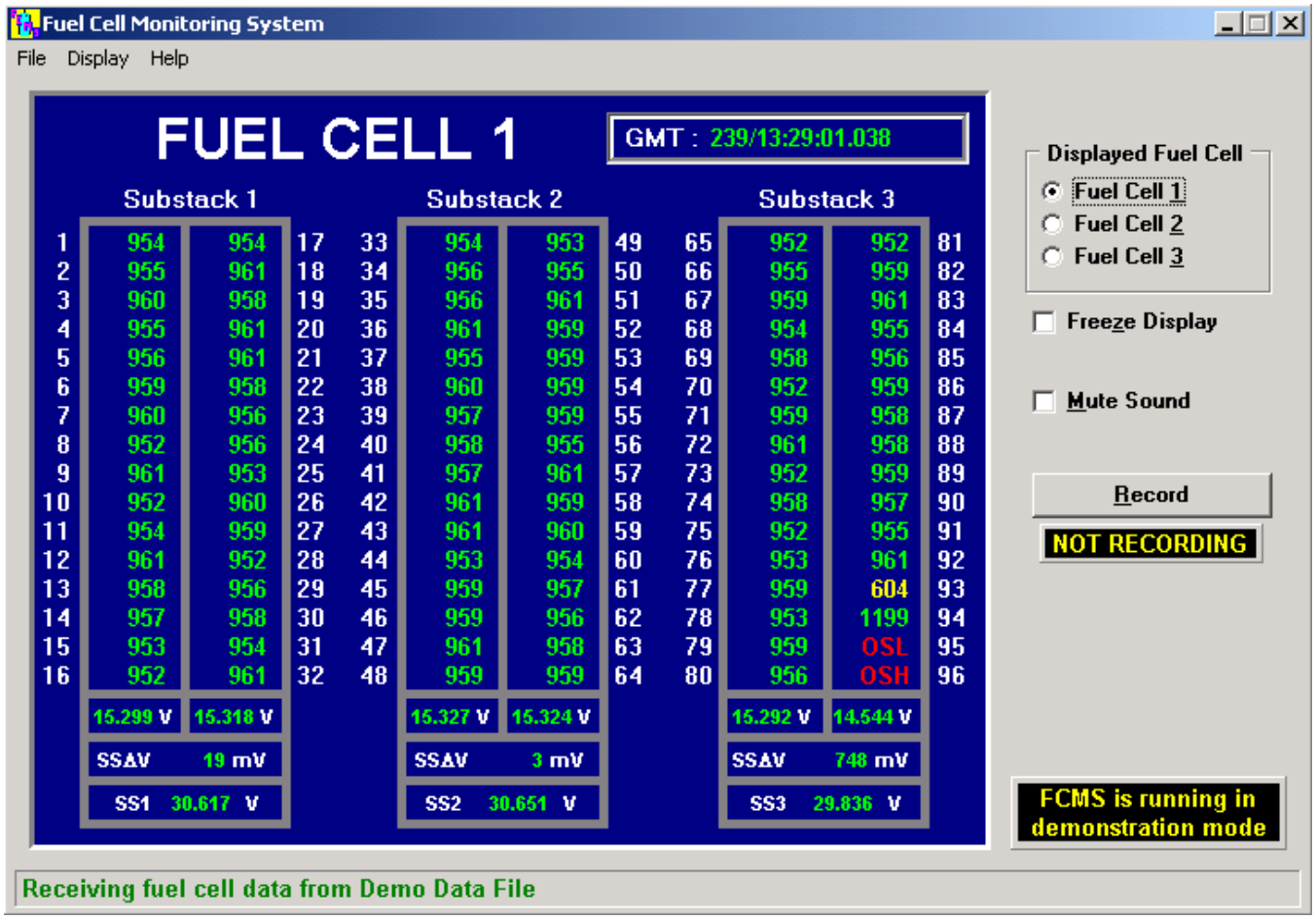
1.0 FUEL CELL MONITORING SYSTEM (version 2.00, 9/2002)

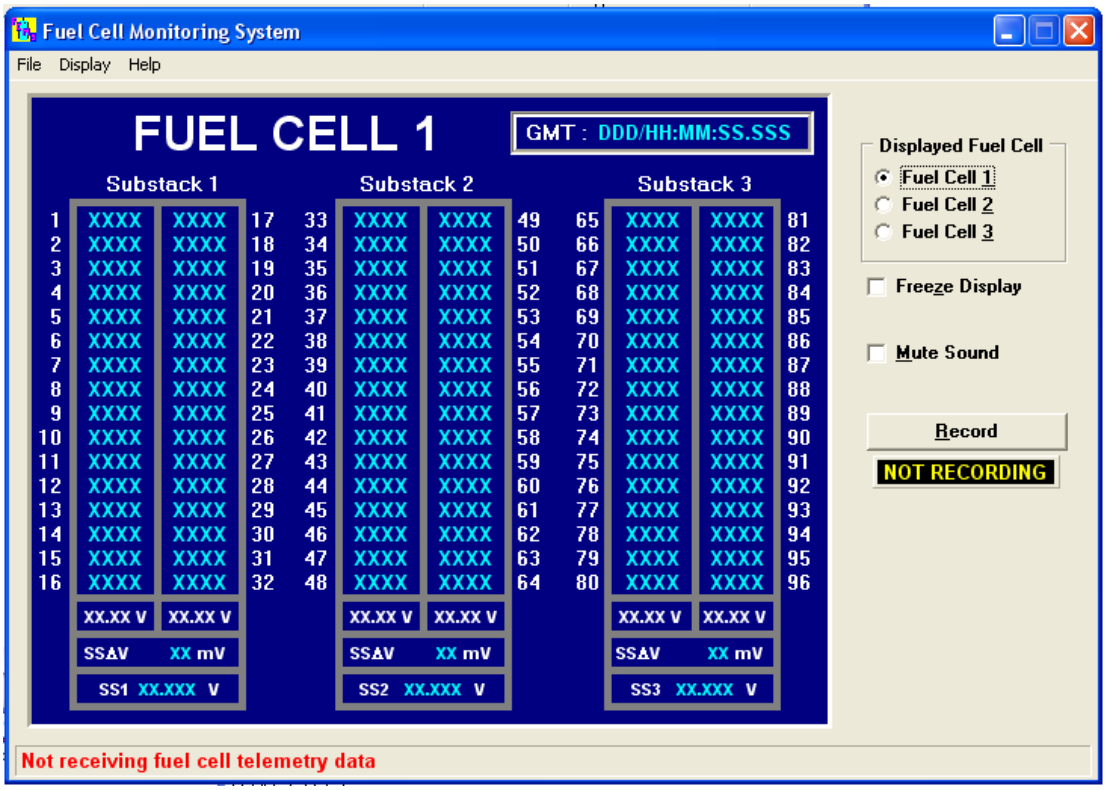
1.1 *FCMS Display and Operation*

Once data is being received, FCMS will be opened and the user will see all three substacks for fuel cell 1, as seen below. Each cell is individually numbered. Cells 1 through 16 are added together and compared to cells 17-32 to compute a substack delta-V. This number should be ballpark close to the value seen on the orbiter CRT but will probably not exactly match due to different software algorithms.

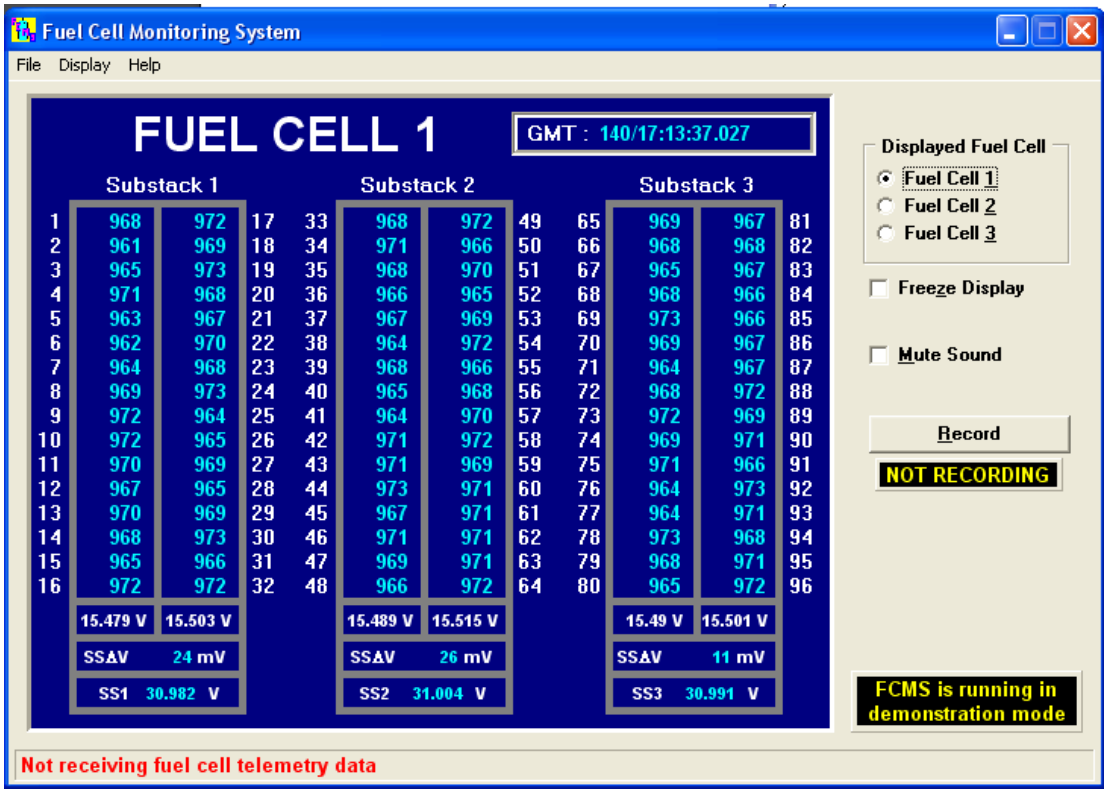


In the lower right corner is a note about the the data being recorded. For the SYS PGSC class, it reads "FCMS is running in demonstration mode". If it's not set to run in Demo mode, it will not be present, meaning it's recording real data.

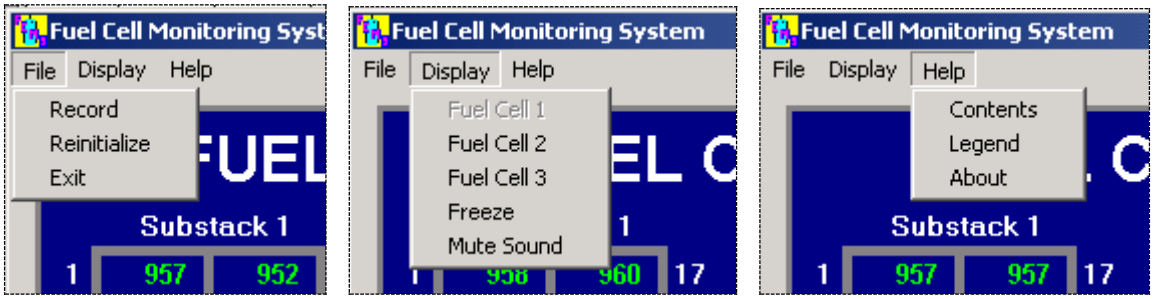
If FCMS is started and data is not available, all the data will be "XXX" in cyan (the color that signifies missing data).



If data becomes unavailable while running, the data on the screen turns cyan and displays the last known value.



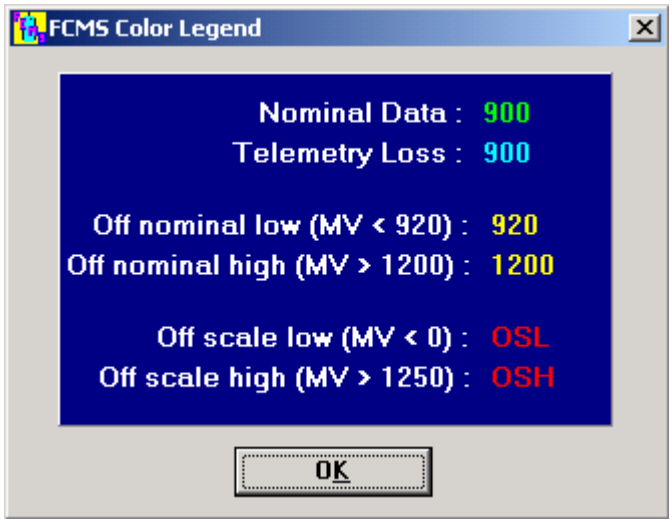
The program is designed to be used via the keyboard only or using the mouse. All of the radio buttons and check boxes on the right side are duplicated via a pull-down menu selection.



Initialization parameters are read from the **`fcms.ini`** file. Initialization settings include display, color and sound settings, data recording and storage, telemetry, error limits, debugging/logging, and the setting for the demonstration mode. A log file can be generated by the FCMS application containing information on activation time, configuration information, user actions, and shut down time. Typically, however, this is not used unless troubleshooting a problem. If the **`fcms.ini`** file is changed, it can be reloaded via the File | Reinitialize menu.

The FC1, FC2, and FC3 radio buttons on the right will change the display to show fuel cell 1, 2, or 3. If data is being recorded, this will not affect the recording since it only changes the display to the screen. The picture above shows Fuel Cell 1 data being displayed. Similarly, the Freeze and Record buttons only affect the data that is being displayed on the screen, they have nothing to do with any data that is being recorded. The Mute Sound option allows the user to suppress the synthesized voice audio. When the Freeze or Mute option is selected, the screen clearly labels what has been done.

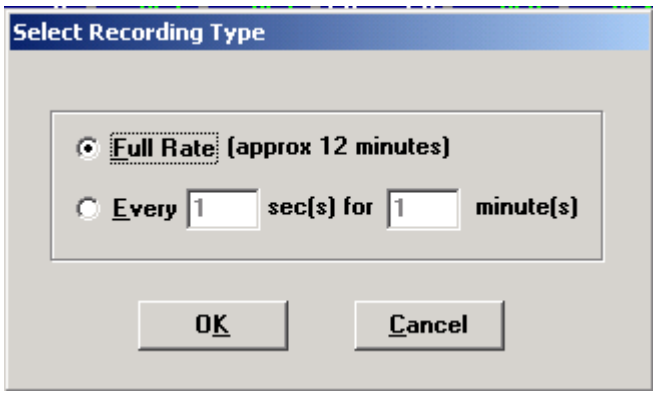
Data that is out of limits will be flagged by the program by color change. Anything out of limits (less than 920, greater than 1200) will turn yellow, while anything off-scale high or low will be red. This legend can be called up by the Help | Legend pulldown menu, and the limits and colors can be set in the **`fcms.ini`** file.



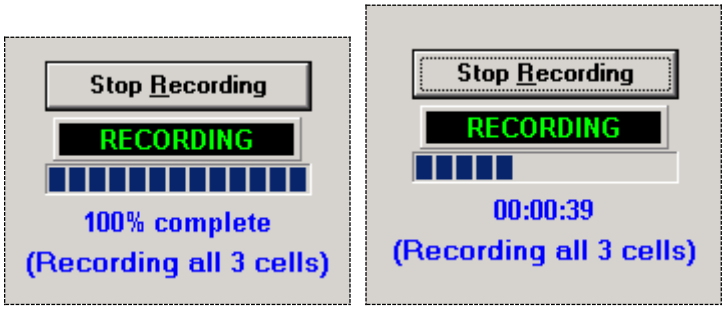
Note that the crew is never instructed by the procedures to look at all three fuel cells as displayed on the screen, and they frequently do not look at fuel cells 2 or 3, so fuel cells other than FC1 with bad telemetry may not be seen until the data is downlinked and processed.

1.2 *Recording data*

Pressing the "Record" button (or selecting the File | Record menu) calls up the "Recording Type" window. FCMS has two recording modes: Full rate or Interval. Full Rate records a sample every 0.96 seconds and records until the maximum file size is achieved. In Interval mode, FCMS records samples at specified intervals for a certain amount of time, as called out by MCC and as selected by the crew. A flag in the `fcms.ini` initialization file limits the maximum file size to 1.44 MB. Originally, the file was transferred via the wired or wireless network to a second PGSC for downlink, but in case there was a problem with the network, the file needed to be able to fit onto a single floppy disk for transfer to the second PGSC. This functionality is not used any more (the file remains on the WinDecom PGSC and is retrieved by MCC from there) but the file size limitation was never changed, as that file size is still adequate for EGIL's purposes.



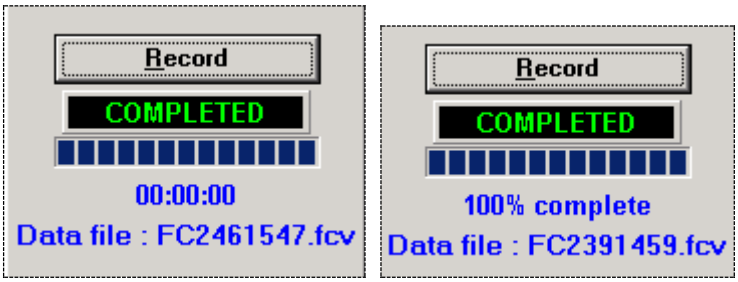
When recording starts, the yellow "NOT RECORDING" label on the main display changes to "RECORDING". The display will also show how big the recorded file is compared to the maximum file size (default is 1.44 MB), expressed as a percent complete (below left). The display that tells the user that the program is recording all three fuel cells, to avoid confusion as to what is being recorded. (One early crew thought they were only recording the data for the fuel cell that was on the screen, so they ran FCMS three times). If the Interval option is selected, the display shows a count-down timer and a completion bar (below right).



FCMS will automatically stop recording when the maximum file size is reached - at the full data rate recording option, this will be about 12 minutes - or the timer runs out. When recording has stopped (either automatically or manually via the "Stop Record" button or pull-down menu), a window pops up with the file name and path of the data on the WinDecom PGSC. The crew then notifies MCC that the data take is complete so that MCC can downlink the data file.

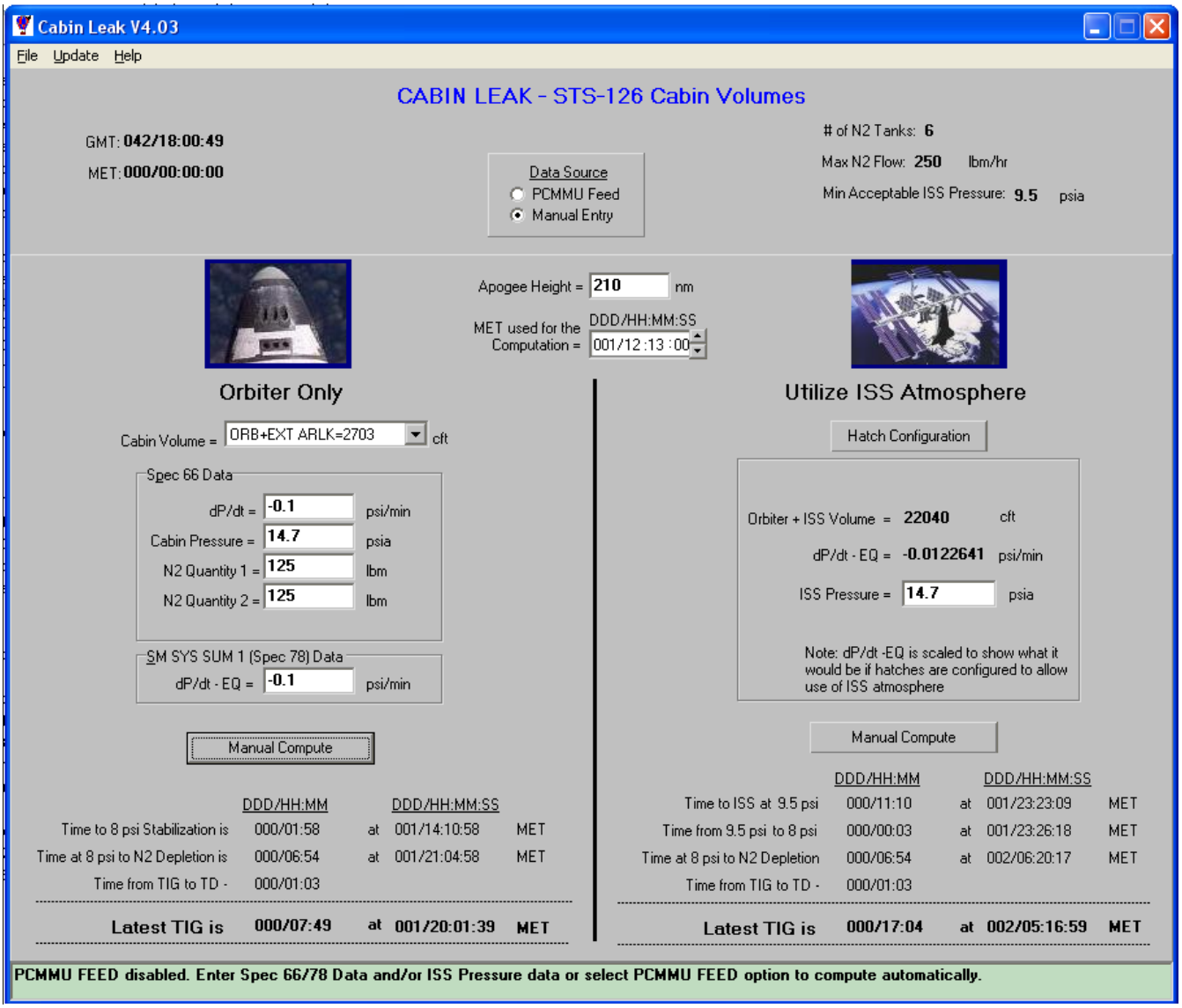
The popup window gives the file name for that data session. The raw data filename is of the form **`fcdddhhmm.fcv`**, where FC stands for "fuel cell"; DDD is the GMT day, HH is the hour, and MM is the minute of the first data point; and "FCV" is the file type "fuel cell volts." Because it is completely ASCII text, there is a lot of "dead space" in the file that can be compressed within the file, on the order of 90-95%. The FCMS program automatically creates a compressed file (a "zip" file) along with the text file, the only difference being the file extension (.zip instead of .fcv).

When the recording is complete, the "RECORDING" label changes to "COMPLETED" and the raw data file name shows up below that.



2.0 CABIN LEAK (version 4.03, 7/2007)

2.1 *Overview*



The Cabin Leak application is used primarily to compute the time remaining before the orbiter should perform a deorbit burn to safely reach an Earth landing site. The latest deorbit burn time, or latest Time to Ignition (TIG), is the MET in which enough O2 and N2 exist to sustain survivable orbiter cabin environment until landing.

Cabin Leak is an electronic version of the cabin leak nomographs found in the Orbit Pocket Checklist. The application, reconfigurable for all on-orbit operations, provides the times of 8 psi Stabilization, N2 Depletion, and Latest TIG in both elapsed time from when at which the solution was computed to the event (i.e., Latest TIG, N2 Depletion, etc.) and MET. Cabin Leak is preferred over the nomographs as it provides more precise information without having to interpolate as on the nomographs and is in fact called out in the Flight Data File as the preferred method.

Cabin Leak has both an automatic mode and a manual mode.

- The default mode is Automatic: PCMMU data is received via the Telemetry Server and calculation occurs every 10 seconds or at the user-specified rate.
- Manual Mode is entered by selecting the “Manual Entry” radio button. In Manual Mode, parameters such as dP/dt and cabin pressure can be entered manually and the Manual Compute button is enabled to calculate the times.

The Time/Vector Server supplies current MET and GMT to Cabin Leak and the Update functions for the MET and State Vector. The present Cabin Volume configuration is selected from a treeview Control (a drop down list) specified by the flight specific INI file. Manual and Auto operations will be discussed in following sections.

The Cabin Leak program is located in the **<c:\spocapps\cabinleak>** directory or can be accessed from the Shuttle Apps window.

Across the top of the display are three menus: File, Update, and Help.

2.1.1 *File*

The File menu has three options: Reset, Settings, and Exit.

- Reset: Resets the Cabin Leak application. Use this if Cabin Leak doesn’t attach to the Time-Vector Server or Telemetry Server correctly when first started. If the MET Server or Telemetry Server has not been installed on this computer, Reset will be ineffective. Cabin Leak can still be used in Manual Mode without automatic Telemetry data.
- Settings: Allows the user to change the default update time from every 10 seconds to another value.
- Exit: Closes the Cabin Leak application.

2.1.2 *Update*

The Update menu has two options: State Vector & Times, and Update Parameters. In general, the Systems Instructor will not have to use any of these.

- State-Vector & Times: Brings up the Update Orbiter State Vector and Update Time Values windows of the Time-Vector Server (MET Server). Cabin Leak is paused until the Update Orbiter State Vector window is closed.
- Update Parameters: Allows the user to change the default values for number of N2 tanks (default = 6, but set flight-specific), maximum N2 flow in lb/hr (default = 250), and minimum acceptable ISS pressure (default = 9.5 psi).

2.1.3 *Help*

The Help menu has two options: Contents and About.

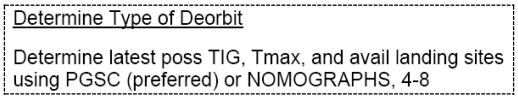
- Contents calls up the “help file” for the cabin leak program.
- About calls up information on the program version number and programmers (as seen at the top of this section).

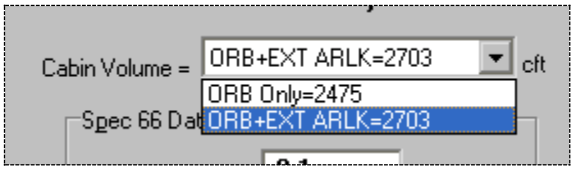
2.2 *Inputs*

The cabin leak program has a number of fields that will be filled in either manually or automatically if telemetry is available, as well as fields that are set prelaunch as part of the initialization file (**cableak.ini**).

2.2.1 *Pre-initialized data*

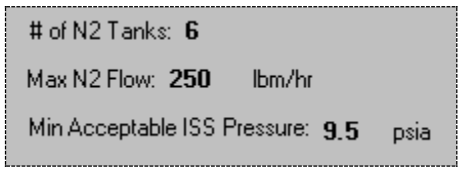
According to the FDF Cabin Leak procedure, the crew is instructed to close all hatches (including airlock) to try to isolate the leak. If the leak is in the crew compartment, the crew opens the airlock hatch to use that volume, and only then are they instructed to use the cabin leak program (as seen below). When they do call up the program, the cabin volume is defaulted to be orbiter plus airlock (2,703 ft^3), to match the orbiter hardware config and the nomograph. The crew can change that value by using the pull-down menu to select orbiter only volume (2,475 ft^3), if needed.



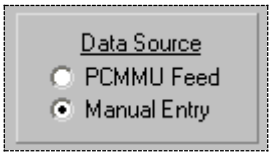


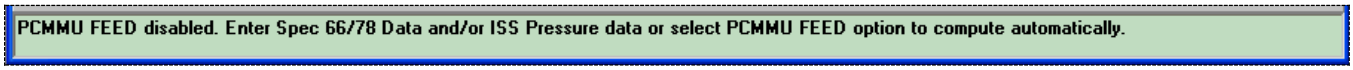
The input fields for the number of N2 tanks, the maximum N2 flow, and the minimum acceptable pressure for the additional volume are all set in the Update | Update Parameters pull-down menu and are generally not changed during the execution of the program (though the values can be updated if needed).

- Number of N2 Tanks: the flight-specific number of N2 tanks flown on the shuttle flight. Valid values are 4, 5, 6, 7, or 8. This has an effect on the amount of N2 that is unusable due to being trapped in the tanks. Default is 6, but this will be set flight-specific.
- Max N2 Flow: Input field for the maximum N2 flow (typically set to 250 lbm/hr).
- Minimum Acceptable Additional Volume Pressure: If the orbiter has a leak while docked to ISS, the volume of air in the ISS segments may be used to extend the time to latest TIG. The nominal value to leave the ISS components is 9.5 psi.

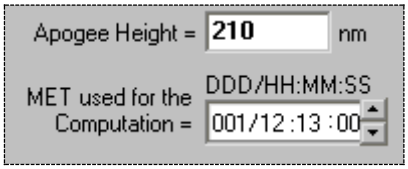


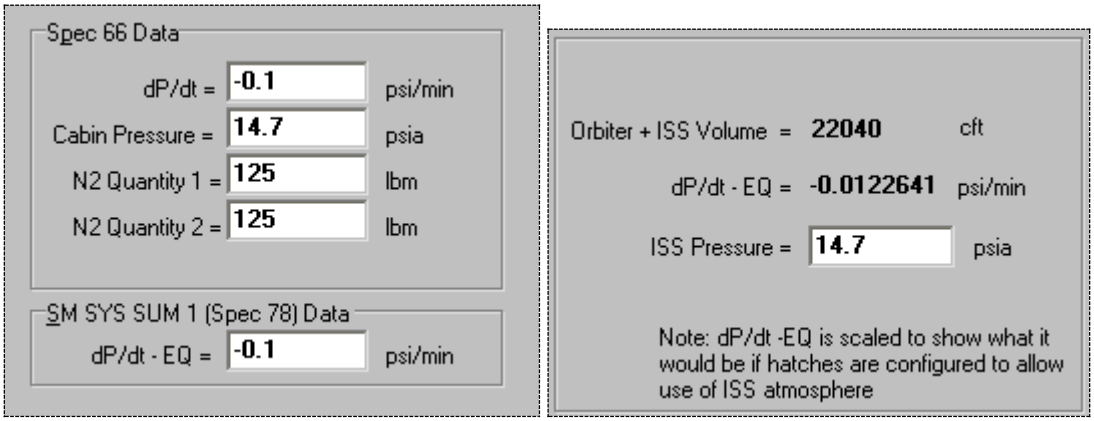
2.2.2 *Telemetry input data*





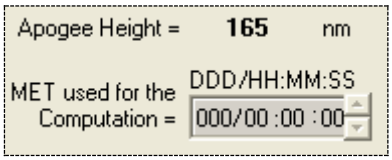
The telemetry data displayed on the screen can be found by the crew on various CRT MDU displays. The status box at the bottom displays whether telemetry is available or not; if for some reason telemetry is not available to the PGSC (for example, some sort of PCMMU failure) then the user may select the Manual Entry radio button in the Data Source section. When PCMMU Feed is selected, the telemetry data elsewhere on the display is grayed out and the user may not change anything, but when Manual Entry is selected the fields turn white and may be manually entered.

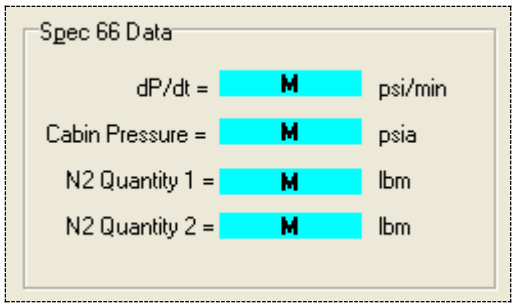


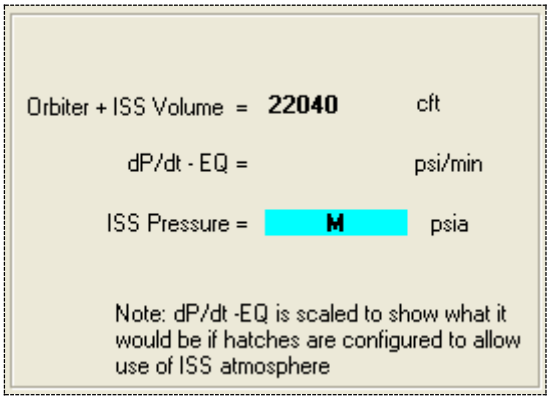


- Apogee Height: This information is displayed on the crew's GNC MNVR OPS 2 MM202 and OPS 3 MM301, 302, and 303 displays. Although there is a 400 nm default limit, a higher value can be set within the INI file. This field is used in calculating the time from TIG to Touchdown, and will typically be in the neighborhood of 1:05 hr for ISS altitudes. For the paper nomographs in the checklist, this value is assumed to be one hour.
- MET for Computation: The standard format is ddd/hh:mm:ss. The number of hours cannot exceed 23, minutes cannot exceed 59 and seconds cannot exceed 59.
- dP/dt: If dP/dt is positive or less than -0.0001 psi/min a cabin leak is not occurring.
- Cabin Pressure: A valid Cabin Pressure cannot exceed 20 psia.
- N2 Quantity 1 & 2: The maximum value should not exceed 800 for the combined quantities of both N2 tanks.
- dP/dT-EQ: If this is positive or less than -0.0001 psi/min a cabin leak is not occurring. This is just the dP/dt normalized to a 14.7 psi cabin pressure.
- Orbiter + ISS Volume: not telemetry, and will be covered in the next section.
- dP/dt-EQ (ISS): This value is the dP/dt-EQ from the shuttle, scaled to show what it would be (hypothetically) if the hatches to the ISS were open, and is inversely proportional to the total volume (e.g., if the stack volume is 10x greater than the orbiter volume, then the dP/dt will be 10x smaller when the hatches are all open). Recall that when this Cabin Leak program is executed, the hatch from the shuttle to ISS is closed. This value will be used later in determining whether or not the ISS volume may be used to extend the orbiter's time on orbit. This function will be covered later.
- ISS Pressure: this is the pressure in the US Lab module on ISS.

If the PCMMU Feed radio button is selected, meaning the user wants telemetry to populate the fields on the display, but that the telemetry is not available, the white fields are filled in cyan with an "M" to indicate missing data. Manual Entry must be used in this case. The Height of Apogee reverts to a default value of 165 nm and MET reverts to liftoff.

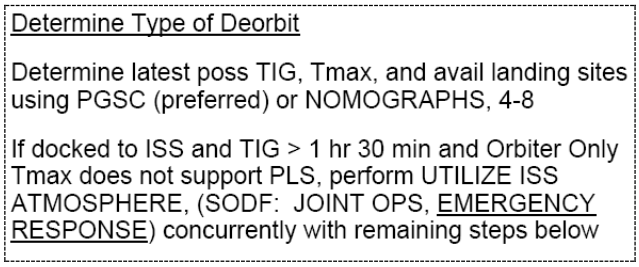






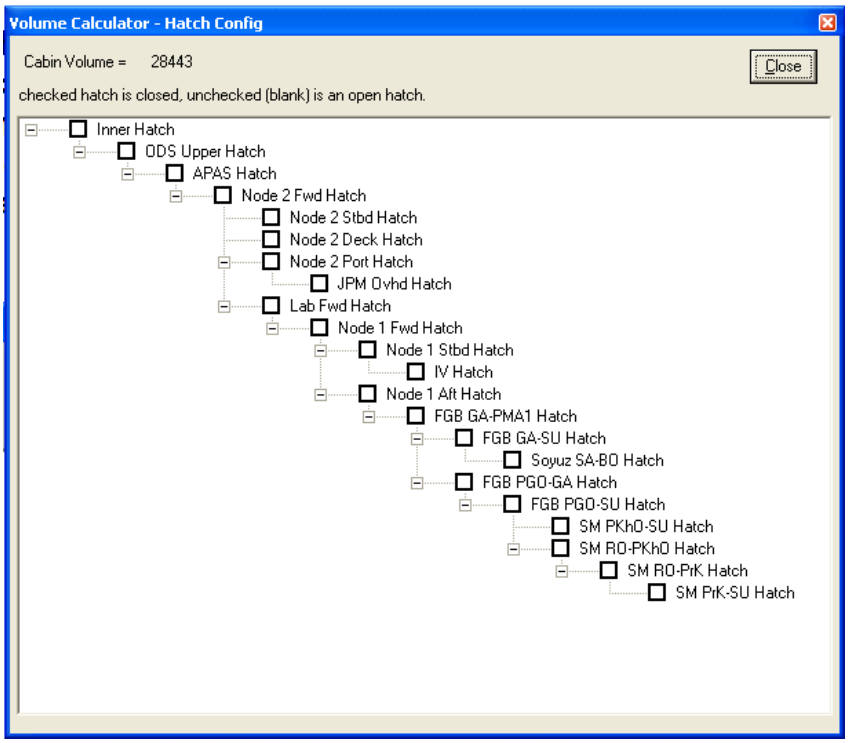
2.2.3 *ISS Volume/Hatch Configuration*

In the case where the orbiter will remained docked to the ISS in order to use their atmosphere, the user must manually set the ISS volume, as there is no telemetry to be read regarding the status of the various hatches inside the ISS. Any closed hatch seals off the volume behind it (relative to the orbiter), rendering it unusable for the shuttle. The FDF sends the crew to work the “Utilize ISS Atmosphere” steps in the procedure below, but those steps assume that the entire ISS volume is available. The right side of the Cabin Leak display covers the case where the orbiter is remaining docked to conserve air.



On the ISS side of the Cabin Leak display, the user is shown a field with the ISS volume. That value cannot be entered manually, but by using the Hatch Configuration tool, the proper volume can be set. The crew must select the hatches in this window to be closed as appropriate to match the current config.

This window has a “tree view” control of the various hatches from the orbiter middeck all the way to the back of the ISS. The “Cabin Volume” label at the top of this window will be calculated for that configuration. The check box logic matches the ISS and orbiter configuration so that when an inner hatch is closed, the hatches further out don’t matter and are grayed out - for example, when the orbiter inner hatch is closed, it no longer matters to the calculation whether the hatch into the FGB is open or closed. All hatches are always initialized as open when called up for the first time, and the program will remember the hatch status when the window is closed.



Note that it is **VITALLY IMPORTANT** to have the correct volume setting when running the program. An incorrect setting will give the crew an incorrect TIG.

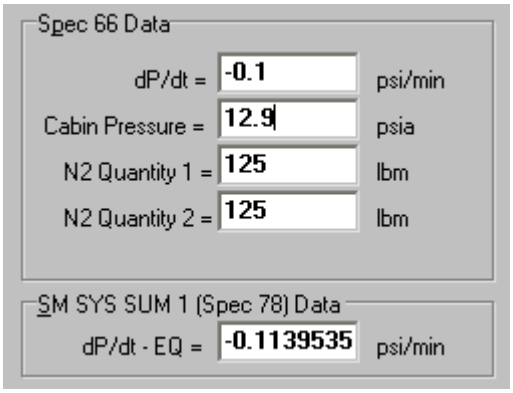
- If the volume setting in the program is bigger than the actual volume at the time the program is run, the program will display a time that is less than the crew actually has. This could result in the crew rushing or taking a deorbit opportunity that is not as good as another.
- If the volume setting is smaller than the actual volume at the time the program is run, the program will display a time that is more than the crew actually has. This could result in the crew running out of air.

2.2.4 *Equivalent dP/dt*

With Manual Entry selected, the program automatically calculates the value of Eq dP/dt, given dP/dt, using the formula for calculating Equivalent dP/dt:

$$\frac{dP}{dt}EQ = \frac{dP}{dt} \times \frac{14.7}{cabin\_P}$$

Inputting dP/dt will set the value of the Equivalent, so if the cabin pressure is less than 14.7 psi (unlike all of the previous examples), then the two dP/dt values will be different:



2.2.5 *Settings in the `cableak.ini` initialization file*

Following are some of the parameters in the **`cableak.ini`** file that control how the program operates. Only the parameters that are relevant to training will be discussed. Any line that is preceded by a semicolon is commented out and the program ignores what comes after the semicolon. The file is located at **<c:\spocapps\cabinleak\cableak.ini>**

```
[FLIGHT_DATA]
Flight=STS-XXX
```

- This controls what is seen on the top of the display

```
[DefaultValues]
;Defaults should be used for flight initialization.
MaxN2Flow=250
;Default DpDt=0 (leak rate)
DpDt=0
;Default DpDtEQ =0( Eq leak rate)
DpDtEQ=0
;Default ISSDpDtEQ =0( Eq leak rate)
ISSDpDtEQ=0
;Default Cabin Pressure=14.7
CabPress=14.7
;Default ISS Pressure=14.7
ISSPress=14.7
;Default N2 Quantity 1=128
N2Q1=128
;Default N2 Quantity 2=128
N2Q2=128
;Default Apogee Height=165
HA=165
```

- In general, these default values should not be changed in this file. The dP/dt values, N2 quantities, cabin pressure, and apogee height will be read in from telemetry if PCMMU data is available, but can be set from the main window if needed. The default values will appear if there is no telemetry.

```
[FLT_SPEC_CONSTANT]
N2Tanks=6
;If the orbiter will not be docked to the ISS, use a value
;Minimum Acceptable Additional Volume Pressure = 8,
;however If the orbiter will dock to the ISS,
;use Minimum Acceptable Additional Volume Pressure =9.5
PSI=9.5
```

- These flight-specific parameters will be determined by EECOM prior to the flight and will be in the flight PGSC load. The minimum cabin pressure for the ISS is 9.5 psi for the Russian segment.

```
[ORBITER_CONFIG]
```

```
;Inner_Hatch,228
;Single_SH,1211
;Double_SH,2422
ORB Only=2475
ORB+EXT ARLK=2703
 [HATCH_CONFIG]
;These HATCH_CONFIG parameters are used only when Use_ISS_Volume=True
CABIN_ONLY_VOLUME=2475
NUM_HATCHES=22
```

- The **CABIN_ONLY_VOLUME** is the default value for the cabin volume, used until something else is chosen from the volume calculator
- The number of hatches in this parameter should match the number of "**THATCH**" parameters below.

```
; key it links to (its parent node), name of the hatch, key (usually the name), and
; Volume of that area

; Orbiter volume including cabin_only_volume
THATCH_1=,Inner Hatch,228
;Iss volume
THATCH_2=Inner Hatch,ODS Upper Hatch,1,40
```

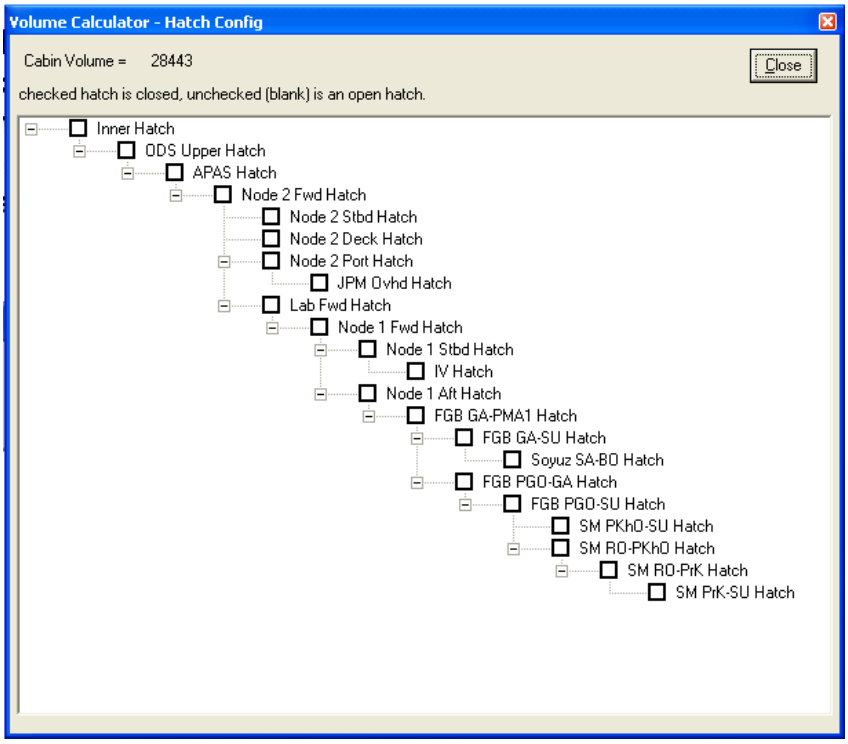
- The sequence of fields for the hatches is:
  - hatch number
  - Name of the hatch immediately upstream (towards the orbiter) of this hatch, aka "parent hatch". If there's nothing between the equals sign and the first comma, like Hatch 1, then it's at the top of the tree and closest to the orbiter and has no "parent".
  - This hatch's display name (what it shows on the volume calculator window)
  - A flag (1, 2, or 3) – see below
  - volume size

```
THATCH_3=ODS Upper Hatch,APAS Hatch,1,183
THATCH_4=APAS Hatch,Node 2 Fwd Hatch,1,2237
THATCH_5=Node 2 Fwd Hatch,Node 2 Stbd Hatch,1,2308
THATCH_6=Node 2 Stbd Hatch,Node 2 Deck Hatch,2,1637
THATCH_7=Node 2 Deck Hatch,Node 2 Port Hatch,2,4443
THATCH_8=Node 2 Port Hatch,JPM Ovhd Hatch,1,1437
THATCH_9=Node 2 Ovhd Hatch,Lab Fwd Hatch,3,3497
THATCH_10=Lab Fwd Hatch,Node 1 Fwd Hatch,1,1948
THATCH_11=Node 1 Fwd Hatch,Node 1 Stbd Hatch,1,908
THATCH_12=Node 1 Stbd Hatch,IV Hatch,1,201
THATCH_13=IV Hatch,Node 1 Aft Hatch,3,203
THATCH_14=Node 1 Aft Hatch,FGB GA-PMA1 Hatch,1,230
THATCH_15=FGB GA-PMA1 Hatch,FGB GA-SU Hatch,1,239
THATCH_16=FGB GA-SU Hatch,Soyuz SA-BO Hatch,1,133
THATCH_17=Soyuz SA-BO Hatch,FGB PGO-GA Hatch,3,1925
THATCH_18=FGB PGO-GA Hatch,FGB PGO-SU Hatch,1,262
THATCH_19=FGB PGO-SU Hatch,SM PKhO-SU Hatch,1,845
THATCH_20=SM PKhO-SU Hatch,SM RO-PKhO Hatch ,2,2719
THATCH_21=SM SM PKhO-SU Hatch,SM RO-PrK Hatch,1,124
THATCH_22=SM RO-PrK Hatch,SM PrK-SU Hatch,1,221
```

- The last of these hatches should have the same number as the **NUM_HATCHES** parameter earlier.

```
;Each hatch opens into a certain volume as opened going from the shuttle orbiter.
;Each volume for an open hatch is added to the cabin volume until a closed hatch
; (checked) is found so that the resulting volume is always correct no matter which
; hatches are closed or in what order they were closed. Hatches closer to the
; orbiter determine the volume regardless of whether outer hatches are closed or
; open.
;The CABIN_ONLY_VOLUME= parameter specifies the volume when the innermost
;hatch is closed - the smallest volume.
```

For the explanation of the flag in the hatch sequences above, it helps to refer to this hatch config schematic and to think of it as a “family tree”, with parents, children, branches, and generations. A “parent” hatch is the next one immediately above the hatch in question on this diagram, usually closer to the orbiter at the upper left. A “child” hatch is generally the next one immediately after the one in question, farther away from the orbiter. A ‘branch” represents a hatch off of the main “core”, for a volume that sticks off of the side, which may have more hatches downstream of it.



A “1” means that this hatch is the “child” of the one immediately preceeding it in the list. Thus, **`THATCH_11=Node 1 Fwd Hatch,Node 1 Stbd Hatch,1,908`** means that Hatch #11 is the Node 1 Stbd Hatch and is immediately downstream of the Node 1 Fwd Hatch, and that the next volume after the Node 1 Stbd Hatch (towards the bottom right of the display, or towards the aft of the ISS) has a volume of 908 cu ft.

`THATCH_12=Node 1 Stbd Hatch,IV Hatch,1,201` means that the IV Hatch is downstream of the Node 1 Stbd Hatch, and the volume after the IV Hatch is 201 cu ft.

Now, the next hatch, **`THATCH_13=IV Hatch,Node 1 Aft Hatch,3,203`** has a “3” flag instead of a 1. Notice on the picture that the next hatch vertically up from the Node 1 Aft Hatch is the IV Hatch, which is in a different branch. You have to go up 3 “generations” on the diagram in order to get to the previous hatch in sequence from the orbiter, as both the Node 1 Aft and Node 1 Stbd both are downstream (or “children”) of the Node 1 Fwd Hatch.

2.2.6 *Future volumes on ISS*

The current version of the program will be able to handle additional volumes by adding lines as appropriate to the HATCH CONFIG section.

At this writing, only Node 3 and the Cupola remain to be installed. Node 3 will be off of the Node 1 Port Hatch, and the Cupola will be off of the Node 3 Deck Hatch. These will eventually go on the diagram between the Node 1 Stbd and Node 1 Aft hatches:

Node 1 Fwd Hatch
Node 1 Stbd Hatch
IV Hatch
Node 1 Port Hatch
Node 3 Deck Hatch
Node 1 Aft Hatch
FGB GA-PMA1 Hatch
Etc.

Thus, the flag for Node 1 Aft Hatch will eventually have to be changed to a “5” to represent the two additional hatches required in the program to get back to the Node 1 Fwd Hatch.

Other volumes not accounted for on this diagram include the MPLM and HTV (both off of the Node 2 Deck Hatch).

Additionally, the program assumes that two of the three docking ports on the Russian segment are occupied: a Soyuz at the FGB Nadir (FGB GA-SU Hatch), and a Progress, Soyuz, or ATV at the SM Aft (SM Ro-PrK Hatch). Left empty is the DC Nadir (SM PkhO-SU Hatch).

2.3 *Outputs*

Orbiter Only					Utilize ISS Atmosphere				
	DDD/HH:MM		DDD/HH:MM:SS			DDD/HH:MM		DDD/HH:MM:SS	
Time to 8 psi Stabilization is	000/01:21	at	001/13:33:36	MET	Time to ISS at 9.5 psi	000/09:48	at	001/22:01:05	MET
Time at 8 psi to N2 Depletion is	000/06:03	at	001/19:36:54	MET	Time from 9.5 psi to 8 psi	000/00:03	at	001/22:03:51	MET
Time from TIG to TD -	000/01:03				Time at 8 psi to N2 Depletion	000/06:03	at	002/04:07:09	MET
Latest TIG is	**000/06:21**	**at**	**001/18:33:36**	**MET**	Time from TIG to TD -	000/01:03			
					Latest TIG is	**000/14:51**	**at**	**002/03:03:50**	**MET**

Basically, what we're trying to do is to display two different deorbit TIGs, one that's the most conservative that covers just the orbiter and airlock and gives the soonest they'd have to deorbit, and one that answers the question "if we opened up to the ISS and used some of that air, how much longer could we stay in orbit?"

The bottom section of this display is for the calculated data that the crew will use to base their deorbit plans. It consists of two tables, one with times for the undocked case ("Orbiter Only") and one with times for the docked case ("Utilize ISS Atmosphere"). In each, the first column is read as "time or duration of this event from now" while the second column is read as "this event will occur at this MET (Mission Elapsed Time, from liftoff)".

First, we'll talk about the Orbiter Only case.

- Time to 8 psi stabilization: this is the time it will take for the cabin pressure to fall to 8 psi. Once the pressure is below 8 psi, the emergency cabin regulator valves will open and flow either O2 or N2, depending on how the PCS valves have been configured. In the above example, it will take 1 hours 21 minutes for the pressure to drop to 8 psi, which will occur at 001/13:33:36 MET.
- Time at 8 psi to N2 depletion: assuming the crew has performed the rest of the cabin leak procedures in the Orbit Pocket Checklist, by the time the cabin pressure has dropped to 8 psi, the valves have been configured to flow N2 into the cabin to make up cabin pressure. The cabin P is required to be no less than 8 psi (the lowest pressure at which the hardware in the cabin has been certified). O2 will flow as needed to keep the PPO2 within limits while the crew is not yet in their ACES suits. But since the O2 is also used for fuel cell production, there is far more O2 than N2, thus the N2 is the limiting constraint, so the crew must be on the ground by the time the N2 runs out so the cabin pressure will stay at or above 8 psi. This represents the time from when the cabin pressure first drops to 8 psi until the N2 is depleted and the pressure falls below 8 psi. In the above example, once the cabin pressure drops to 8 psi in 1:21 from now (at 001/13:33:36 MET), the N2 will last a further 6 hours 3 minutes beyond that until 001/19:36:54 MET.
- Time from TIG to TD: is the time between the deorbit burn and touchdown. At ISS altitudes (around 200 nm) this is about 1:05 hr.
- Latest TIG: is the combination of three factors that have already been calculated – the time until the cabin pressure drops to 8 psi, the time while at 8 psi until the N2 is depleted, and the time from deorbit burn TIG until touchdown. These factors will determine the latest time that the crew can do the deorbit burn and not run out of N2 before landing. The simple equation is (time to 8 psi) + (time at 8 psi until N2 depletion) – (time from TIG to touchdown) = time until latest TIG. This time of Latest TIG is read by the Deorbit Manager PGSC program in order to determine what landing sites are available up to this TIG. In the above example, adding the time to 8 psi (1:21), the time at 8 psi until N2 depletion (6:03), and subtracting the time from TIG to touchdown (1:03) results in a TIG no later than 6 hours 21 minutes from now, or 001/18:33:36 MET.

Things are a little different when docked to ISS. In this case, the objective is to find out how long it will take for the entire stack (orbiter plus ISS) volume to drop to the minimum pressure. The idea is to see how much additional time can be gained remaining on orbit with a shuttle cabin leak, in order to make a better landing site or to perform repairs.

- Time to ISS at 9.5 psi: is the time it will take for the total stack volume to fall to the minimum acceptable pressure (9.5 psi is the lower limit for the Russian Segment modules). The hatches to the ISS would be open until the entire stack dropped to 9.5 psi, after which the hatches would be closed and the volume would be the orbiter only from there to landing. In the above example, it will take 9 hours 51 minutes to

bring the entire ISS stack down to 8 psi (9:48 to get down to 9.5 psi, and 0:03 to get from 9.5 to 8.0). The time to N2 depletion is the same regardless of whether it's the orbiter only or the orbiter plus any extra volume, so it's not repeated.

- Latest TIG (Utilize ISS Atmosphere): is calculated similarly to the Latest TIG (Orbiter Only) except that it accounts for orbiter + ISS as well as just orbiter only. In the above example, the ISS/orbiter stack will get to 9.5 psi in 9:48 from now, followed by orbiter-only O2/N2 maintenance which ends 6:03 after that, for a latest TIG of 14:51 from now at 02/02:03:50 MET. By utilizing the ISS atmosphere, the shuttle crew has gained an additional 8 hrs 30 min to complete repairs or land at a more desirable landing site.

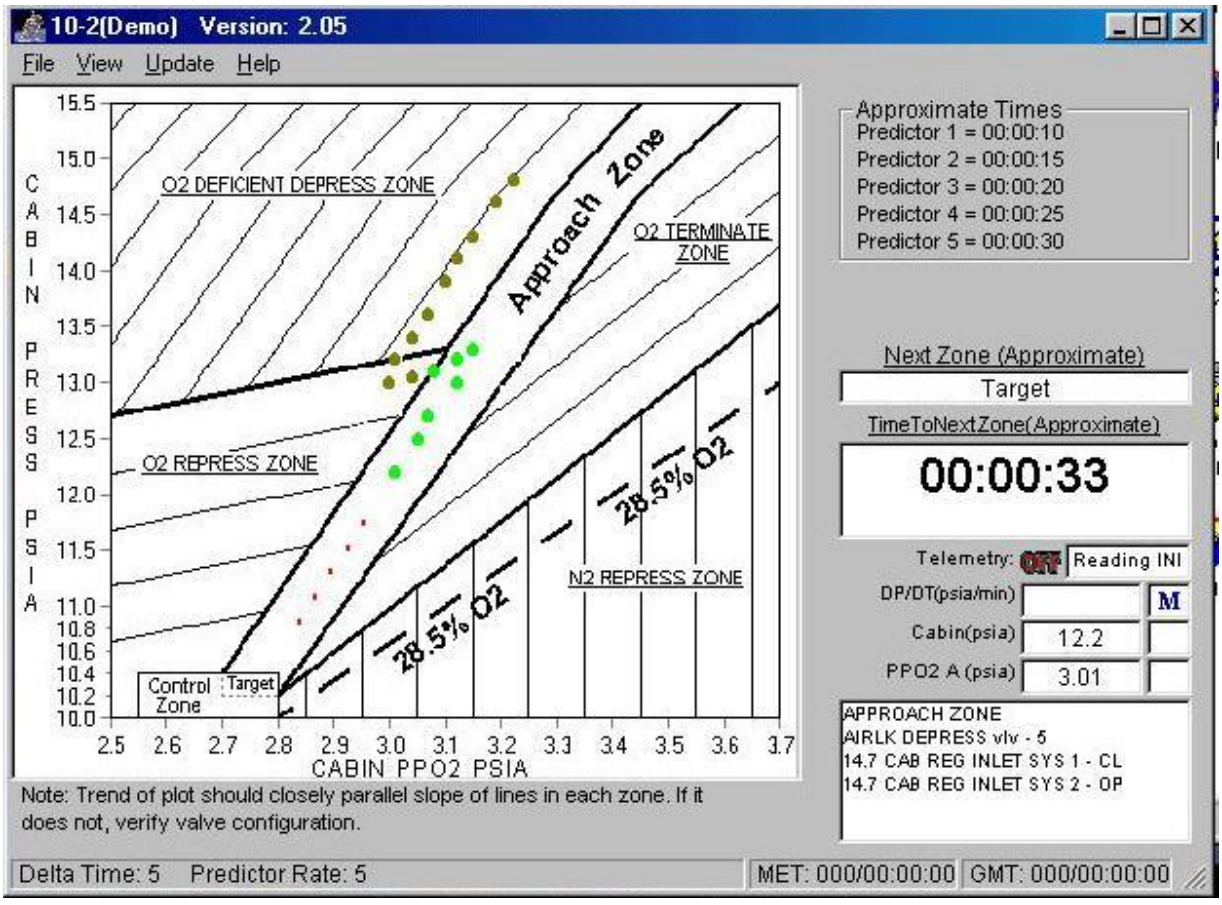
3.0 10-2 DEPRESS (version 2.05, 4/2001)

3.1 *Overview*

The 10-2 Depress application automatically displays the current Cabin Pressure and PPO2 Pressure on the Ten2 Depress Chart. The Cabin and PPO2 Pressures are also displayed numerically, along with the DP/DT value, changing actively as the PCMMU sample rate allows. Ten2 Depress also displays the current valve configuration based on the current zone, the MET and GMT, Approximate Next Zone and its corresponding crossing time.

The 10.2 Depress program is located in the **<c:\spocapps\10-2>** directory or can be accessed from the Shuttle Apps window.

As data feeds the application, a point will be plotted on the chart representing the Cabin Pressure versus the PPO2 Pressure. As the Cabin and PPO2 pressures change, the application will automatically display the current zone information in the right-side status bar. While points are being displayed, outside the control and target zones, the application plots predictor points for the next five positions. If the values have not changed since the last time a sample was taken from PCMMU, then no prediction is made, based on a stand-still. When a zone boundary is crossed, an audible alert is initiated, as well as making the valve configuration flash in the right-side status bar.

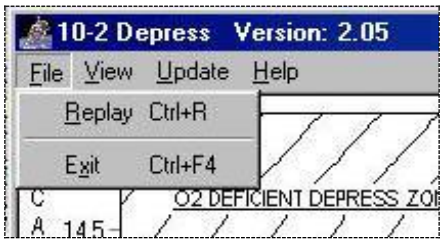


The program is designed for minimal crew intervention. When the program is opened, it immediately begins looking for telemetry. A red "OFF" or green "ON" in the lower right corner indicates whether it is reading demo data from the initialiazation file or telemetry from one of the various packets.

The left side of the screen duplicates the 10.2 depress chart from the EVA checklist, but by automatically plotting data, it frees a crewmember from having to monitor a CRT and plot the points by hand. With the PGSC program, a crewmember can be on the middeck (where the switches that need to be moved are) monitoring the display. The right side of the screen includes information on the predictor bugs, the next zone projected, cabin atmosphere info, and the expected current PCS valve positions.

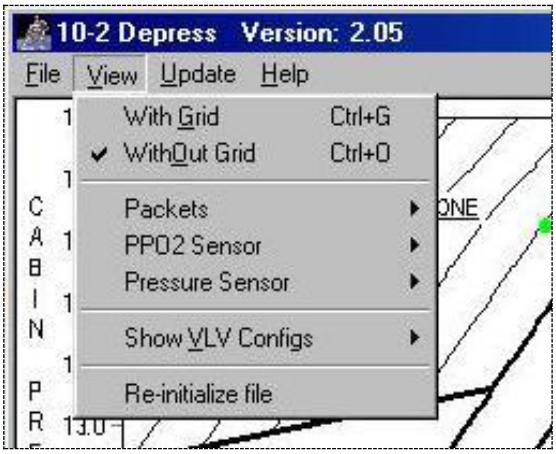
3.1.1 *The "File" Menu*

The only option under the File menu (aside from Exit) is to Replay a previously recorded data file. This is analagous to being able to go back to the paper diagram and look at an old depress plot; data on cabin pressure and PPO2 are saved to a file that is uniquely identified. The operation of the Replay option will be discussed later.

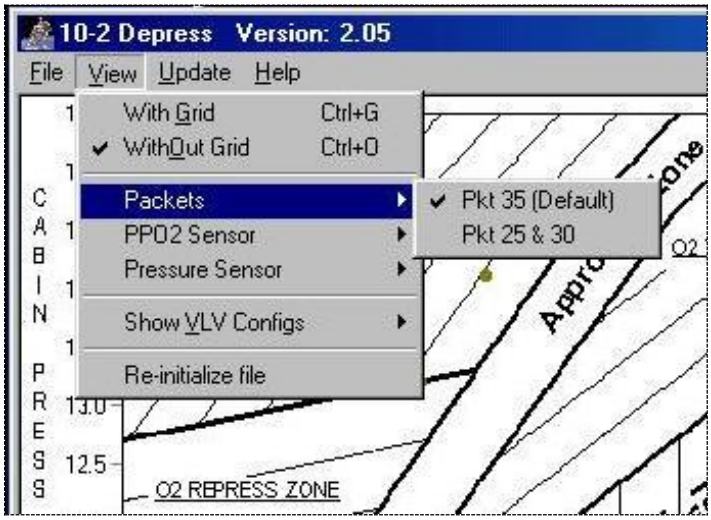


3.1.2 *The "View" Menu*

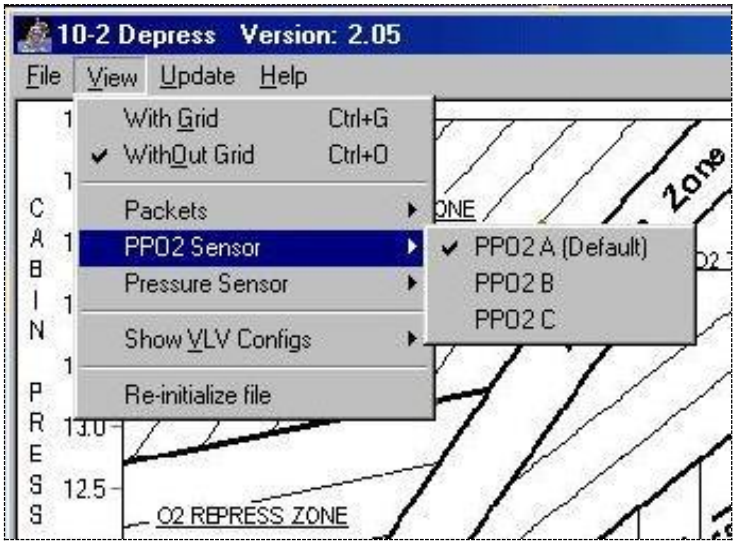
Through use of the pull-down menus, the user can configure the program in various ways, modifying the reading of the data or how the data is presented. The first option in the View menu allows the user to show the plot either with or without a grid. The "without" option is the default. The use of a grid would make it easier to determine the values of a data point plotted previously. Three other options – Packets, PPO2 Sensor, and Pressure Sensor – are greyed out when the Demo mode is selected. To show these options, select the Update | Data Source | Telemetry menu option (to be discussed shortly).

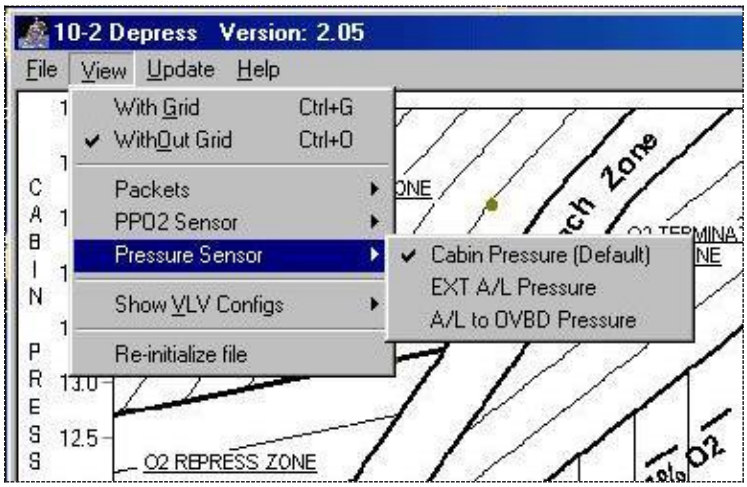


Selecting View | Packets allows the user to choose between Packet 35 (the default) and Packets 25 & 30. See Section 0 for an overview of packets.

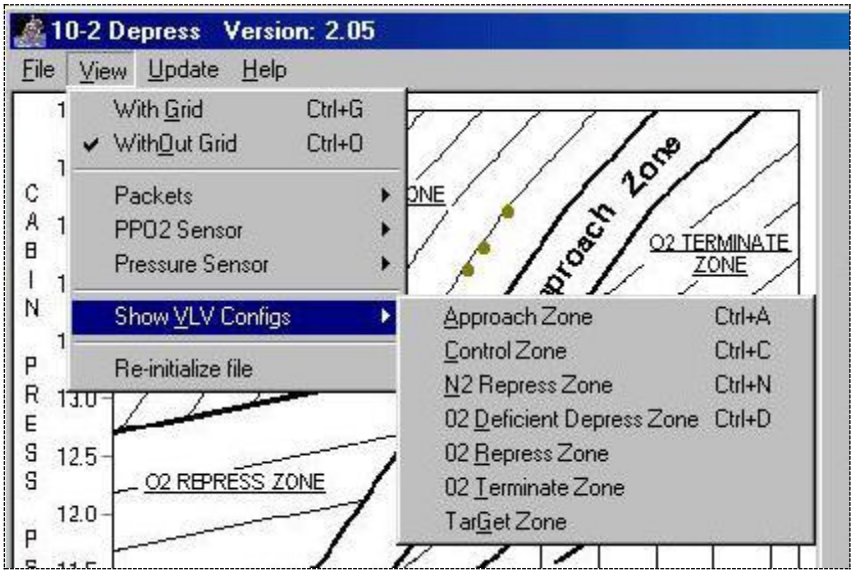


Also under the View menu, the user may choose an alternate PPO2 or Pressure sensor. PPO2 sensor A and the Cabin Pressure sensor are the defaults, but if either is considered failed, the user may bypass that sensor (for example, PPO2 A and Cabin P are both powered by a single circuit breaker on panel O14) in order to use the program.



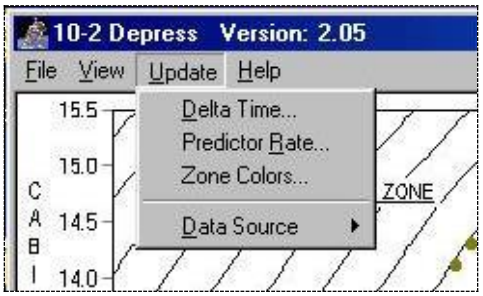


The user can also select the valve configuration for a particular region by way of the View menu.



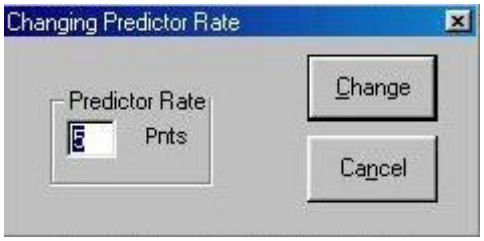
3.1.3 *The "Update" Menu*

The Update menu allows the user to make changes to how the program operates and plots points on the display.

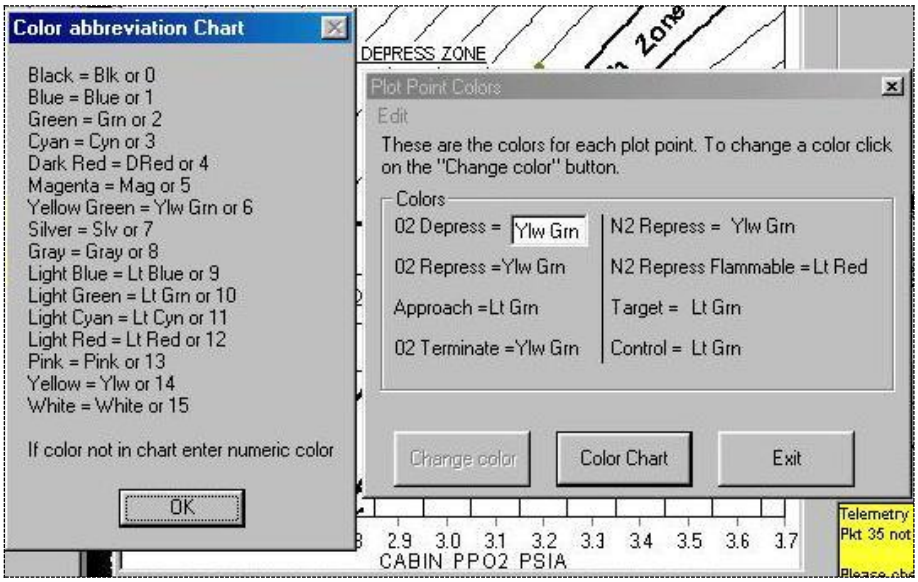


The first three options bring up dialog boxes to make selections, while the last option lets the user decide between real telemetry and demo mode. The first one allows for the setting of the "delta-time", that is, the time duration between data points on the display. The default for a typical depress procedure would be 60 (seconds); the EVA Checklist calls for a new data point every 1 minute. For training purposes, this can be set to something like 5 to show a semi-realistic update rate.

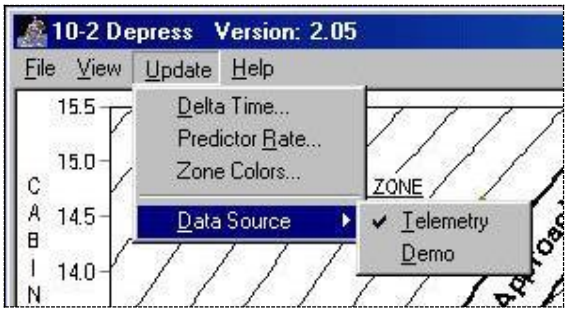
The predictor rate allows the user to select how many predictor bugs are used in determining the next zone and the time to the next zone. Typically 5 or 6 is good enough.



When the "color chart" button is selected, the color abbreviation chart appears and the text for the particular color becomes a dialog box.



Finally, the user can select between "real" data and demo telemetry. For training purposes, the only reason to select "telemetry" is to let the View menu show some additional options. If telemetry is selected and no telemetry is available, the data box in the lower right corner turns yellow, warning of the "loss" of data.

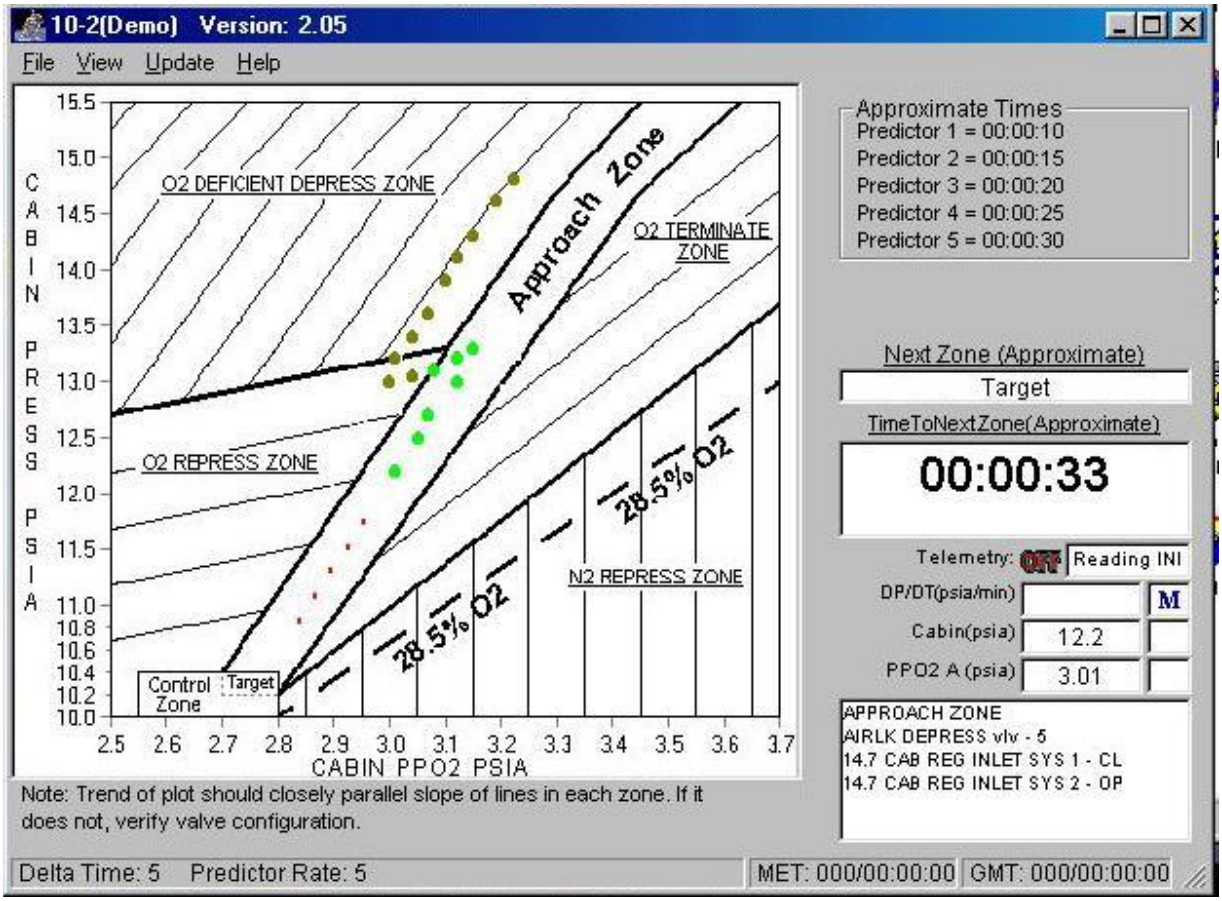


3.2 *10-2 OPERATION*

The 10-2 program is essentially hands-off unless the user wants to change options. The program will display data as soon as it is called up, and the only manual intervention required is to change valves at the appropriate times.

As the cabin pressure and PPO2 change, a series of dots are plotted on the display. A green dot means a data point inside the Approach Zone, while it is brown outside of it. The small red dots are predictors for the program to calculate the next zone and the time to the next zone. All of these parameters may be changed manually (as discussed above in the Update menu).

Since there is no telemetry associated with the airlock depress valve and both 14.7 psi cabin regulator inlet valves, the program displays the expected valve position for the current region in the lower right.



Moving the cursor over any zone's underlined title (such as O2 REPRESS ZONE or APPROACH ZONE) turns the cursor from an arrow into a pointed-finger, and clicking the region's title brings up a text box with the valve config for that region (for example, to remind the crewmember what the valve config will be for the next zone). The text box can also be called up using the View | Show Valve Configs menu option.

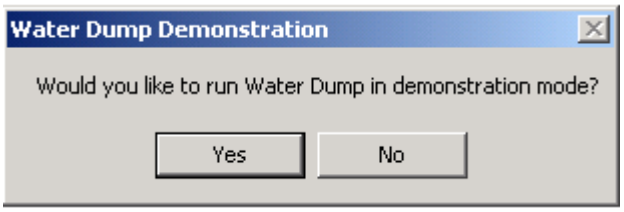
4.0 WATER DUMP (version 3.0, 9/2002) & CONTROL PANEL (version 2.00, 9/2002)

The Water Dump program (along with the training-only Control Panel demo) is an electronic version of the Flight Data File "Supply/Waste Water Dump" procedure. The Water Dump program uses telemetry to determine when to advance from one step to another, and when telemetry is not available (such as during a standalone training session), the Control Panel must be used to simulate telemetry.

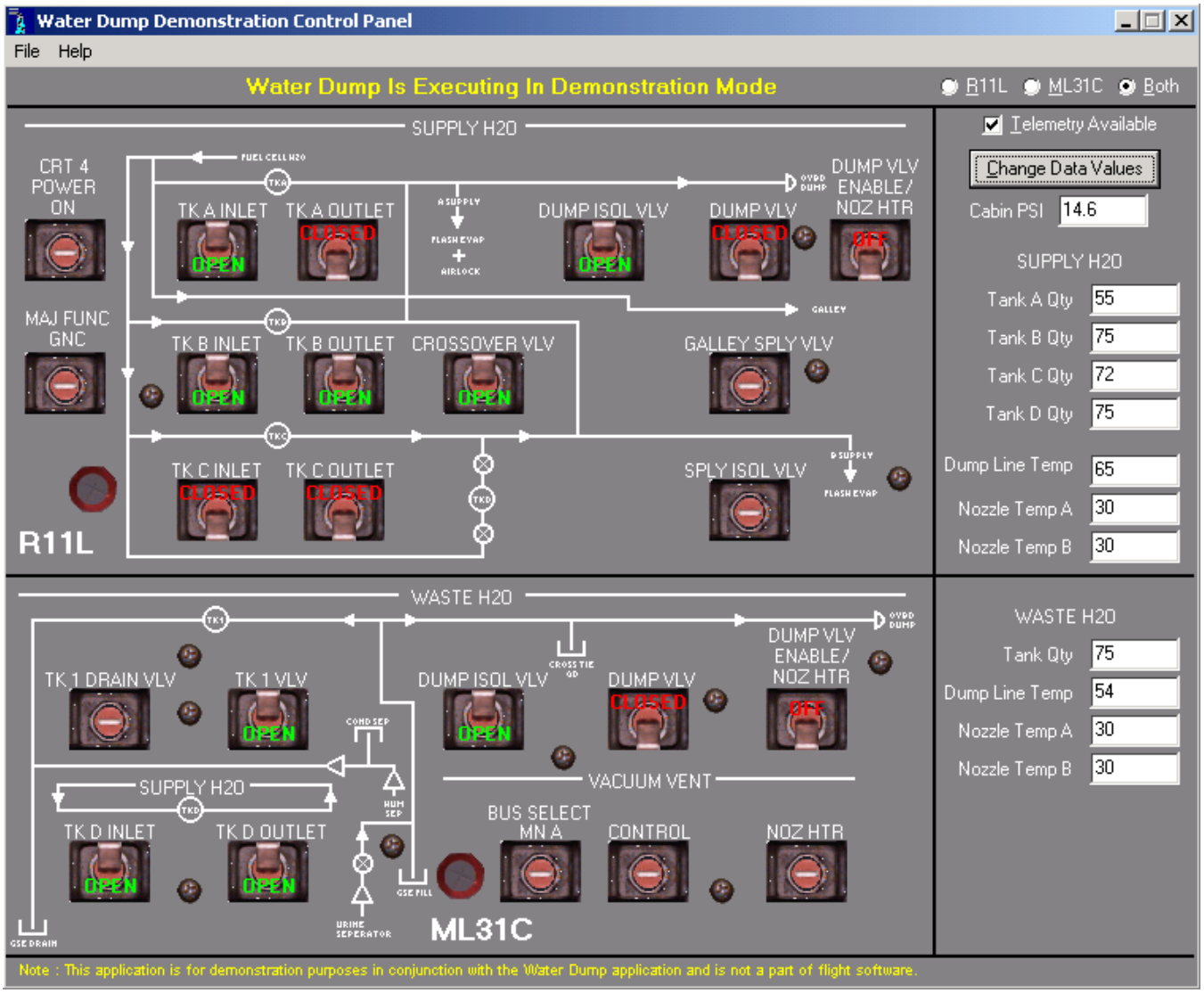
The Water Dump and Control Panel programs are located in the **<c:\spocapps\WaterDump>** directory or can be accessed from the Shuttle Apps window. The Control Panel will only be installed for standalone training (not in the SMS) and is not part of the regular PGSC load that the crew uses in orbit.

4.1 *Control Panel Demo*

Because the SST and classrooms do not have simulated PCMMU data to display on the screen, the Water Dump program cannot tell when the supply/waste water switches have been moved, and the program will not automatically advance to the next step when appropriate. For standalone lessons, a demo program may be run to simulate the switches on panels R11L and ML31C in conjunction with the water dump program. This program is only available on standalone PGSCs and must be manually installed.



In order to run the Water Dump program in demo mode, the Water Dump Demonstration Panel must first be called up.



The demo panel has simulated switches for the supply and waste system on panels R11L and ML31C (any switch not shown in the up or down position is a dummy switch for display only). The tank quantity and line/nozzle temperatures can all be manually entered, and the "Set" buttons must be pressed to send the data to the main program. Telemetry droputs can also be modeled from a button at the top of this page. By use of a radio button at the top right, you can have the program display either R11L, ML31C, or both.

When using this program for standalone training, the tank valves should be set to either the standard configuration (A outlet closed, B&D tied, C isolated, crossover open) or the water transfer configuration (A&B tied with B inlet closed, C&D tied, crossover closed) depending on the specifics of the mission. Tank quantities should be set appropriately, and the dump line temp should be set to at least 65. The nozzle temps should be set fairly low.

As the Water Dump program progresses through the timeline, the operator will need to change the values of the nozzle temps and tank quantities at various points. Remember to hit the "Set" button to send the data.

The initiliazation file **`WtrDemo.ini`** contains only the status of the switches, heaters, and temperatures that are set via the demo panel, so there is no need to modify the **`WtrDemo.ini`** file.

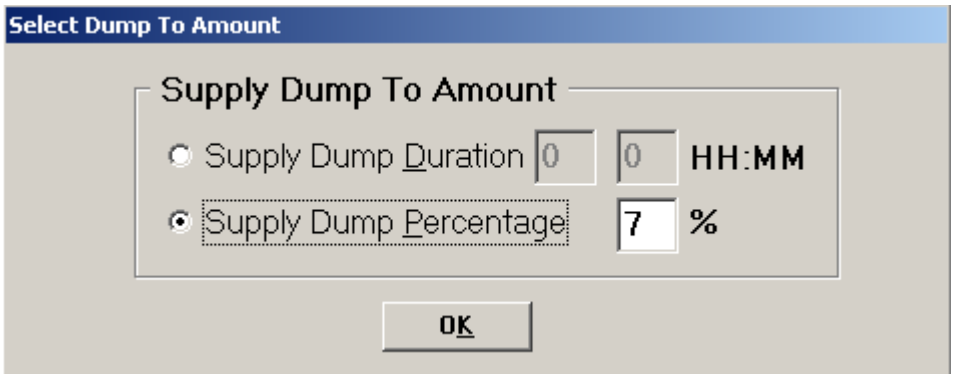
4.2 *Water Dump program*

4.2.1 *Menus*

There are four pull-down menu options: File, Update, View, and Help. The File menu allows the user to select Exit, to quit the program. The Help menu allows the user to call up the Help file and to view the About information (as seen above). Update and View are discussed below.

4.2.1.1 Update

During operations of the Water Dump program, the user may change the dump target (by duration or quantity) by either pressing the “Change Amount” button in the upper right corner of the display or by the Update pull-down menu and selecting “Dump to Amount”.

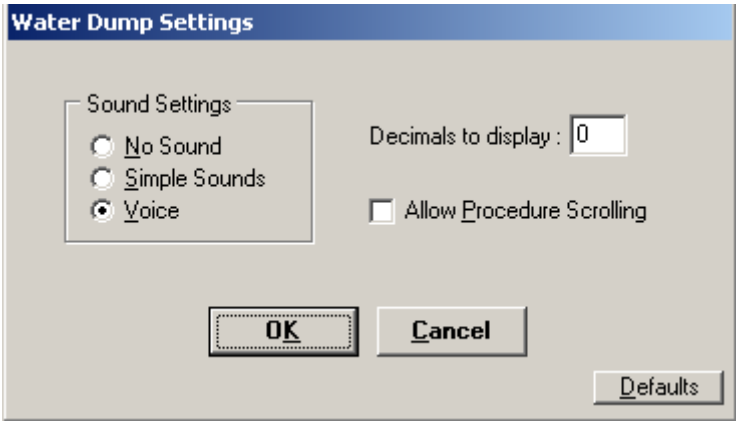


Also under the “Update” menu is “Time Data” which allows the user to modify the GMT, MET, launch time, and related parameters.

4.2.1.2 View

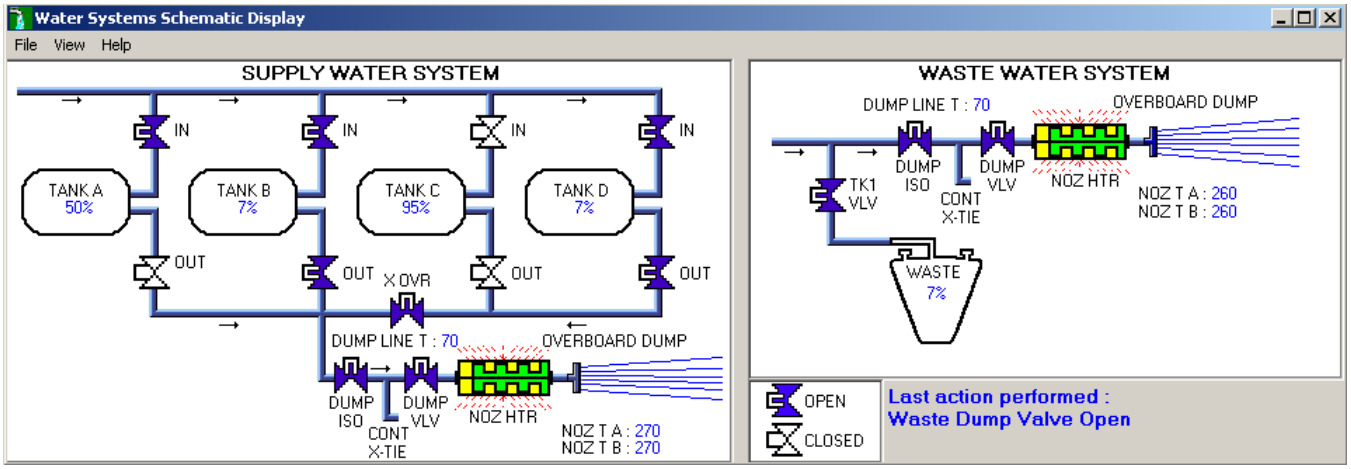
The View menu has four options: Settings, Schematic, Spec 66, and Event Log.

- Settings allows the user to change the sound (no sound; simple sounds, typical of Windows; or voice), the number of digits to be shown on the display, and the scrolling capability. The program will normally show only the current step, the one ahead, and the one behind. The scrolling option allows the user to review steps that have already occurred, but does not allow future scrolling because the next steps are determined based on various events occurring or not.

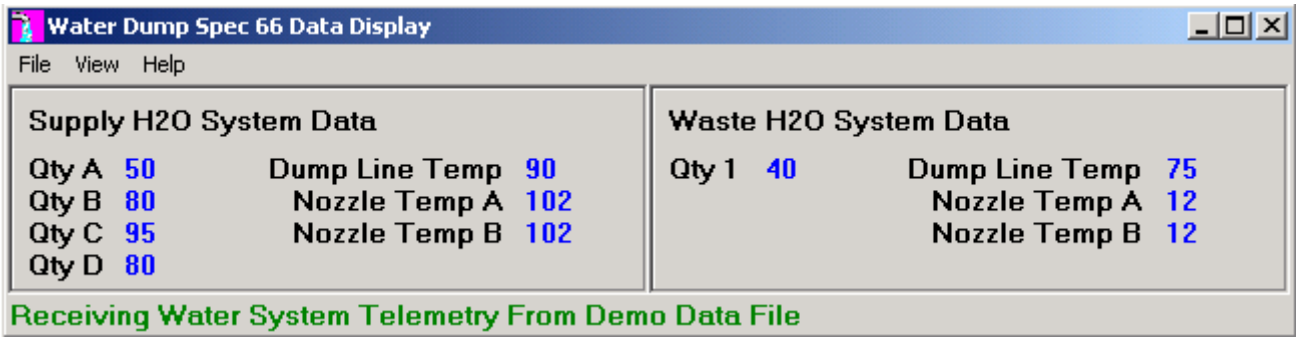


- The Schematic menu choice calls up the combined supply and waste water schematic. This diagram is dynamic and will change as appropriate based on the various switch throws and telemetry (simulated or

true). This display notes the most recent action. The Schematic automatically appears when either kind of dump starts, but may be called up separately if desired.



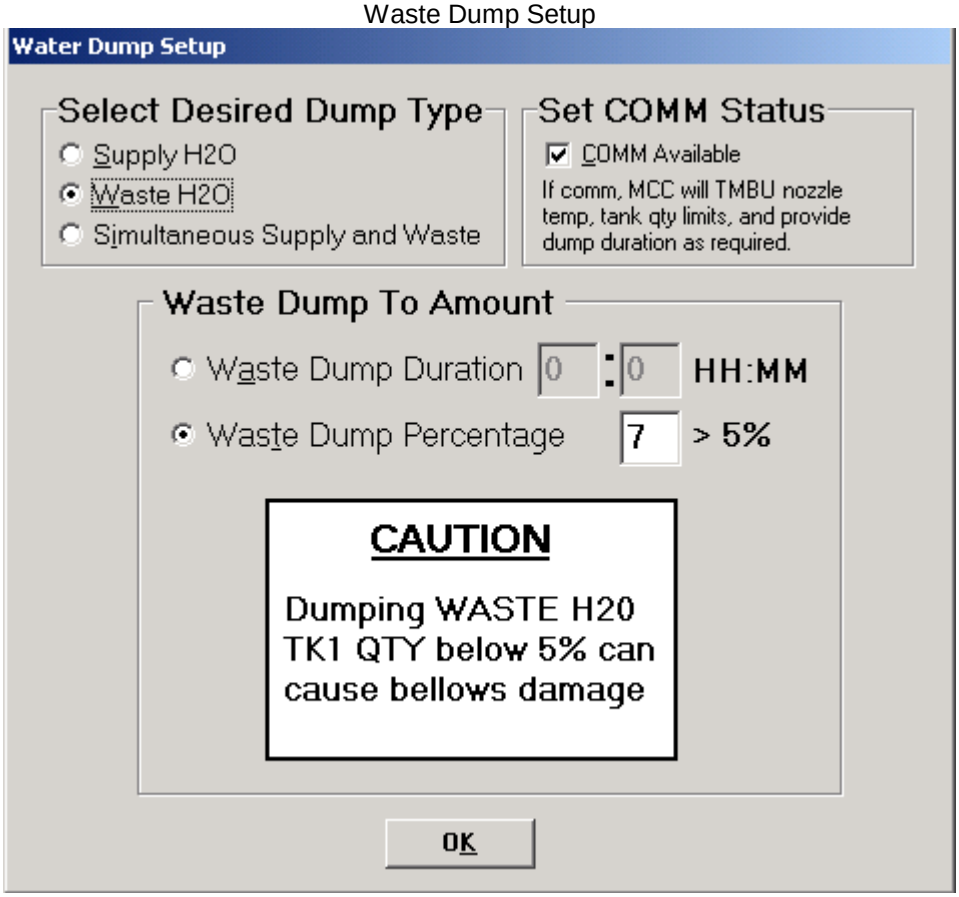
- The “Spec 66” menu choice brings up a digital summary of the dump status as if the crew were looking at it on the Spec 66 display. This is not called up automatically like the Schematic is.



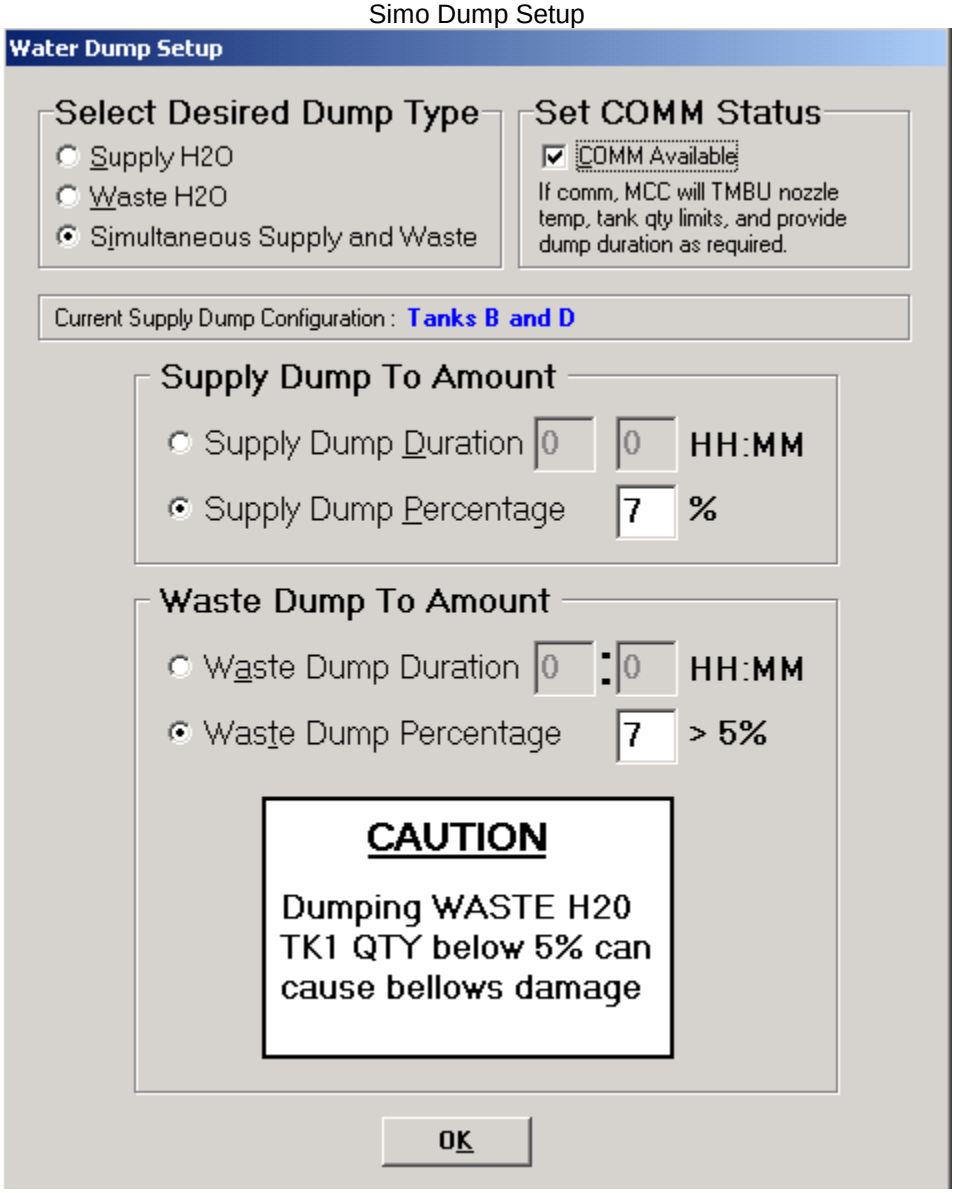
4.2.2 *Program setup*

Before any switches are thrown, the user must first tell the program which type(s) of dump(s) will be performed: supply only, waste only, or simo. Additionally, telling the program whether comm is available or not will suppress some messages. Finally, the user must enter either the duration or the target quantity of the dump. For the waste and simo dumps, a Caution to not dump the waste tank below 5% appears.

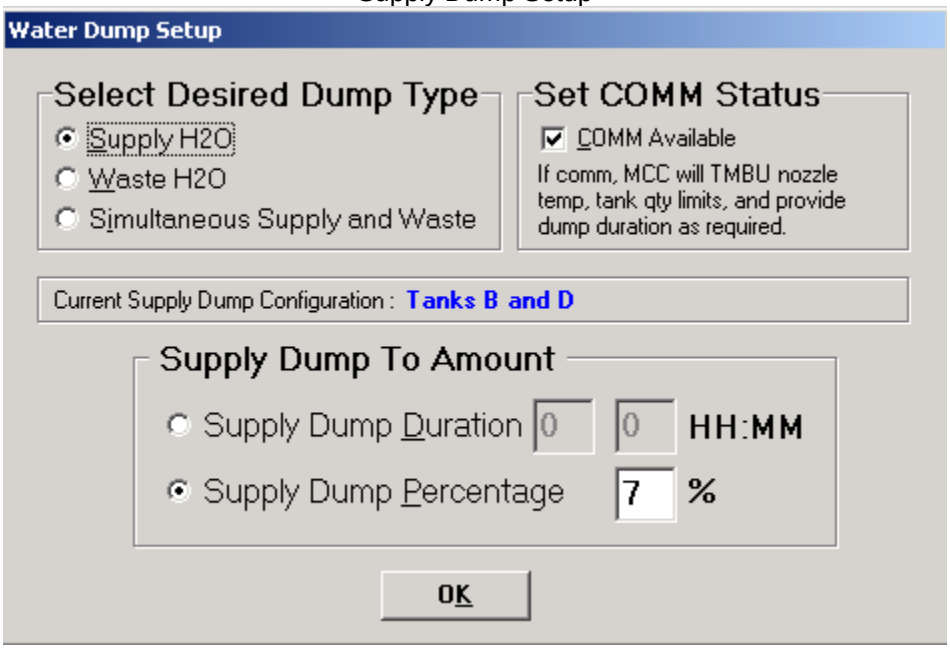
Waste Dump Setup



Simo Dump Setup

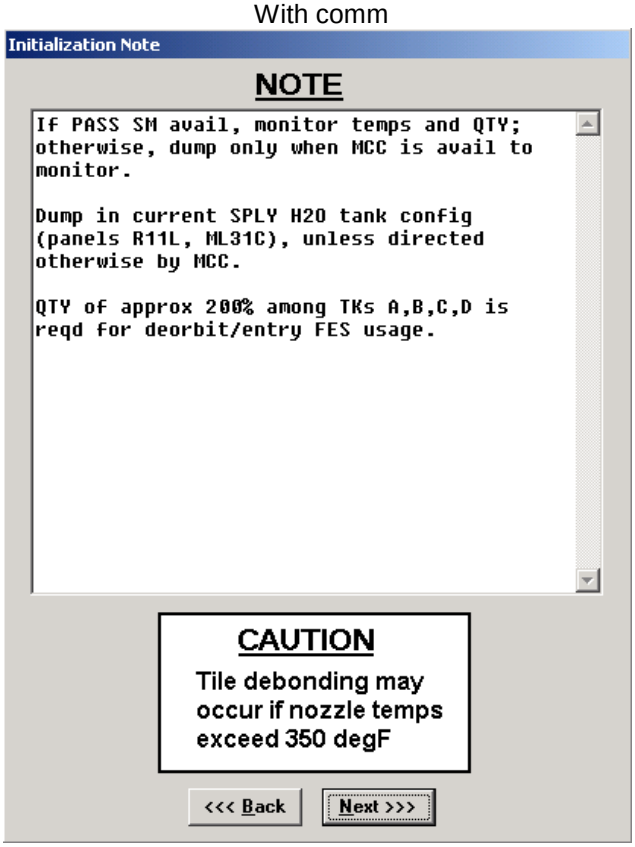


Supply Dump Setup

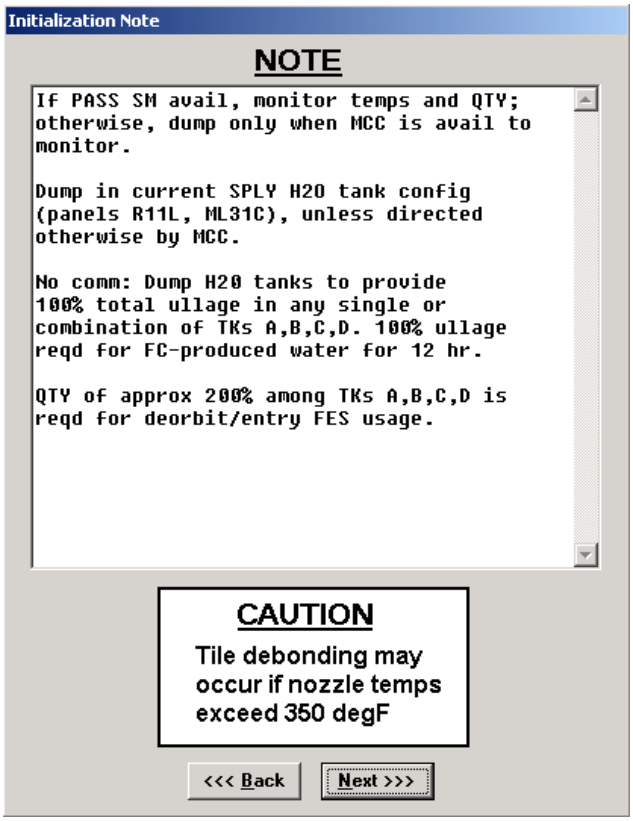


The next window is a series of notes for the crew regarding the dump. The content is based on whether the "Comm available" was checked on the previous window or not.

With comm



No comm

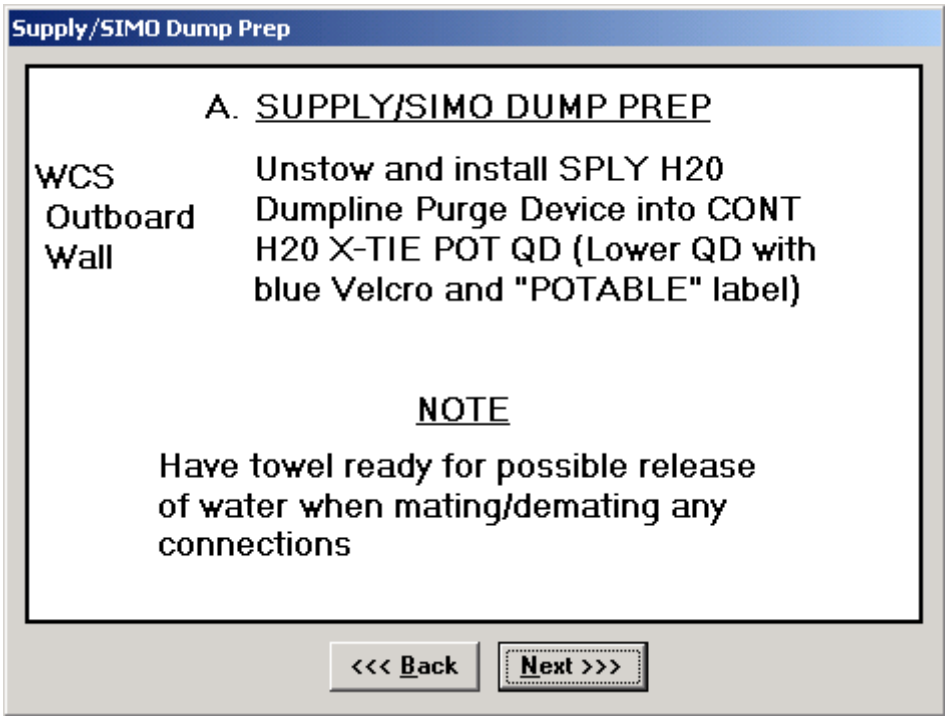


The various windows from this point on are based on supply, waste, or simo dump. Each follows the FDF procedures.

4.2.3 *Procedures*

4.2.3.1 Step A: Supply/Simo Dump Prep

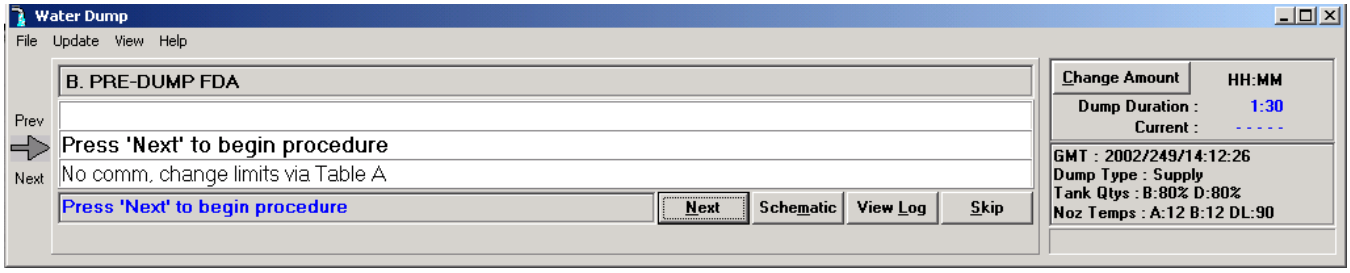
For a supply or simo dump, the crew is given a note about the Supply Water Dumpline Purge Device. The mechanism is inserted into the Potable quick-disconnect (QD), which lies between the dump valve and the dump isolation valve. It allows air to flow through the device and into the dump line and then overboard, at the point in the procedure when the dump isolation valve is closed and the dump valve is open. This is intended to prevent water accumulating at the dump valve and freezing, which has caused some water to leak overboard through the cracked valve.



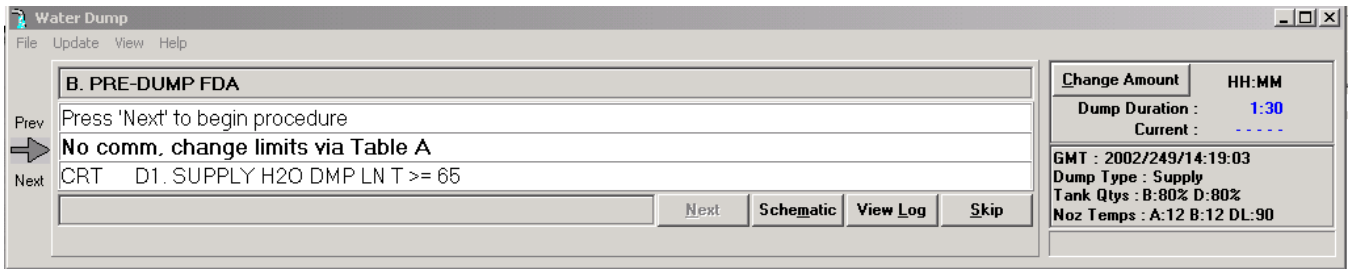
The QD is explicitly referred to not only by name but also by color. This is intended to prevent the crew from inadvertantly inserting the device into the wrong QD (the yellow Waste QD), which then contaminates the purge device (as has happened on previous flights). The Next button brings up a window to follow along with the various switch throws.

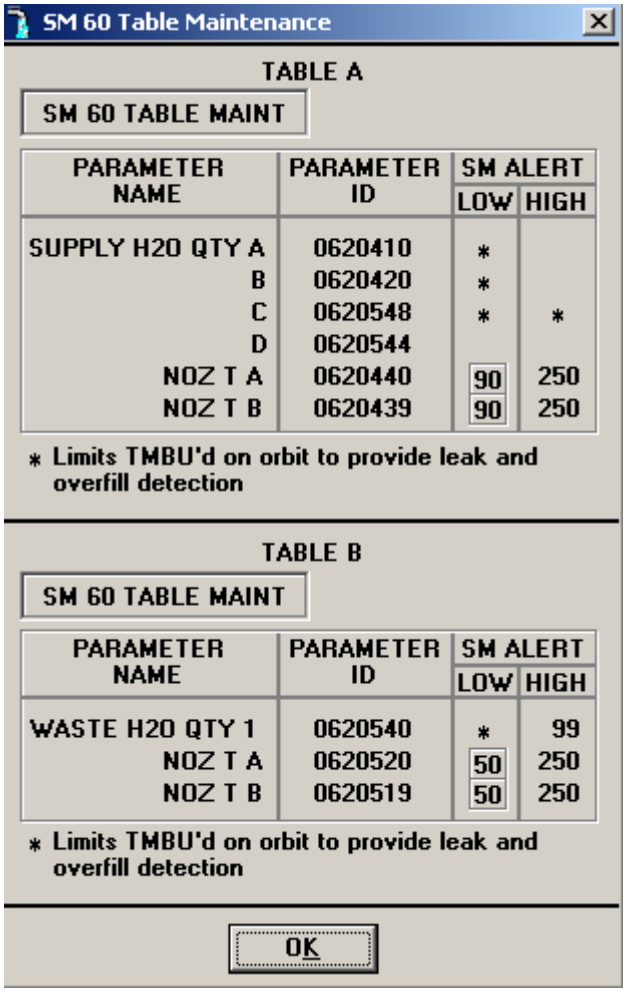
The top of the display reminds the user that Demo Mode is running, it repeats the dump mode (Supply, Waste, or Simo), and it reminds the dump type (duration or percent), which can be changed at any point.

4.2.3.2 Step B: Pre-Dump FDA



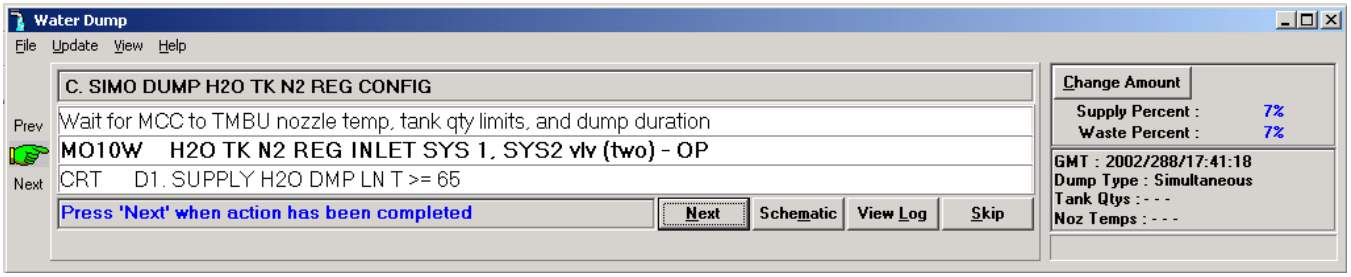
If comm is available, a reminder that MCC will TMBU the various limits shows up. If not, a Spec 60 window appears with the various parameters for the crew to change. Tables A and B data will be on this window depending on whether it is a supply, waste, or sim o dump.





At this point, the program is waiting for the crew to hit Next. The black arrow points to the current step.

4.2.3.3 Step C: Simo Dump H2O Tk N2 Reg Config

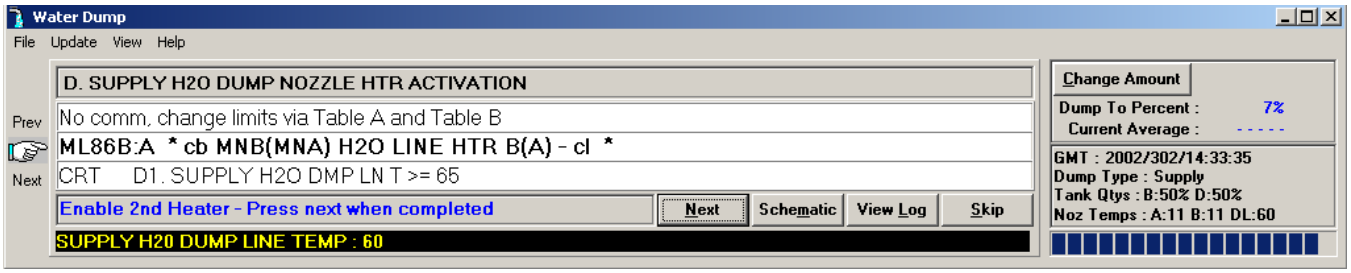


The program stops on an action: in this case, the crew should open the N2 valves. Since there is no telemetry on those valves, they will have to press Next to continue with the program after opening the valves. The flashing green hand indicates an action for the crew.

At this point for a simo dump, a second window appears so that the user can do both a supply and waste dump in separate windows.

4.2.3.4 Step D: Supply H2O Dump Nozzle Htr Activation

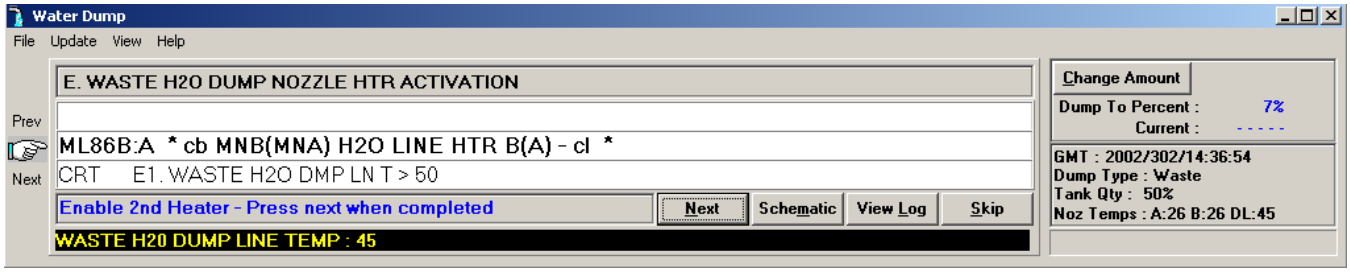
The program first checks the temperature of the supply water dump line. If it is below 65, a star block in the procedures tells the crew to activate dual heaters.



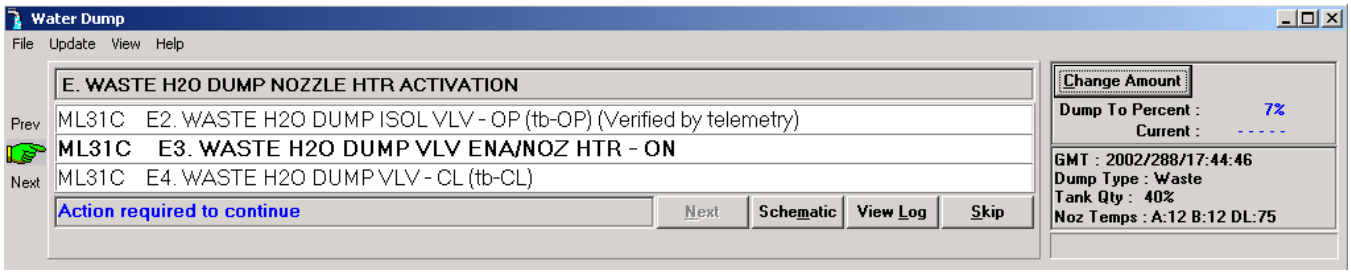
Once the temps are above 65, or when the second heater is activated, the program verifies that the dump isol valve is open (step D2), then waits for telemetry on the dump valve enable/nozzle heater to show on. The green flashing hand points to a step that is required. The program will verify the position of the dump valve in step D4.

4.2.3.5 Step E: Waste H2O Dump Nozzle Htr Activation

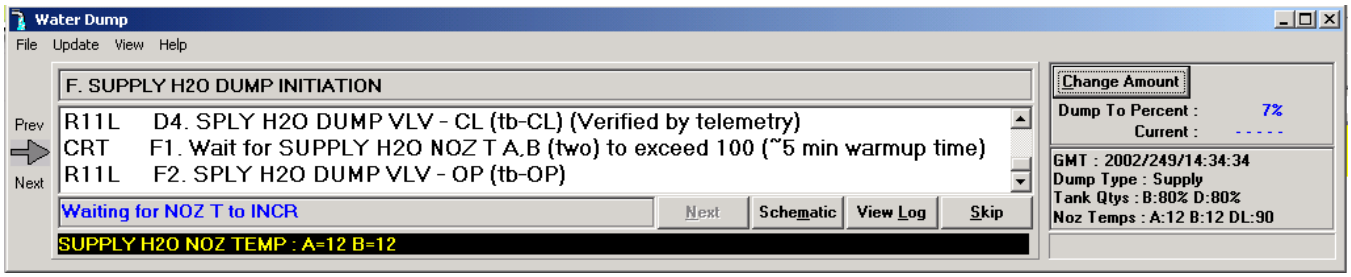
The program first checks the temperature of the supply water dump line. If it is below 50, a star block in the procedures tells the crew to activate dual heaters.



Once the temp is above 50, or when the second heater is activated, the program verifies that the dump isol valve is open (step E2), then waits for confirmation of the dump valve enable/nozzle heater to be on. The green flashing hand points to a step that is required. The program will verify the position of the dump valve in step E4.

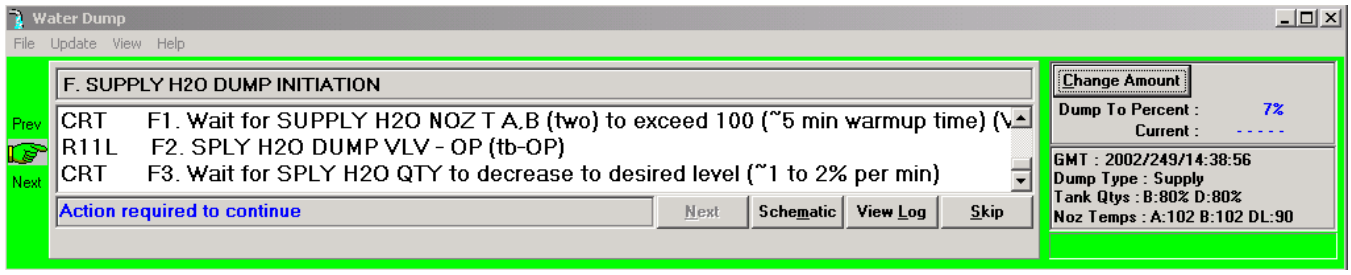


4.2.3.6 Step F: Supply H2O Dump Initiation

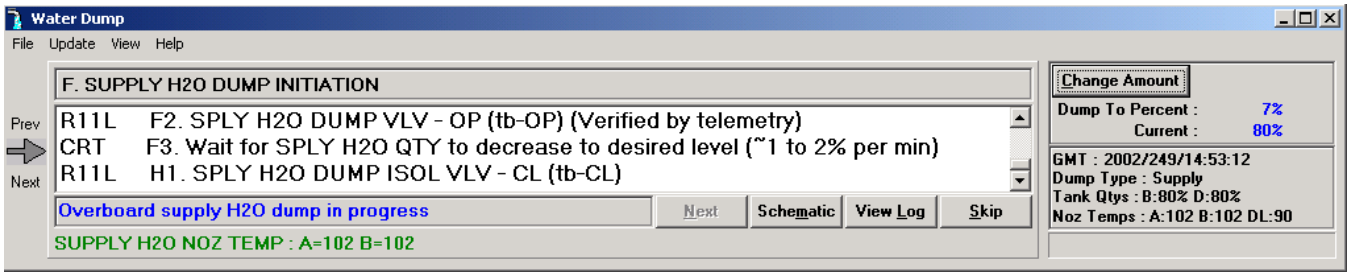


The program will proceed when the nozzle temps exceed 100 degrees, so set the temps greater than 100 and hit the "Set" button on the control panel. This is not required if operating in the SMS with "real" telemetry.

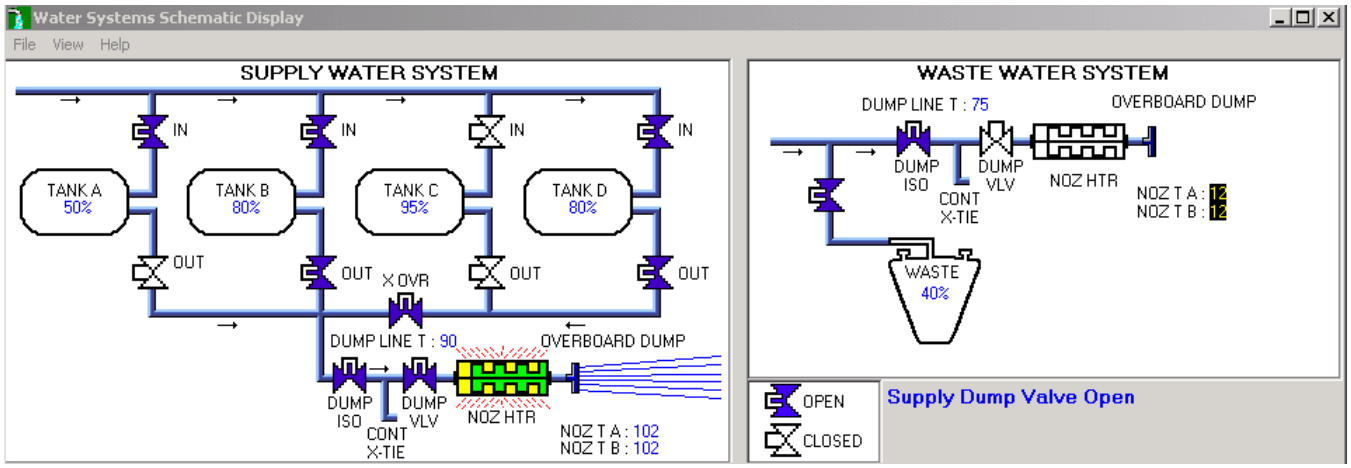
When the temps exceed 100 degrees, the background flashes green. The flashing green hand points to the next step, to open the supply dump valve.



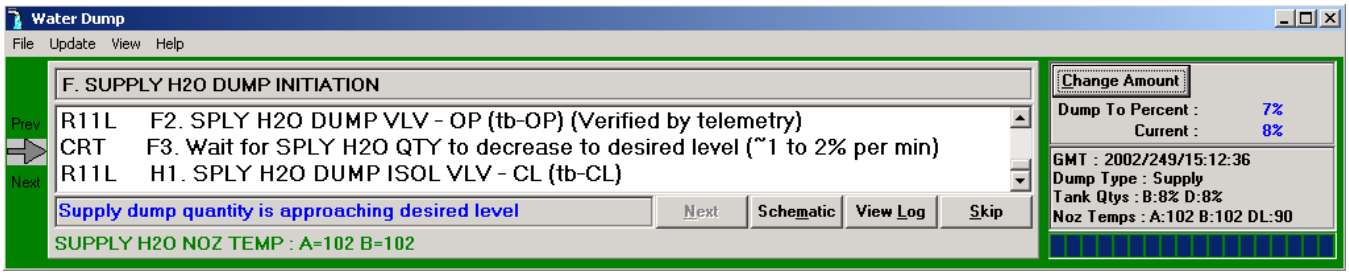
When that's complete, the program waits for the quantity to get down to the specified level (in the upper right corner).



A schematic of the supply and waste water system appears when the program starts. The status of the valves, heaters, and water dump is color coded based on telemetry. The view below shows a dump from tanks B and D, with the nozzle heater on and no waste dump in progress.



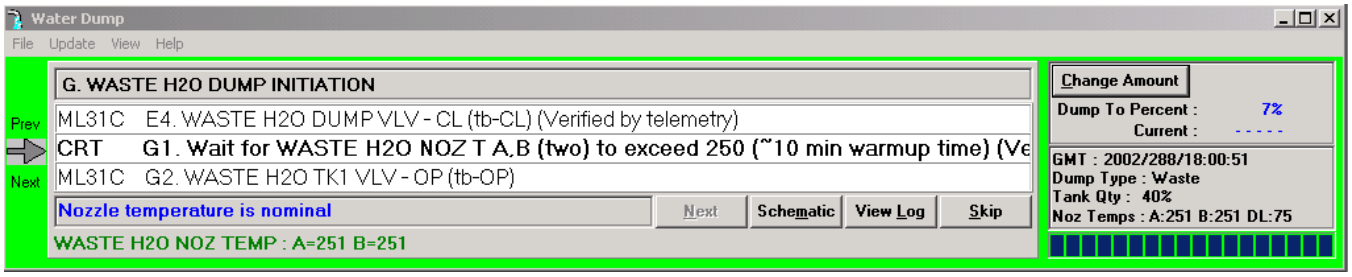
When the current value of the tank quantities are within 2% of the desired level, the display background flashes dark green.

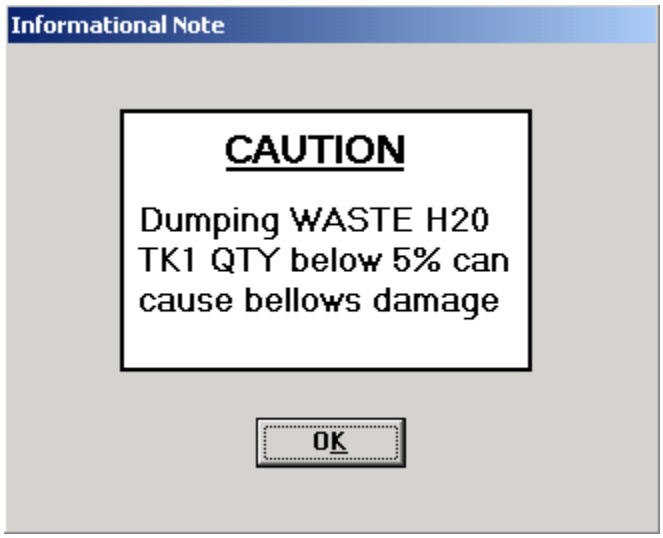


Note that the current tank quantities will be close (within 1%) but may not be identical to what's displayed on the crew's displays, if they compare the PGSC output to orbiter data. The WaterDump program apparently truncates while the data on the display is rounded. This would have the effect of triggering the "lower limit" warning on the PGSC slightly sooner than would be annunciated as an SM Alert, but the difference is not significant.

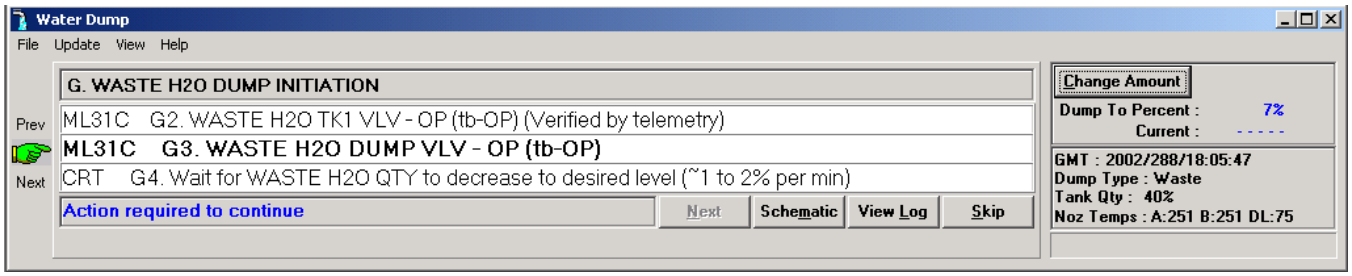
4.2.3.7 Step G: Waste H2O Dump Initiation

When the waste nozzle temps exceed 250 and the tank valve is verified open, the program steps to the next item, to open the dump valve, and shows the warning not to dump to less than 5% on the waste tank.

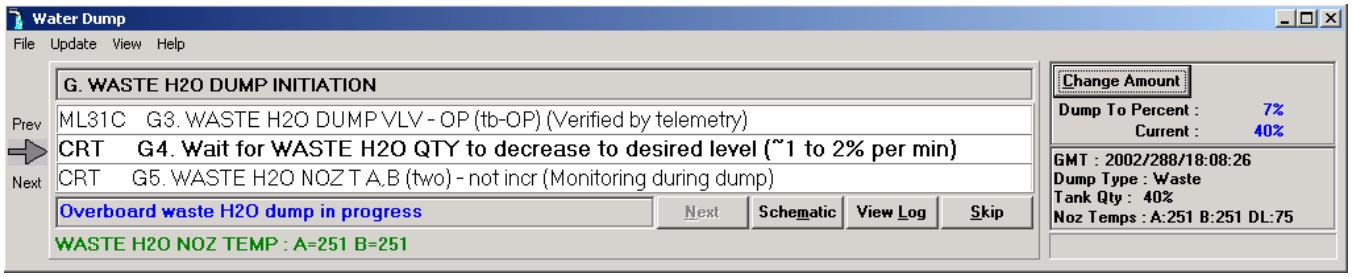


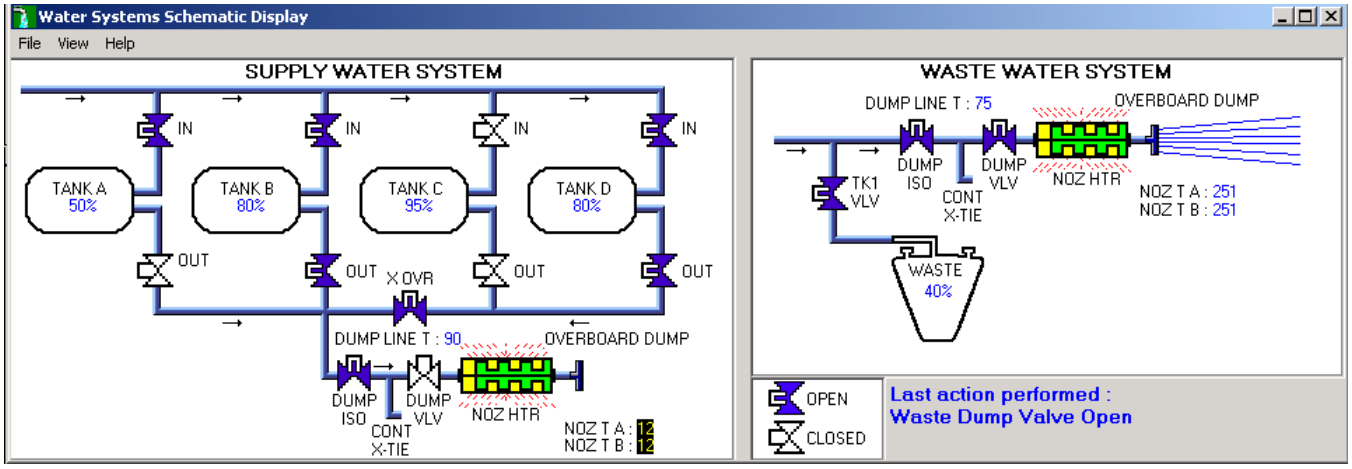


Acknowledging the warning moves the program to the next step.

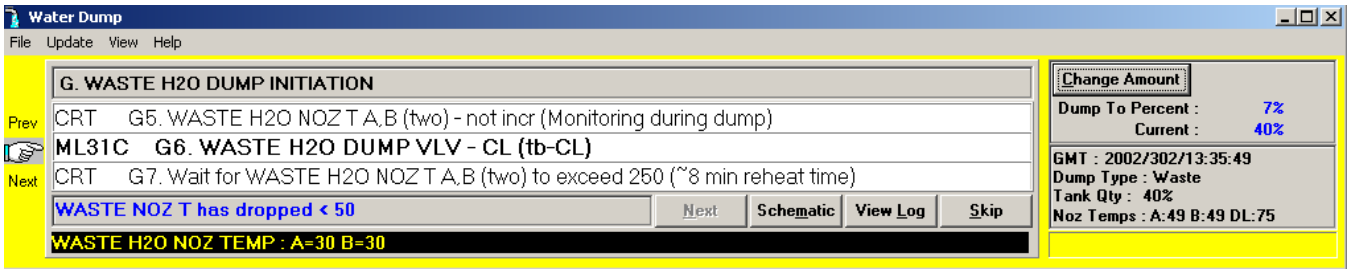


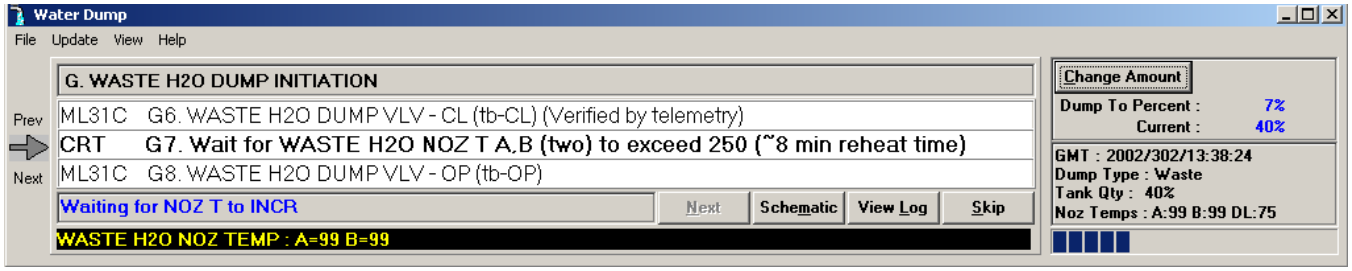
When that's complete, the program will wait for the quantity to drop to the lower limit.

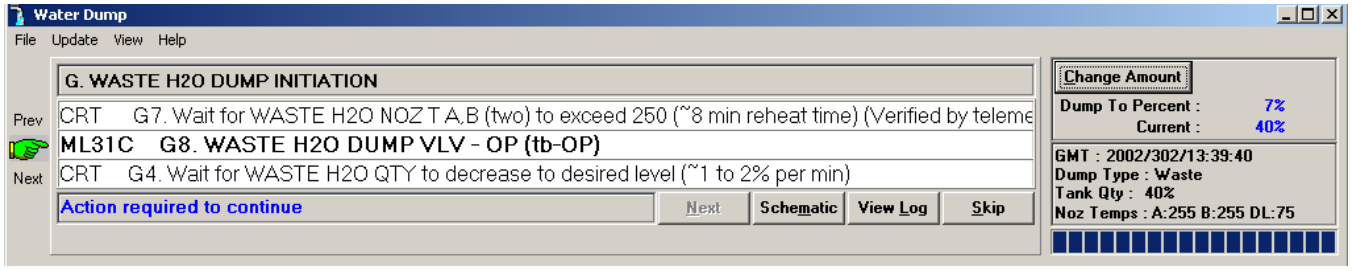




If the dump is required to be terminated early due to low nozzle temps, the background will flash yellow and give an audible alarm. The next step is to immediately terminate the dump by closing the dump valve, wait for a bakeout of the lines and nozzle, and then try again.

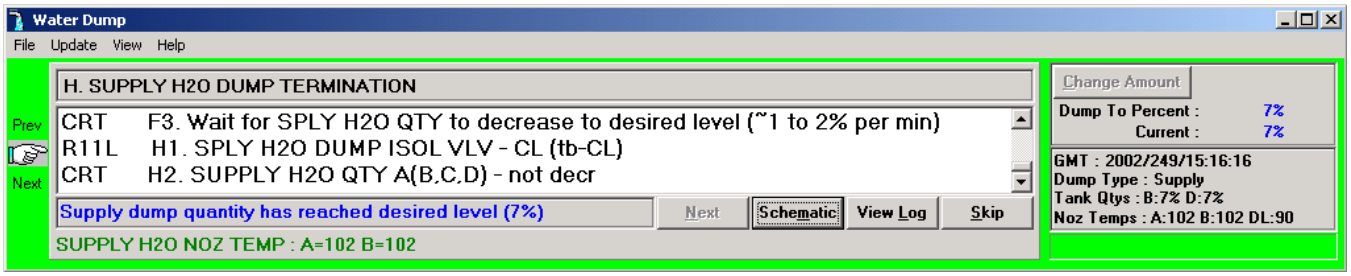




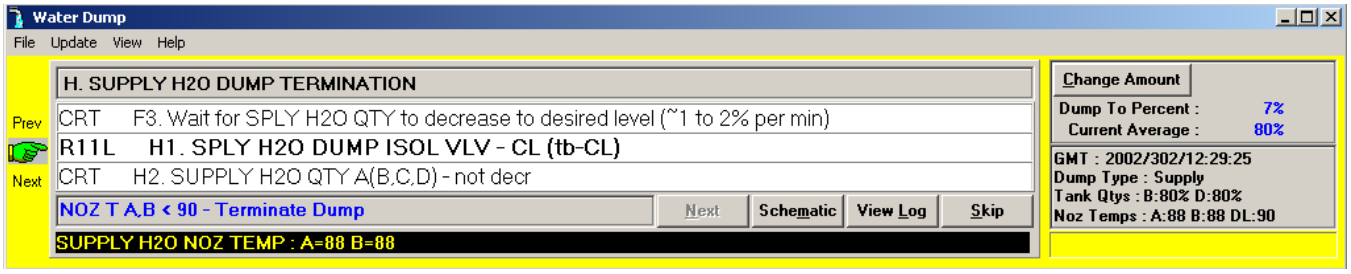


4.2.3.8 Step H: Supply H2O Dump Termination

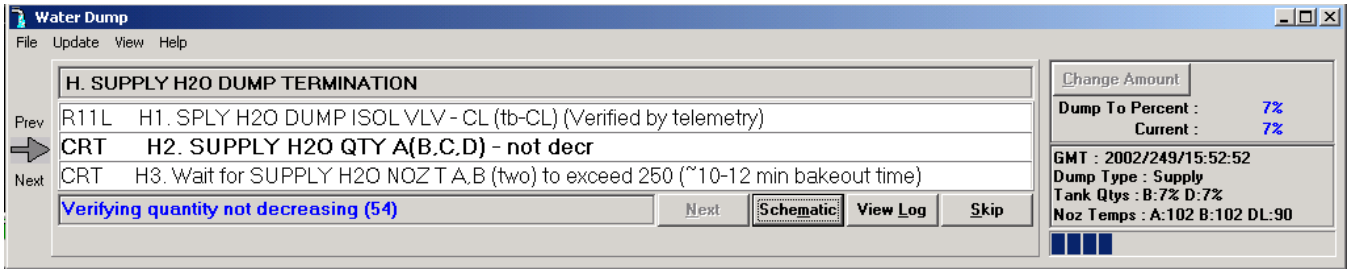
When at least one of the tank quantities is at the lower limit, another tone sounds and the background flashes bright green.



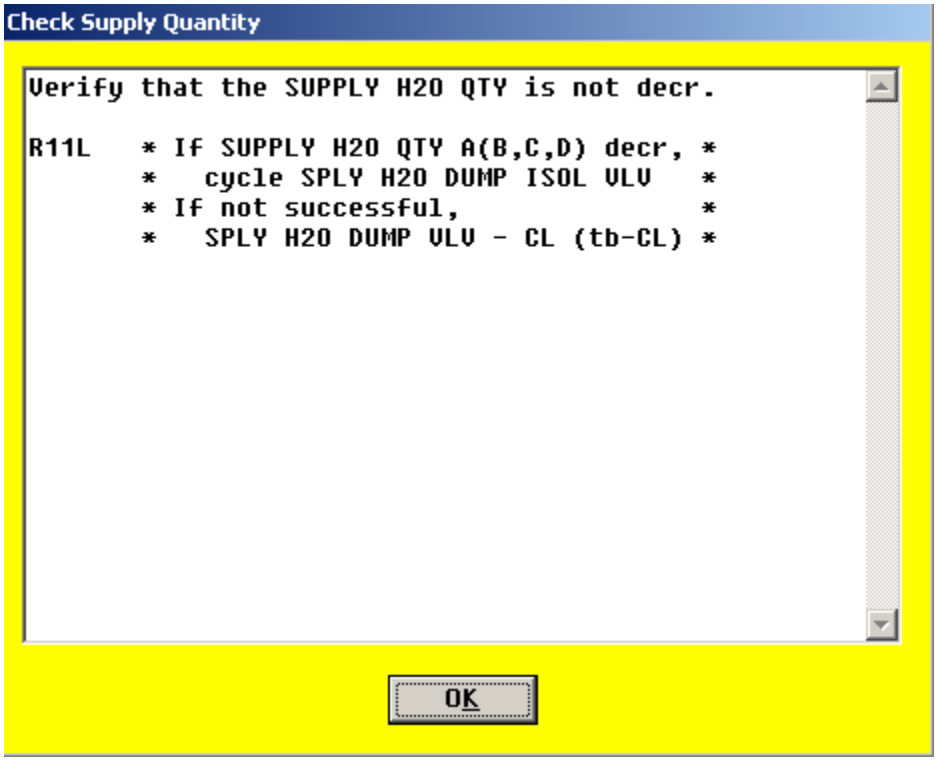
Alternatively, if the dump is required to be terminated early due to low nozzle temps, the background will flash yellow and give an audible alarm. The next step is to immediately terminate the dump by closing the dump isol valve, and then proceed to step H (dump termination). The crew should check with MCC about performing a supply dump through the FES to complete the dump.



The dump isol valve is closed (using the Control Panel if required) and then the program waits 60 seconds to verify that the tank quantities are not decreasing.

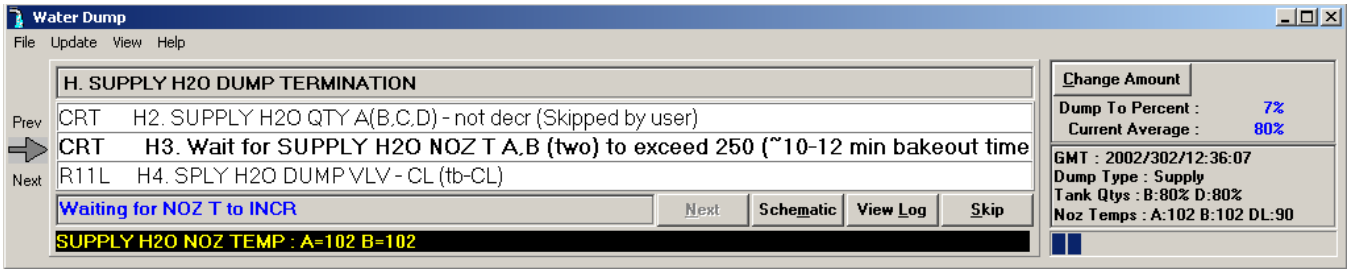


If the quantities do continue to decrease, a yellow warning box appears with actions

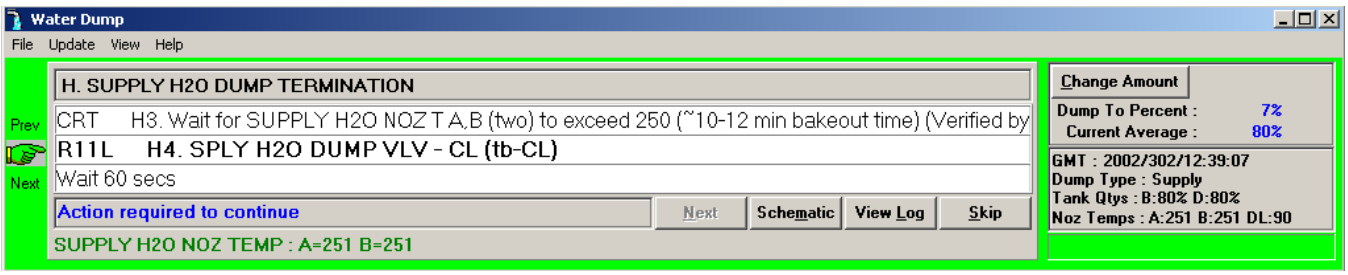


While water was dumping overboard, the pressure in the lines (31 psi) was greater than the cabin pressure (14.7 psi) so water did not come into the cabin and cabin air did not go overboard. Now that the dump isol is closed, air is flowing through the purge device that was plugged into the contingency cross-tie. This air is meant to purge the line so that water does not collect at the dump valve. Prior to using this purge device, water would freeze at the dump valve and crack the valve, causing trickle flow overboard.

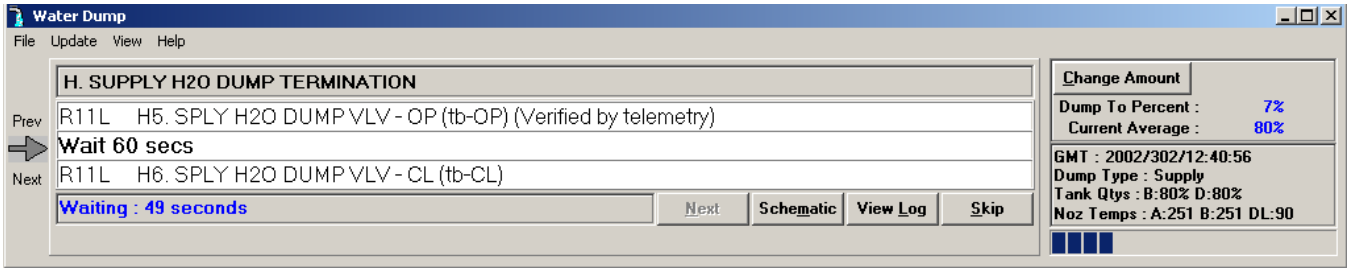
The dump isol valve is kept closed until the nozzle temperatures exceed 250 degrees for the bakeout of water in the lines. For standalone training, this must be done using the Control Panel demo.

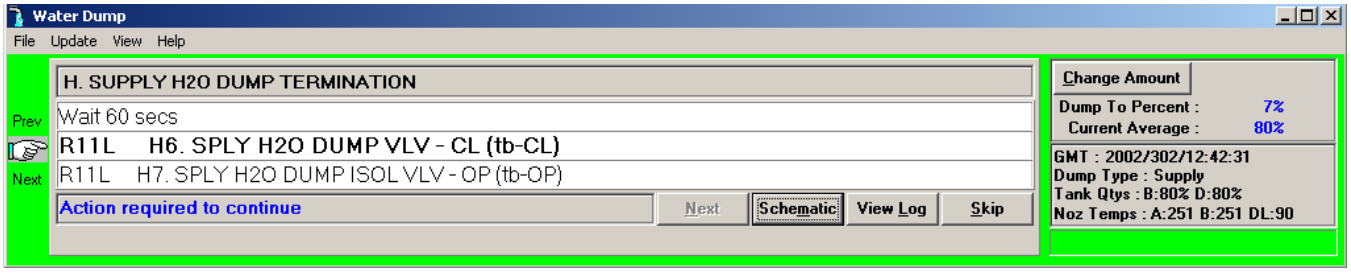


The background flashes bright green when that occurs.

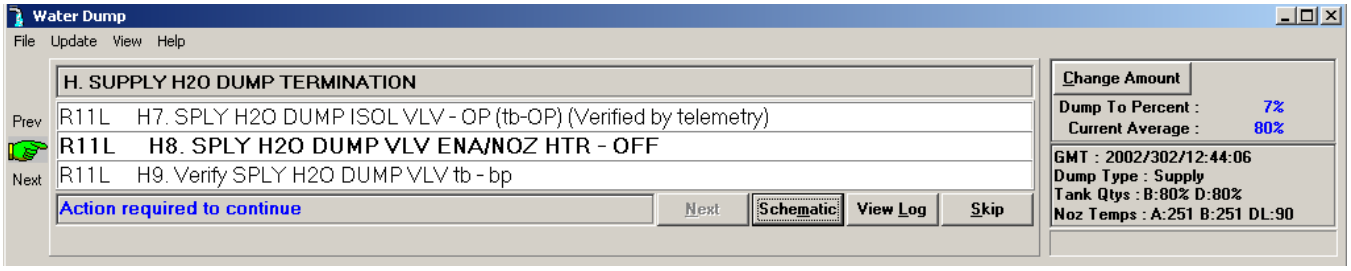


After the bakeout of the lines, the dump valve is cycled closed for 60 seconds (while the purge device pressurizes the line segment), then open for 60 seconds (while the purge device flows more air), then closed again. This will be reflected on the schematic if it is called up.



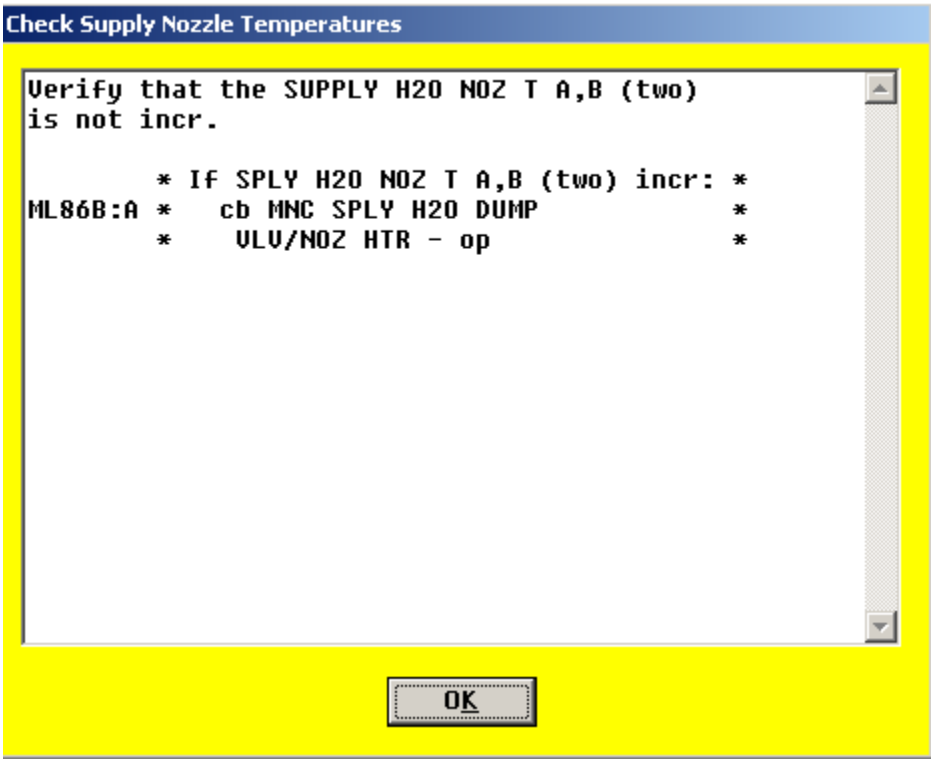


Once the dump isol valve is closed, the nozzle heater is turned off.

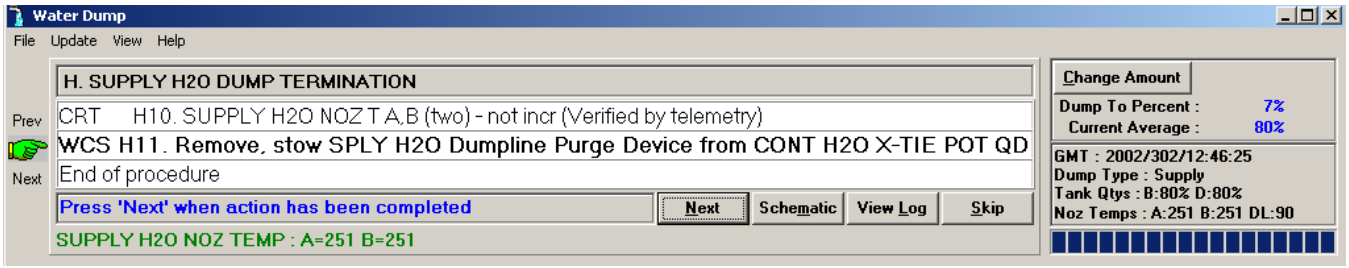


The program steps through each of these switch throws once the valve or switch position has been verified through telemetry. After 30 seconds, the temperatures are verified to be not increasing.

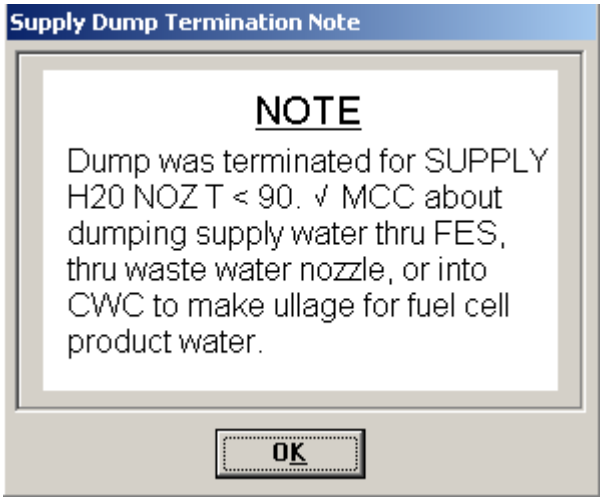
A yellow warning box appears if the temps are still increasing, with actions for the crew to disable the heaters.



The crew is reminded to remove the purge device and stow it until the next dump. The "Next" button completes the nominal dump procedures.

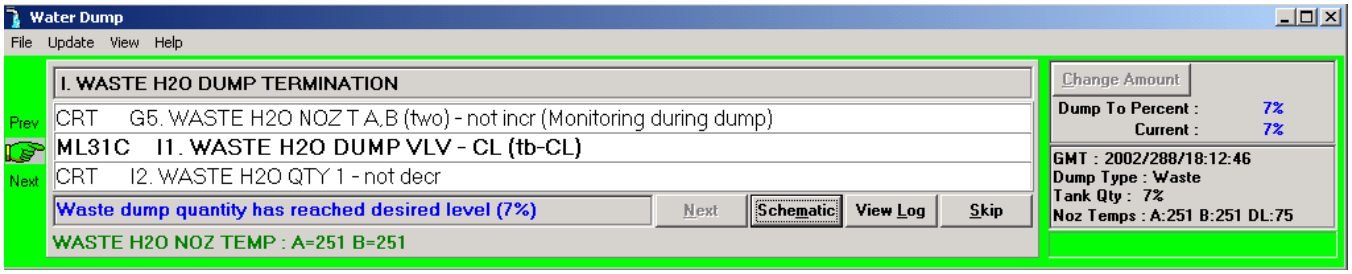


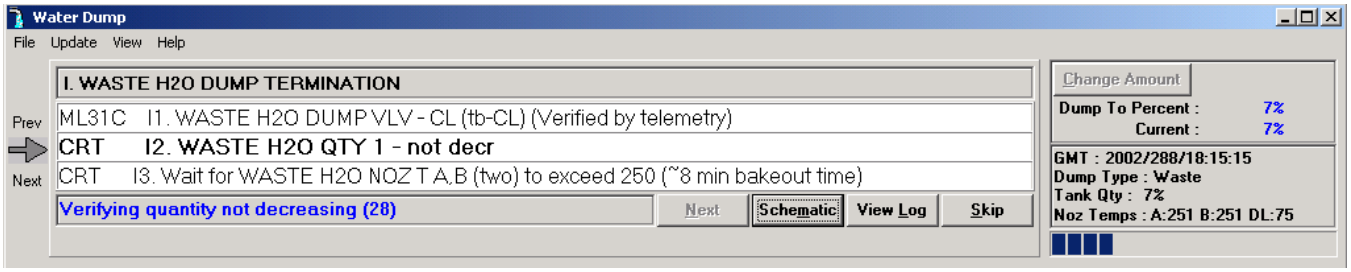
If the dump was terminated early due to low temperatures (suggesting that the water is freezing at the nozzles), a note tells the crew to check with MCC for future dump acations.



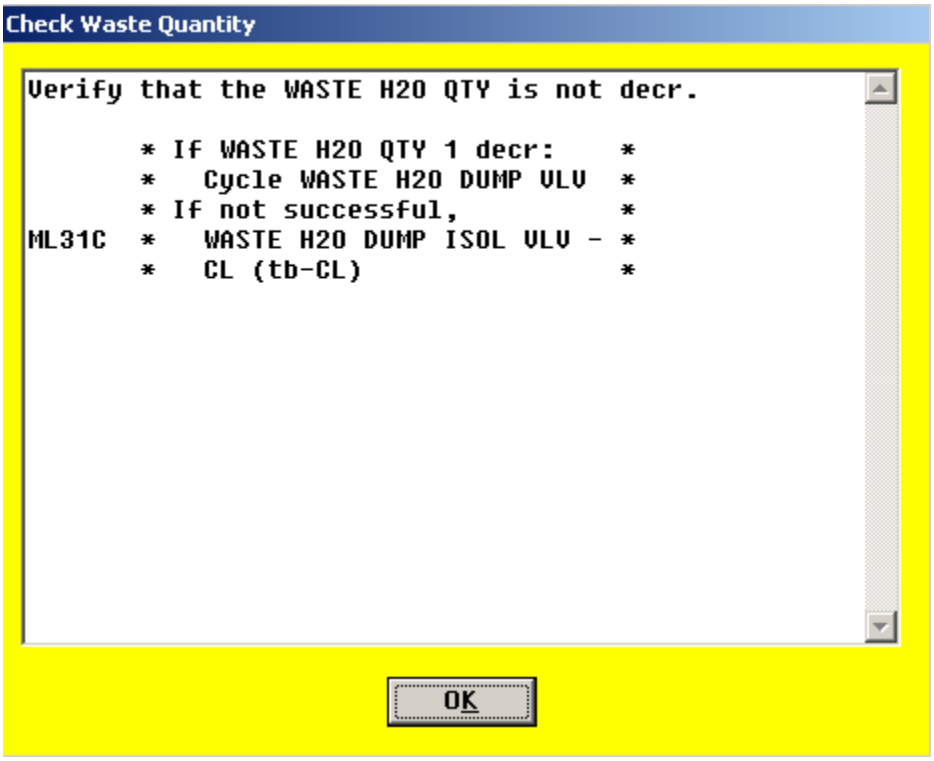
4.2.3.9 Step I: Waste H2O Dump Termination

When the appropriate point for terminating the dump (based on time or quantity) has occurred, it's time to close the waste dump valve. Then the program verifies that the quantity is not decreasing over 60 seconds.

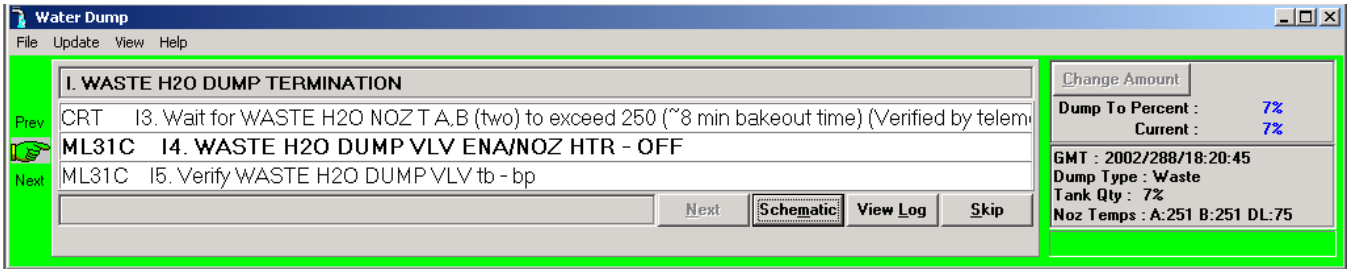




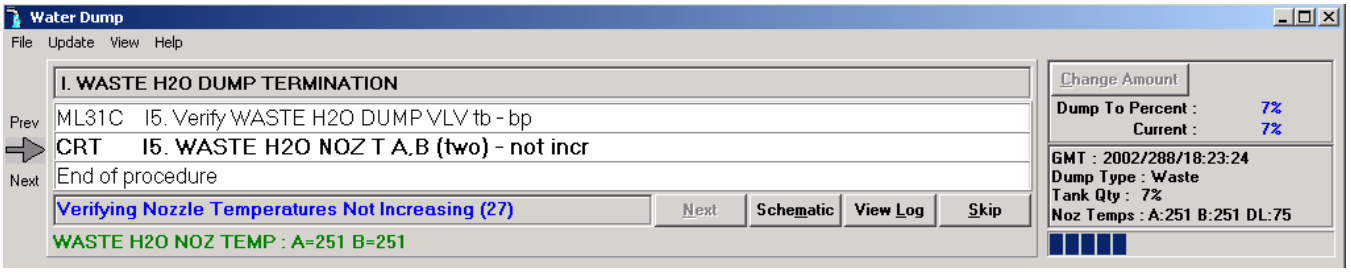
If the quantity does decrease, a yellow warning block appears to have the crew cycle the dump valve.



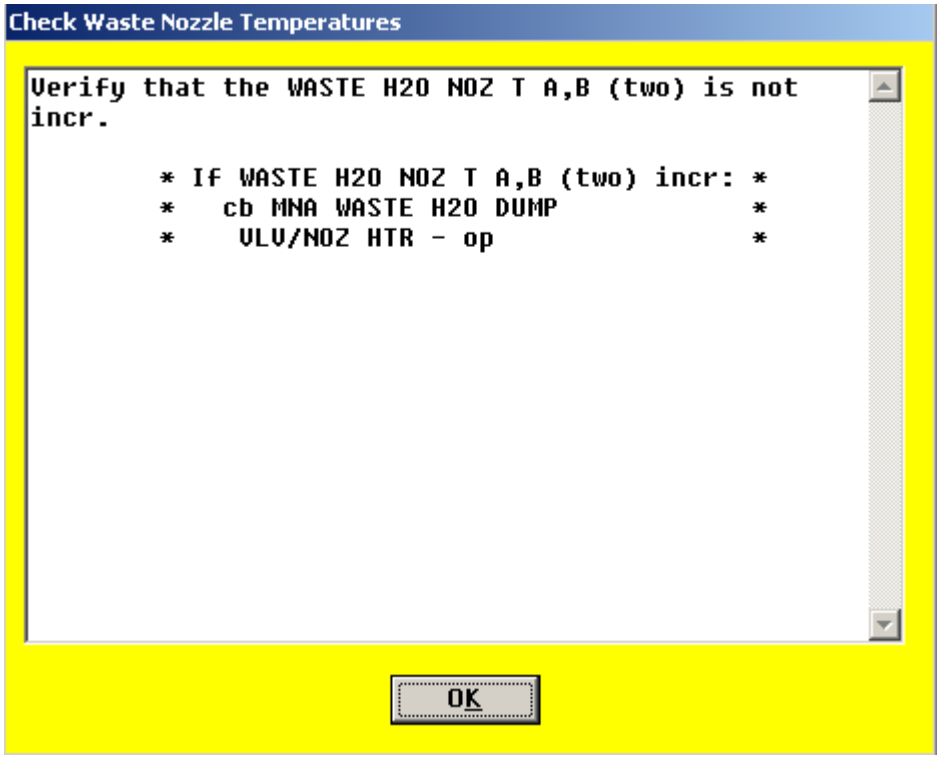
Meanwhile, the program is also monitoring the nozzle temps. When they exceed 250 degrees, the background flashes bright green. The next step is to turn the nozzle heater off.



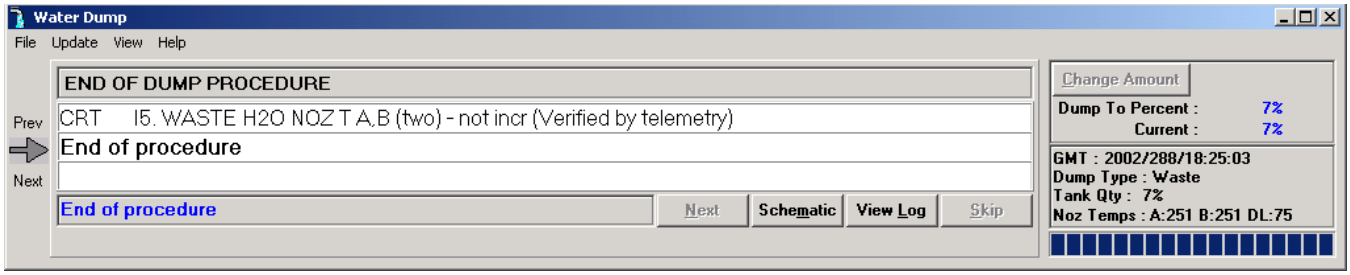
Once the dump valve talkback is verified to be barberpole, the program continues to monitor the temps to make sure they are not continuing to increase.



If the temps do rise, a yellow warning box appears with actions to disable the heaters.

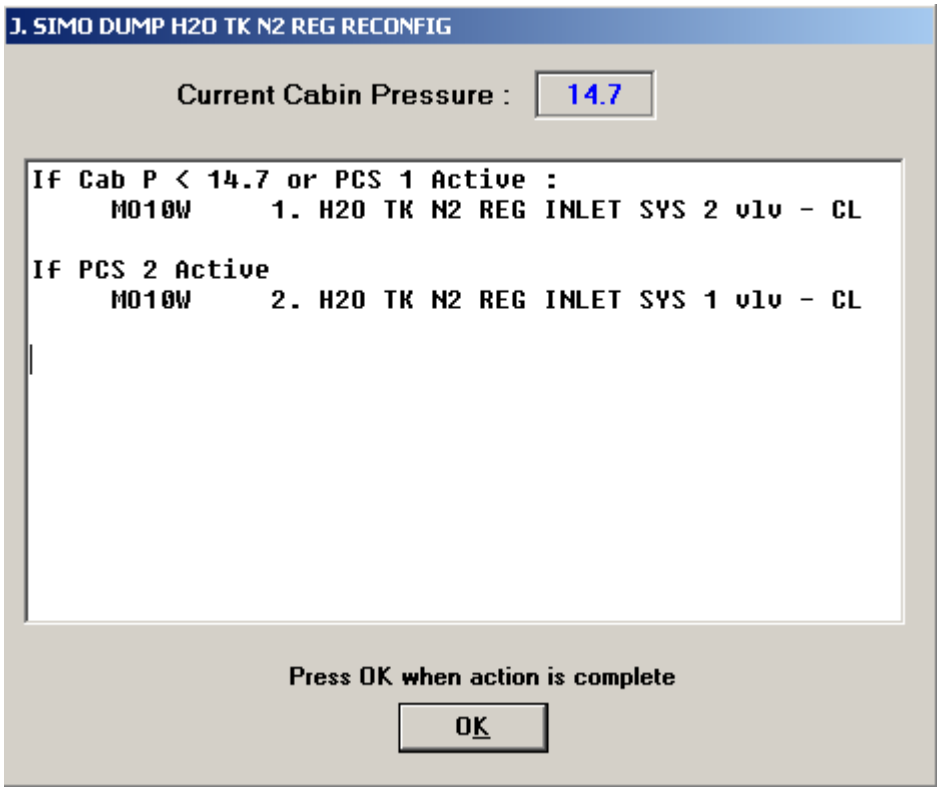


Finally, when it is determined that the heaters are indeed off, that's the end of the dump procedure!



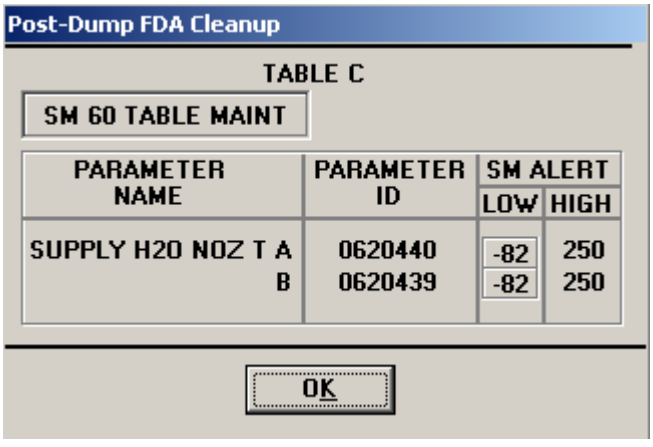
4.2.3.10 Step J: Simo H2O Tk N2 Reg Reconfig

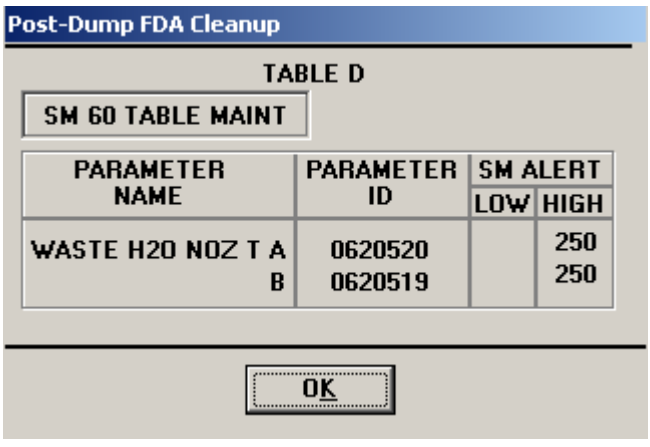
After both the supply and waste dumps are completed, reconfigure the N2 regs. These valves have no telemetry.



4.2.3.11 Step K: Post-Dump FDA Cleanup

A note says that if comm is available, MCC will reset the FDA limits If not, a window pops up with new limits that the crew should set.





Finally, the crew is reminded to check with MCC if dual heaters had been used during this supply and/or waste dump.