-COORDINATES
   ((792.0 -28.0) (788.0 -21.0) (715.5 -20.840206))))
 :GRAPHICS-COORDINATES (793.0 -52.0))
(:DEVICE-NAME "mv-bio-54" :CLASS "3-WAY-MOTOR-VALVE" :VCS
 ((:VC-NAME "PORT1" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
   ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
  (:VC-NAME "PORT2" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
   ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
  (:VC-NAME "PORT3" :VC-TYPE "FLUID-PORT.VC" :VC-KIND :PORT :VARS
   ((:VAR-NAME "PHASE" :VALUE UNKNOWN)))
  (:VC-NAME "DATA1" :VC-TYPE "FLUID-STATE.VC" :VC-KIND :INTERNAL :VARS
   ((:VAR-NAME "CLEAR?" :VALUE TRUE) (:VAR-NAME "O-DIR" :VALUE NONE)
```