FRESENIUS MEDICAL CARE

2008® SERIES
TECHNICAL TRAINING

STUDENT GUIDE AND WORKBOOK

The 2008K, 2008K^2, 2008K@Home™, & 2008T machines constitute the 2008® Series Hemodialysis Machines. In this manual the 2008T, 2008K, 2008K^2 & 2008K@Home™ hemodialysis machines may be referred to as “2008 Series”.

i. Typical Daily Class schedule:

   a. 8:30 AM - class starts

   b. 12:00-12:30 - Lunch break

   c. 5:00 PM - class ends

   d. Breaks - two ten-minute breaks in the morning; one in the afternoon

ii. Ground Rules:

   a. Keep your cellphone in silent mode or turn it off

   b. Be punctual to class and from breaks

   c. No exposed legs or open-toe footwear (cut-off jeans and flip-flops)

   d. No web-surfing or personal emails during class

iii. Reference Documents:

   a. 490114 2008K Level 1 Training Manual

   b. 508990-01 Training Presentation: Introduction to Hemodialysis

   c. 508990-02 Training Presentation: Hydraulics- Primary Side

   d. 508990-03 Training Presentation: Hydraulics- Secondary Side

   e. 507297 2008K Preventive Maintenance Procedures

   f. 507781 2008K Semi-Annual Preventive Maintenance Procedures

iv. Training material handed out in class:

   a. Hydraulic flow path diagrams

   b. Calibration resistors for temperature sensor

   c. Potentiometer adjusting tool

v. **CLASSROOM COPIES ONLY – PLEASE DO NOT WRITE ON OR TAKE HOME THE FOLLOWING**:

   a. Level one Training manual

   b. Calibration procedures

   c. Preventive Maintenance procedures.

   d. Description of debug screens

   e. bi*b*ag® Technician Manual

vi. **For a copy of the classroom ONLY documents and class agenda, please refer to Fresenius Medical Care website:**

   https://fmcna.com/product-support-documentation/

I. Introduction to Dialysis

Learning Objectives:

1. _____
2. _____
3. _____
4. _____

II. Kidney Functions:

1. _____
2. _____
3. _____
4. _____
5. _____

III. Hemodialysis Basics:

The HEMODIALYSIS MACHINE performs four major functions:

1. PREPARES AND MONITORS _____
2. MONITORS THE PATIENT _____
3. CONTROLS _____ FLOW
4. REMOVES _____ (ULTRAFILTRATE) FROM THE PATIENT'S BLOOD
    1. Dialyzer _____
        i. Blood Compartment _____

        _____
        ii. Dialysate Compartment_____

        _____

2. Dialysate Preparation

_____

_____

_____

3. Blood Circuit

_____

_____

_____

4. Controls Dialysate Circuit Flow

The _____ consist of two cylindrical chambers, each with volume 30 (+/- 1)ml

_____#20 loads one of the balancing chamber with **FRESH** dialysate

_____#21 loads one of the balancing chamber with **SPENT** dialysate

_____#22 removes water from patient circuit 1ml per stroke of the pump

5. Diffusion: The passage of **_____** from an area of high concentration to an area of low concentration. _____

6. Osmosis: The passage of **WATER** through a semi permeable membrane from an area with a **_____** ***pressure*** gradient to one with a **_____pressure** gradient.

7. KUF _____

8. 2008 Series Blood Circuit Modules:

   Arterial Blood Pump:_____

   Level Detector:

   Venous Pressure :_____

   Air detector: _____

   Venous Line Clamp: _____

   Optical detector: _____

   Heparin Pump: _____

9. Blood Alarms Reactions:

i. _____ _____

ii. _____ _____

iii. _____ _____

iv. _____ _____

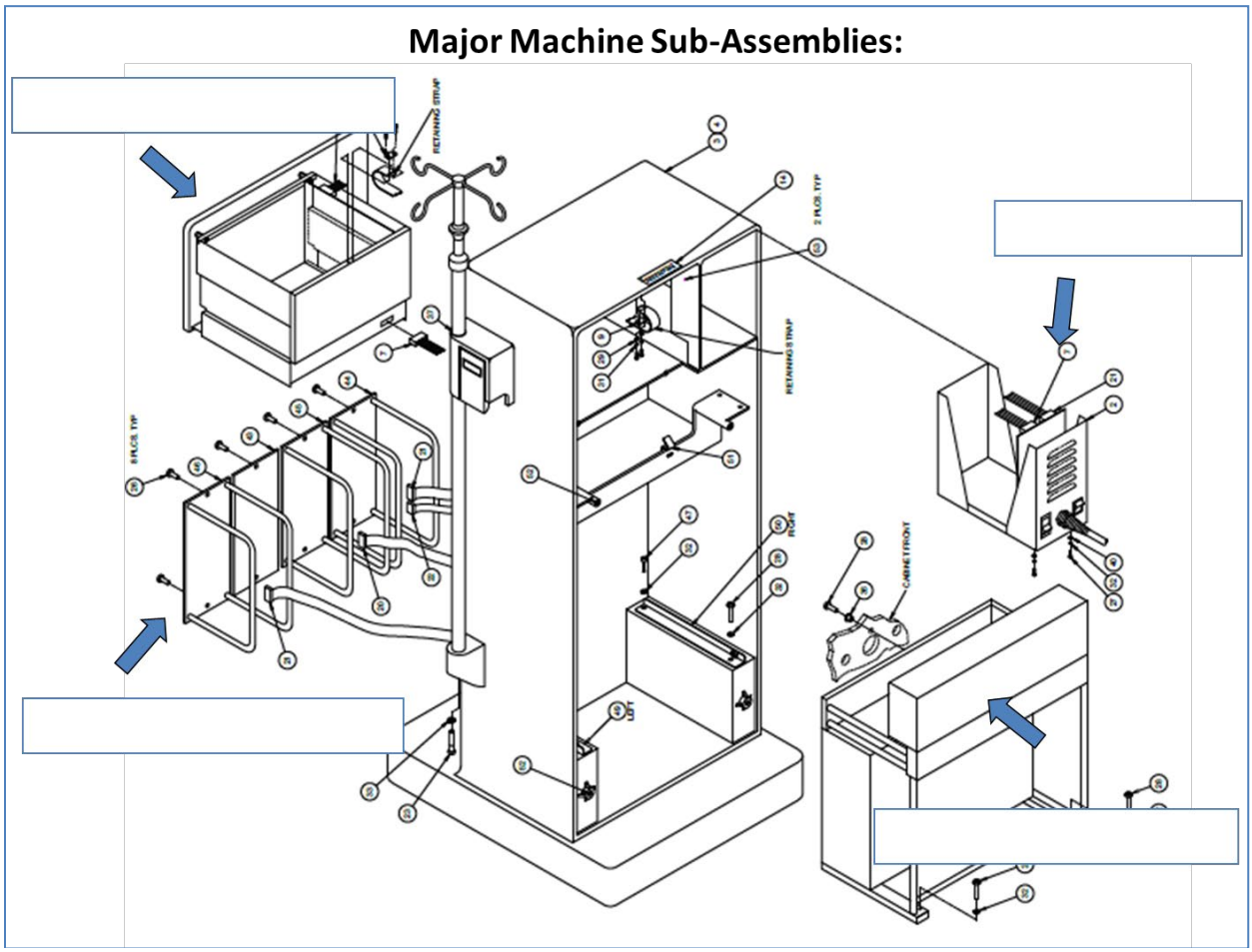
v. _____ _____

10. Dialysate Alarms Reactions:

i. _____ _____

ii. _____ _____

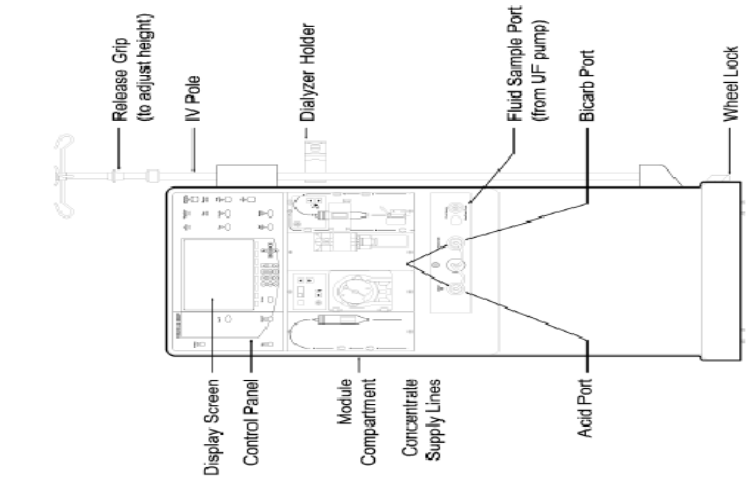
11. Major Machine Sub-Assemblies:

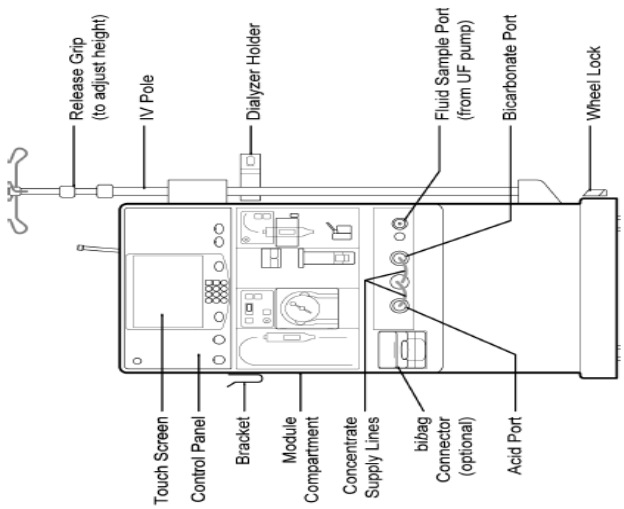


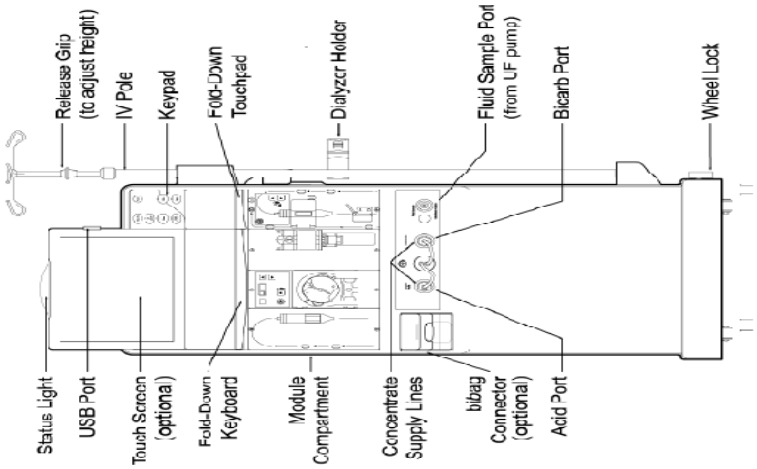
I. MACHINE OPERATION

a. Machine Function - The 2008 Series is designed to provide hemodialysis treatment by controlling and monitoring both the dialysate and extracorporeal blood circuits

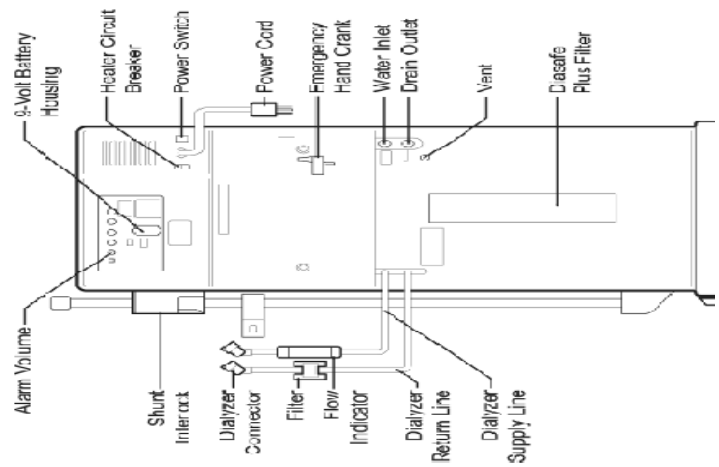
b. Front View:

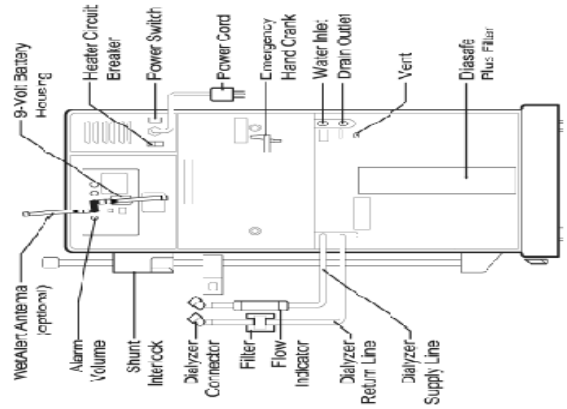


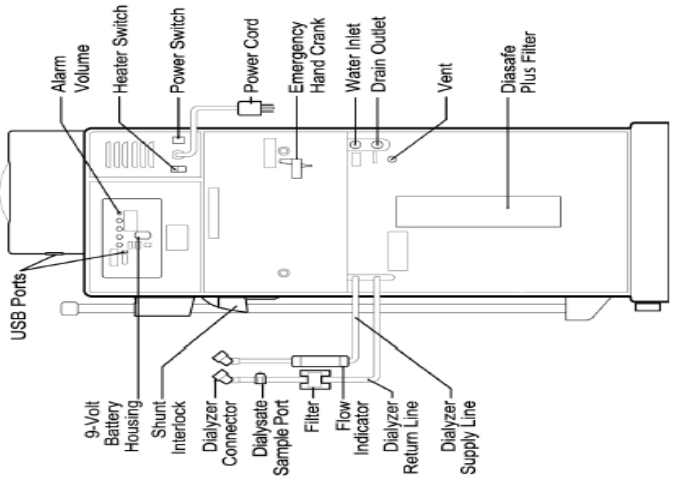




c. Rear View:

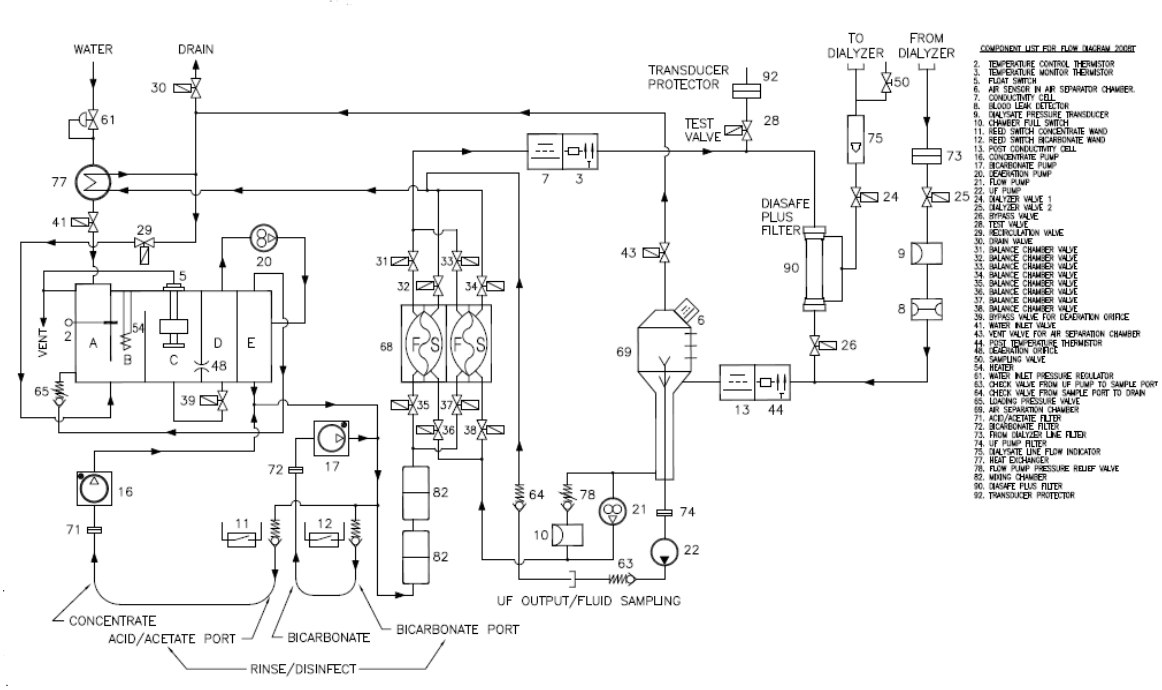

9-Volt Battery Housing
Heater Circuit Breaker
Power Switch
Power Cord
Emergency Hand Crank
Water Inlet
Drain Outlet
Vent
Diasafe Plus Filter
Alarm Volume
Shunt Interlock
Dialyzer Connector
Filter
Flow Indicator
Dialyzer Return Line
Dialyzer Supply Line


9-Volt Battery Housing
Heater Circuit Breaker
Power Switch
Power Cord
Emergency Hand Crank
Water Inlet
Drain Outlet
Vent
Diasafe Plus Filter
WebAlert Antenna (optional)
Alarm Volume
Shunt Interlock
Dialyzer Connector
Filter
Flow Indicator
Dialyzer Return Line
Dialyzer Supply Line


Alarm Volume
Heater Switch
Power Switch
Power Cord
Emergency Hand Crank
Water Inlet
Drain Outlet
Vent
Diasafe Plus Filter
USB Ports
9-Volt Battery Housing
Shunt Interlock
Dialyzer Connector
Dialysate Sample Port
Filter
Flow Indicator
Dialyzer Return Line
Dialyzer Supply Line

FEATURE	2008T	2008K^2	2008K	2008K@Home
Touchscreen	X		X	X
Keyboard	X			
Touchpad	X			
CDX capability	X			
On-Line Clearance	X	X	X	
Dialysate on/off key		X	X	
Bypass led		X	X	
WI-FI	X			
Ethernet port	X			
USB ports	X			
RS232 port	X	X	X	X

HYDRAULIC BLOCK DIAGRAM



II. HYDRAULIC ASSEMBLY: PRIMARY SIDE

Main function of Primary side: to make _____

a. Inlet Water Regulator #61:

Manually calibrated to approximately ____when incoming water valve #41 is closed.

_____

b. Heat Exchanger #77:

The heated 'spent' fluid, on it way to the drain passes through the exchanger and warms the plate which _____as it is passing though.

_____

c. Valve #41(27) (incoming water valve):

Opens when the float bob (#5, in hydrochamber C) _____; Closes when the float bob _____.

d. Solenoid valve characteristics:

1. Controlled by the _____
2. Valves are normally _____
3. Energized with ___ volts DC, valve opens
4. Approximately __ Ohms.

e. Hydro block/Hydrochamber (five chambers, A, B, C, D, E):

_____

_____

_____

f. Heater Element #54:

1300 Watt, _____element with an internal **resistance** of approximately **_____ohms**. Voltage is switched to the heater by **a triac** (located in the power supply).

g. NTC #2 (Heater Control Sensor):

Measures temperature and **_____**#54 via the triac

_____

h. Float Switch #5:

controls the **water level in the _____.**

_____

i. Deaeration #20:

A strong gear-type pump magnetically coupled to a DC motor controlled by the _____ board.

_____

_____

j. Restrictor Orifice #48:

Restricts _____ to the deaeration pump #20 in Dialysis Program.

_____

_____

k. Loading Pressure Valve #65:

Located at the bottom side of chamber A this valve is manually calibrated to open when the deaeration pump's #20 output pressure reaches **approximately _____psi.**

l. Concentrate (acid) Pump #16 and Bicarbonate Pump #17

These are piston-diaphragm pumps that must draw and _____ to accurately _____profiles

_____

_____

m. Acid Filter #71 and Bicarbonate Filter #72

Located inside the _____. They prevent dirt from being drawn into the pump that may damage internal soft parts

n. Mixing Chambers #82

The _____and _____ concentrates are injected into the loading pressure _____stream, post hydroblock/hydrochamber and then stirred by the **mixing** chambers. This is the final step of _____before the Balancing Chambers

o. #11 Reed Switch Concentrate Wand and # 12 Reed Switch Bicarbonate Wand

Hall effect (reed) switch located at the_____and_____ rinse port

_____

III. HYDRAULIC ASSEMBLY SECONDARY SIDE

Main function of the Secondary side: to deliver _____

a. Balancing Chamber #68:

The balancing chambers consist of two cylindrical **30 ml** (approximately) chambers. Each chamber contains a non-permeable, _____that provides complete isolation between _____***('F', pre-dialyzer) and*** _____***('S' post-dialyzer) fluid***

_____

_____

Valve Cycle 1: Valves # ___, ___, ___, ___ open; Valves # ___, ___, ___, ___ closed.

Valve Cycle 2: Valves # ___, ___, ___, ___ closed ; Valves # ___, ___, ___, ___ open .

Balancing Chamber Valve Dead Time: _____

b. CFS Pressure Transducer #10:

Strain gauge transducer notifies the Actuator board that it is time to switch the Balancing Chamber valves into the _____. _____

_____

c. Conductivity Cell #7 (pre-dialyzer):

The _____of the fluid flowing through the cell affects the AC resistance path between the probes which in turn varies AC frequency. Frequency is converted to _____**(mS/cm)** which is displayed digitally to the front panel.

_____

d. NTC #3 (Temperature Monitor Sensor, pre-dialyzer):

Changes in temperature (i.e. changes in voltage) are converted to standard temperature units **(degrees Celsius)** and then displayed digitally to the front panel. NTC#3 values are also _____readings from Conductivity Cell #7.

e. Heater Runaway Protection:

In the event of a heater control runaway when temperature increases to _____(way beyond the target value) the _____ (located in the power supply) switches off.

f. Diasafe® PLUS filter Test Valve #28:

is used to _____the Diasafe® PLUS filter by allowing air into Diasafe® PLUS filter through filter #92.

g. Diasafe Filter #90:

Removes _____**and**_____material prior to entering the dialyzer

h. Valve #24 (Dialyzer valve) and Valve #26 (Bypass valve):

Valve# _____open if _____**and**_____readings are within limits

Valve# _____open if _____or _____reading are NOT within limits

i. External Flow Indicator #75 and External Filter #73:

When the machine is _____ (i.e. valve #24 open, #26 closed), dialysate enters the dialyzer which causes the 'bob' to rise and fall.

j. Shunt Door Interlock Switches:

If the shunt door is open **'**_____**'** (i.e. valve #24 closes, #26 opens) and also valve #25 closes

k. External Filter #73:

_____from re-entering the hydraulics via the dialyzer

l. Valve #25:

Solenoid valve that remains open unless the machine is performing

_____**(**PHT) or the **_____**

_____

m. Dialysate Pressure Transducer #9:

This strain gauge transducer senses pressure in the **_____.**
TMP=_____-_____

_____

_____

n. Blood Leak Detector #8:

Optically monitors for _____ that may leak through the dialyzer membrane.

_____

o. Post-Dialyzer Temperature Monitor NTC #44:

This monitors temperature post dialyzer. Its only purpose is to **_____**readings from Conductivity Cell #13.

_____

_____

_____

p. Post-Dialyzer Conductivity Cell #13:

Used by the machine's **_____** function,

_____

_____

_____

q. Level sensor #6:

The **"_____"** is a hydraulic function that removes air from the spent dialysate before it enters the balancing chamber

_____

_____

_____

r. Air Removal Chamber #69:

Captures and _____in the fluid prior to entering the Balancing Chambers

_____

s. Valve #43:

Solenoid valve that opens during **'**_____' and at various times in the Cleaning Programs to disinfect/rinse it flow path.

_____

_____

_____

t. Flow Pump #21:

is a _____that is magnetically coupled to a DC motor controlled by the Actuator-Test board that precisely controls _____through the dialyzer

_____

_____

_____

u. CFS Pressure Transducer #10:

_____

v. #78 Flow Pump Relief Valve:

This valve prevents the flow pump from creating _____. It is mechanically **adjusted to _____ PSI or _____ PSI** (depending upon if the machine is Diasafe® PLUS Filter equipped).

_____

_____

w. Valve #30 (drain valve):

The **drain** valve allows spent dialysate to enter **_____.**

_____

_____

x. Pre-UF Pump Filter #74:

_____

_____

y. Ultrafiltration (UF) Pump #22: The pump is mechanically calibrated to deliver _____/stroke. It is responsible for _____ (weight) from the patient

_____

_____

z. UF Pump Check valve #63 and #64:

The purpose of check valve #____is to isolate the UF Pump from the sample port.

The purpose of check valve #____is to prevent back flow from the sample port

_____

aa. Valve #39: Opens only in the _____. When open restrictor orifice #48 is bypassed and allows deaeration pump #20 to draw fluid directly out of chamber C. The result is a drastic decrease in deaeration pressure (drops to between 0 and -15 inHg). _____

_____

_____

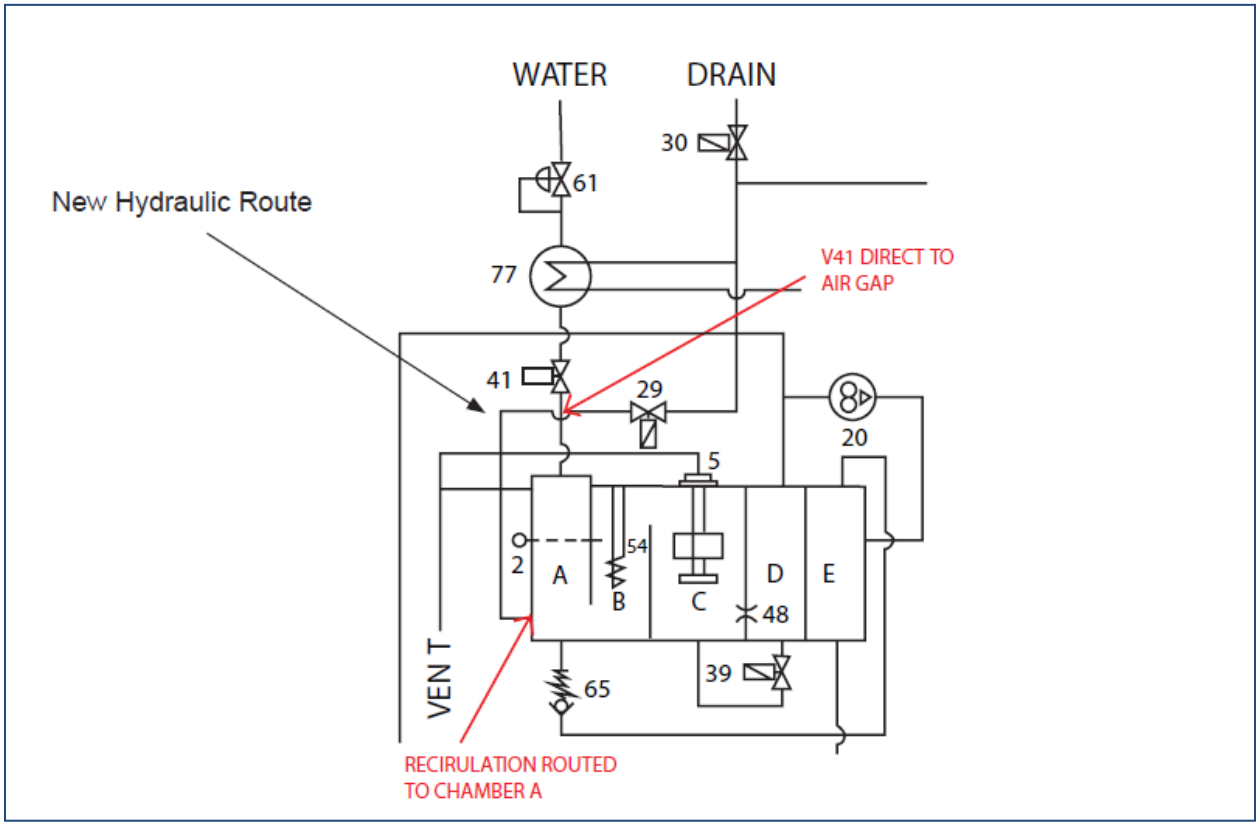
a.

bb. Valve #29 (recirculation valve):

Allows fluid to the drain to be **_____**; used in heat disinfect to heat up faster and to conserve energy

_____

_____


WATER
DRAIN
30
61
New Hydraulic Route
77
V41 DIRECT TO
AIR GAP
41
29
20
5
2
A
54
B
C
D
48
E
39
65
VEN T
RECIRULATION ROUTED
TO CHAMBER A

a. Start Up Screen

_____

_____

_____

b. Dialysis Screen

_____

_____

_____

c. The Control Panel

_____

_____

_____

d. Treatment Display Section

_____

_____

_____

e. Pressure and Alarm Test

_____

_____

_____

f. Online Clearance

_____

_____

_____

g. Concentrate Select Menu

_____

_____

_____

h. UF Profile Menu

_____

_____

_____

i. Blood Pump Module

_____

_____

_____

j. Level Detector Module

_____

_____

_____

IV. Electronic Circuit Board Review

***Warning! E*lectro *S*tatic *D*ischarge PRECAUTIONS REQUIRED**

a. Power Supply

i. Incoming power is stepped down to 24 Volts DC

ii. Heater Triac

iii. Power Cord

1. Connects machine to 120V AC power source
2. Provides 120V AC to Heater connections in distribution board

iv. Power Control Board

1. 12 Volt Standby
2. Heater Relay
3. 24 Volt Relay
4. Mains Fuses (6.3 Amp)

b. Power Logic Board

i. Machine Power On Signal From Power Button
ii. Modified versions (now with -12V inverter incorporated)
iii. Auto Off option
iv. 9 Volt Battery Test
v. DC to DC Converters (+5 & +12 Volt DC “regulators”)
vi. Heater Control signals
vii. Alarm Tones Generated

c. Actuator & Actuator / Test combination Board

i. Drives Pumps, Valves & Motors for Hydraulic control
ii. Has Its Own **A**nalog to **D**igital **C**onverter (ADC)
iii. **ADC** for communication with Functional board
iv. Own software
    1. Utilizes Flash Memory
    2. Software version not compatible between machine models.
v. Secondary Monitor for Hardware Alarm Limits
vi. Actuator / Test Combo board ***TEST*** circuit
    1. Used during POST (Power On Self Test)
    2. Runs Alarms Test

d. Functional Board

i. Controls all machine Functions (MPU)
ii. Watchdog Circuit
iii. Calibration EEPROM
iv. LCD Drivers
v. Software Upgrades are performed using a PAL2 device.
vi. All Options are set in Service Mode
vii. Runs Pressure Holding Tests
    1. Negative Pressure
    2. Positive Pressure

e. Test Board

NOTE will not be present if machine equipped with Actuator / Test Combo Board (see above)

i. Used during POST (Power On Self Test)

ii. Runs Alarms Test

iii. EPROM software

f. Sensor Board

i. Primary Monitor Board

ii. Has Primary **A**nalog to **D**igital **C**onverter for communication with the Functional Board

g. UI / MICS / CDX board -**T machine ONLY!**

i. UI = User Interface / MICS = Medical Information Computer System / CDX = Clinical Data Exchange

ii. Transfers screen data from the functional board and up-scales it to the 15 inch LCD display.

iii. UI portion provides interface between user input and electronic control (Functional board)

iv. MICS & CDX portion incorporates vendor software installed on the internal flash drive to manage medical information collected or entered during treatment

h. Motherboard

NOTE Motherboards manufactured post September 2007 have additional pin connections (3rd row pins connected @ Act. /Test combo board).

i. Connections for and communication between circuit boards in card cage.

ii. Remote connections for Modules.

iii. Main 24 Volt Power cable connection.

1. Must be plugged in completely!

i. 12 Volts Inverter

NOTE: This board may be incorporated into the Power Logic board (see above)

i. Used by Colin Module

1. NIBP

ii. Used by 2008K machines with OLC

j. Display assembly 2008T

i. LCD graphic display

ii. Touch Screen

iii. Keyboard

iv. Keypad

v. Touch pad

vi. Status Light

k. Display assembly 2008K

i. LCD Display

ii. Display interface board

iii. Front Panel Switch Matrix

iv. Touch Screen

l. Display assembly 2008K^2

i. LCD Display

ii. Display interface board

iii. Front Panel Assembly with additional switch matrix buttons

1. + / − Keys

2. Directional arrow keys around 'CONFIRM' button

CLASS EXERCISES AND LABS

Formulas and examples:

1. $TMP = P_{VEN} - P_{DIAL}$
2. UFR (ml/Hr) = [*Pre-Weight – Dry Weight] ÷ Dialysis Time
3. KUF = ml/Hr/TMP (mmHg)
4. KUF = UFR/TMP = UFR ÷ TMP
5. UFR = KUF × TMP
6. TMP = UFR/KUF = UFR ÷ KUF
7. 1 Kg = 1 Liter = 1000 ml = 2.2 lbs.

EXAMPLE 1.0

A male patient comes in for dialysis weighing 57 Kg. His dry weight is 53 Kg. He receives no saline and will dialyze for 4 hours on a dialyzer that has a KUF of 5 ml/Hr/mmHg. His P_{VEN} is 160 mmHg. Determine:

1) What is his pre-dialysis weight in pounds?
2) How much weight in Kg must be removed during the treatment?
3) What UFR is required to accomplish this?
4) What will the TMP be?
5) What will the dialysate pressure be (P_{DIAL})?

ANSWERS:

1) 57 Kg × 2.2 lbs./1 Kg = 125.4 lbs.
2) PW - DW = (57 - 53) Kg = 4 Kg
3) UFR = PW - DW ÷ DT = (57 - 53)Kg ÷ 4 Hr = 1 Kg/Hr = 1000 ml/Hr
4) TMP = UFR ÷ KUF = 1000 ÷ 5 = 200 mmHg
5) Rearranging Equation 2.0, $P_{DIAL} = P_{VEN} - TMP$ **Equation 2.6**

   $P_{DIAL} = P_{VEN} - TMP = 160 - 200 =$ - 40 mmHg

EXAMPLE 1.1

If the dialyzer, from example 1.0, was changed to one that has a KUF of 50 calculate the: 1) TMP; 2) Dialysate Pressure

ANSWERS:

1) TMP = UFR ÷ KUF = 1000 ÷ 50 = 20 mmHg

2) $P_{DIAL} = P_{VEN}$ - TMP = 160 - 20 = +140 mmHg

Exercise:

EXAMPLE ONLY – NOT TO BE USED IN SERVICING MACHINE

Calibration & Identification Check List

IDENTIFICATIONS:

Electronics card cage ID complete ..... *initials* _____
Main Power supply ID complete ..... *initials* _____
Inlet Water Regulator #61 ..... *initials* _____
#77 Heat Exchanger ..... *initials* _____
Solenoid Valve #41 / ..... *initials* _____
Solenoid Valve #29 ..... *initials* _____
Chamber A ..... *initials* _____
Heater & NTC#2 ..... *initials* _____
The Float in Chamber C ..... *initials* _____
Bypass Valve for Deaeration ..... *initials* _____
Concentrate Pumps ..... *initials* _____
Filters for Acid & Bicarb intake ..... *initials* _____
Acid & Bicarb Rinse Ports & Reed Switches ..... *initials* _____
Mixing Chamber or Chambers ..... *initials* _____
Balancing Chamber Assembly ..... *initials* _____
Conductivity Cell#7 & NTC#3 ..... *initials* _____
Diasafe Filter & Diasafe Test Valve ..... *initials* _____
Solenoid Valve #24 ..... *initials* _____
Solenoid Valve #26 ..... initials _____
External Flow Indicator ..... *initials* _____
Shunt Door and Switches ..... *initials* _____
External Line Filter ..... *initials* _____
Valve 25 ..... *initials* _____
Dialysate Pressure Transducer ..... *initials* _____
Blood Leak Detector ..... *initials* _____
Post Conductivity#13 and NTC#44 ..... *initials* _____
Air Separation Chamber ..... *initials* _____
Flow Pump ..... *initials* _____
Chamber Full Switch (CFS) ..... *initials* _____
Flow Relief Valve ..... *initials* _____
Drain Valve ..... *initials* _____
Pre – UF Filter ..... *initials* _____
UF Pump ..... *initials* _____
Check Valves ..... *initials* _____

EXAMPLE ONLY – NOT TO BE USED IN SERVICING MACHINE

Calibration & Identification Check List (Student's Copy) Cont....

Hydraulic calibrations

1. Inlet Water Regulator - Inlet water pressure 18 - 20psi (**dialysis mode**) **Calibration complete**
   Enter reading from pressure gauge _____ *initials* _____
2. Deaeration & Loading pressure
   a. Deaeration ***at sea level *** –24inHg
      Enter reading from pressure gauge _____ *initials* _____
   b. Loading Pressure 23-25psi
      18-20psi without Diasafe
      Enter reading from pressure gauge _____ *initials* _____
3. Flow Pump Relief Pressure 35 – 36 psi
   29-30psi without Diasafe
   Enter reading from pressure gauge _____ *initials* _____
4. Balance Chamber volume
   Enter volume measured _____ *initials* _____
5. Acid pump volume
   Enter volumes measured 1) _____ 2) _____ *initials* _____
6. Bicarbonate pump volume
   Enter volumes measured 1) _____ 2) _____ *initials* _____
7. UF Pump volume 1cc/stroke
   Enter volume measured _____ *initials* _____

Sensor Calibrations

1. Arterial Pressure Calibration *initials* _____
2. Venous Pressure Calibration *initials* _____
3. Dialysate Pressure Calibration *initials* _____
4. Temperature Sensor Calibration *initials* _____
5. Post Temperature Sensor Calibration (if applicable) *initials* _____
6. Temperature Control Calibration *initials* _____
7. Blood Leak Calibration *initials* _____
8. Conductivity Cell(s) Calibration *initials* _____

Monitor Calibrations

1. Set Clock (service mode or dialysis under B.P. screen) *initials* _____
2. Voltage Detection *voltage reading* _____ *initials* _____
3. Arterial Pump Rate *initials* _____

CALIBRATION DONE IN DIALYSIS MODE!

Level Detector Calibration (channel 1 and channel 2) (**dialysis mode**) *initials* _____