

16D BOP Accumulator Sizing and Performance Tool

Program Version 1.12

User Manual

Companion Tool for API Specification 16D, Second Edition, July 2004



Manual Revision History

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09	10 Dec 2013	Improved the wording of override of wellbore pressure explanation. Added the beginnings of a section on technical topics.
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1 DESCRIPTION OF PROGRAM AND MANUAL

The 16D BOP Accumulator Sizing and Performance Tool Program (Program, in this manual) is designed to accompany API Specification 16D, Second Edition¹ and make it easier to handle the accumulator sizing calculations described in the specification. It is not a substitute for the full Specification. Program users should already have access to and be familiar with Specification 16D, Second Edition.

The Program is designed to run under 32-bit and 64-bit Windows operating systems including Windows 2000, XP, Vista and 7. It should work properly under earlier operating systems back to Windows 95, but that is not guaranteed. Other requirements (memory, hard disk, etc.) are very modest compared to most Windows applications.

2 USER INTERFACE

This section describes features important to operating the software. Even if you are very comfortable with Windows program design, it is a good idea to read the section on Numeric Entry Fields, as you will be using them a lot and they have several helpful features.

2.1 General Layout

The Program is a typical Windows Multiple Document Interface (MDI) application. This means that within the main program window, several accumulator sizing projects can be opened at the same time in “MDI Child” windows.

2.2 Standard Windows Features

The Program is structured mostly with standard Windows controls that should be familiar to most users. These include the main menu, check boxes, radio buttons, command buttons, text and memo fields, and dialog boxes. Since these are common features of Windows programs, they will not be discussed here.

2.2.1 ToolTips (Hints)

Virtually all data entry fields have one line of help text associated with them called a “ToolTip.” To see the ToolTip for a field, just move the cursor over the place where you would enter data and wait one second for the ToolTip to appear.

2.2.2 Click, Double Click, and Right Click

These standard Windows mouse functions are described here only to define the terms used elsewhere in the manual. “Click” means to press the mouse button once. “Double click” means to press the mouse button twice in rapid succession. Click and double click are both done with the left mouse button. “Right click” uses the right mouse button.

2.3 Numeric Entry Fields

The numeric entry fields are not a standard Windows control. Though they resemble a standard text box, they include several useful features specifically for entering engineering quantities.

¹ Note: This program is published and supported by Interlink Systems, Inc. under a license agreement with API. API no longer warrants or supports this software. Address all questions or comments to Interlink Systems, Inc.
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2.3.1 Units of Measure

The most obvious difference between the numeric field and the text box is that the field has two separate parts: a number and a unit of measure. As a result, each input quantity can have its unit of measure specified independently from all of the rest, allowing any desired mix of English and metric values.

2.3.2 Mouse and Keyboard Interactions

2.3.2.1 Completely Manual Entry

You may highlight and type over the characters in a numeric field just like you would in any Windows text box. The control will check your entry for proper form and unit of measure and display an error dialog if a mistake is found.

2.3.2.2 Editing the Number

Move the cursor over the number and double click. The highlighting will allow you to simply retype the number without changing the unit of measure.

The use of a period or comma for the decimal point is controlled by the regional settings in Windows. You cannot control this from the Program. When entering numbers, you must conform to the regional settings selected for Windows. Thousands separators are optional when inputting a number, but, if used, must be correct (Ex: 1000.5 or 1,000.5 are OK in the US but 1,00 is not).

2.3.2.3 Changing the Unit of Measure

Move the cursor over the field and click the right mouse button. A menu will appear that contains all valid units of measure for the field. Click the unit you want to change to. The menu will disappear and the numeric part will be scaled to the new unit of measure.

You may also double click the unit part (which causes it to become highlighted) and then type in a new unit. However, if you do this, the new unit must be recognized as a valid unit for this field or you will get an error dialog box. Also, when you type in a new unit, the numeric part will not be scaled.

2.3.2.4 Formatting the Number

Put the mouse over the field and click the right mouse button. A menu will appear. At the bottom of the menu are the selections "Floating" and "Fixed Format." Click one or the other.

Floating format displays according to a built in set of rules and may include decimal points, and may use engineering notation with exponents.

2.3.3 Calculator Functions

Any time you can enter a number, you can instead enter an arithmetic expression. The field recognizes the operators + - * / and ^ (exponentiation), and allows parentheses like most common algebraic calculators. It also knows the symbol "pi".

For example, assume you are entering the volume of a cylinder 10" long and 3" in diameter. Instead of entering "70.69 cu-in", you can enter "(0.25*pi*3^2)*10 cu-in". When you press Enter or move the cursor to another field, the expression is evaluated.

3 GETTING STARTED

3.1 Parts of a Project

In general, a project consists of two parts: input data describing the stack and the environment, and a project equipment list, which contains descriptions of the various pieces of equipment making up the stack (valves, rams, connectors, etc.). Projects are stored in files with names of the form *.16D. Example project files are provided with the program, representing the examples in the Appendix (Accumulator Volumetric Design Examples) of API Specification 16D.

Any project must have an equipment list containing at least one piece of equipment. Equipment can be entered from scratch or can be imported from an equipment library. For equipment that will appear in more than one project, it is best to initially enter the equipment in a library and then import it to the project as needed. See “Equipment Libraries” below for more information.

3.2 API Design Examples and Errata

Along with the installation of the Program, data files are provided with this program corresponding to the 9 example cases in Annex C of the API 16D spec. These are useful in showing you how the program input and results relate to hand/spreadsheet calculation. The program results may have a small and negligible difference from hand calculation. This is due to round-off effects and to slight differences between the real gas equation of state model used by the program compared to the NIST gas property tables (used for the API 16D examples).

Some numerical typographical and printing errors exist in Annex C with the corrections as follows.

Page 67) *Fluid Densities and Head Pressures*: The sea water head pressure should be 3327 psig, not 3227 psig.

Page 81) *Example 5, Liquid Volumes table, Condition 3*: Total should be 398.0, not 557.3

Page 88) *Example 7 Performance Table*: Gas and liquid volume columns are incorrect.

The following list is correct:

Performance Table	Gas Volume, gal	Liquid Volume, gal
Precharged accumulators @ surface	938.4	0.0
Condition 0: Precharged accumulators	938.4	0.0
Condition 1: Charged	669.6	268.8
Condition 2 MOP: Casing Shear Ram BOP	730.3	208.1
Condition 2 MOP: Blind Shear Ram BOP	765.1	173.3
Condition 2 MOP: LMRP Connector	779.6	158.8
Condition 3: Fully discharged	883.3	55.1

(continued)

Page 91) Example 8, *Performance Table*: Gas and liquid volume columns are incorrect. The following list is correct:

Performance Table	Gas Volume, gal	Liquid Volume, gal
Precharged accumulators @ surface	607.2	0.0
Condition 0: Precharged accumulators	607.2	0.0
Condition 1: Charged	391.1	216.1
Condition 2 MOP: Casing Shear Ram BOP	451.6	155.6
Condition 2 MOP: Blind Shear Ram BOP	486.8	120.4
Condition 2 MOP: LMRP Connector	501.6	105.6
Condition 3: Fully discharged	607.2	0.0

3.3 Quick, Step-by-Step Instructions to Create a New Project

To create a new project, you must fill in several data fields and have at least one piece of equipment listed as part of the BOP Stack. In order to build the stack, at least one piece of equipment must be listed in the project equipment list to select from. The following sections briefly outline how to create a project, get equipment into it, and fill out a BOP Stack.

3.3.1 Create a New Project Using an Equipment Library

3.3.1.1 Import All Equipment Items from a Library into the Project.

- Create a new project (Menu: File / New Project).
- Click the title bar of the new project so that it is highlighted.
- Open the equipment list for the new, as yet unnamed project (Menu: Equipment / Edit Project Equipment).
- Import equipment from a library² (Menu: Equipment / Import Eqpt from Library). When you choose the library you want to import from, it will be opened, all equipment copied to the project, and then closed, leaving the project and project equipment list open.
- Close the Project Equipment list window.
- Fill in data on the Project, Surface and/or Subsea, and Options tabs. Save the project after filling in each tabbed page (Menu: File / Save).
- Click the BOP Stack tab and add elements to the stack in the order that they will be operated (order is not important for API stacks, only for rapid charge or discharge).
- Save the project (Menu: File / Save).
- Press the F9 key or click the Summary, Notes, or Performance tabs to calculate the results.

3.3.1.2 Import Only Selected Equipment Items from a Library into the Project

- Open an equipment library file that will supply the equipment data (Menu: Equipment / Open Library).
- Create a new project (Menu: File / New Project).
- Click the title bar of the new project so that it is highlighted.
- Open the equipment list for the new, as yet unnamed project (Menu: Equipment / Edit Project Equipment).
- Use Copy-Paste or Drag-Drop to move equipment items from the library equipment list to the project equipment list (see Copy from Another Library, below).
- Close the Library window.
- Close the Project Equipment list window.
- Fill in data on the Project, Surface and/or Subsea, and Options tabs. Save the project after filling in each tabbed page (Menu: File / Save).

² Note: See the sections entitled “EQUIPMENT LIBRARIES” and “Edit or Input by Hand”

- Click the BOP Stack tab and add elements to the stack in the order that they will be operated (order is not important for API stacks, only for rapid charge or discharge).
- Save the project (Menu: File / Save).
- Press the F9 key or click the Summary, Notes, or Performance tabs to calculate the results.

3.3.2 Create a New Project Starting with Another Project

3.3.2.1 Copy the Whole Project

- Open the project that you are using as the starting point (Menu: File / Open Project).
- Save it with another file name. This will save all of the original project data and its project equipment list in a new file without changing the one you started with. Notice that the file name in the title bar will change to the new file name (Menu: File / Save As).
- Change the data that needs to be changed in the new project.
- Save the project (Menu: File / Save).

3.3.2.2 Only Use Another Project's Equipment List

- Open the donor project (the one that will supply the equipment) (Menu: File / Open Project).
- Open the equipment list for the donor project (Menu: Equipment / Edit Project Equipment).
- Create a new project (Menu: File / New Project).
- Click the title bar of the new project so that it is highlighted.
- Open the equipment list for the new, as yet unnamed project (Menu: Equipment / Edit Project Equipment).
- Use Copy-Paste or Drag-Drop to move equipment items from the donor project equipment list to the new project equipment list (see Copy from Another Library, below).
- Close the donor project equipment list window.
- Close the new project equipment list window.
- Close the donor project window.
- Fill in data on the Project, Surface and/or Subsea, and Options tabs. Save the new project after filling in each tabbed page (Menu: File / Save).
- Click the BOP Stack tab and add elements to the stack in the order that they will be operated (order is not important for API stacks, only for rapid charge or discharge).
- Save the project (Menu: File / Save).
- Press the F9 key or click the Summary, Notes, or Performance tabs to calculate the results.

3.3.3 Create a New Project Entering Equipment by Hand

- Create a new project (Menu: File / New Project).
- Click the title bar of the new project so that it is highlighted.
- Open the equipment list for the new, as yet unnamed project (Menu: Equipment / Edit Project Equipment).
- Use the New Item button on the Project Equipment list window to create new pieces of equipment as necessary.
- Close the Project Equipment list window.
- Save the project (Menu: File / Save).
- Fill in data on the Project, Surface and/or Subsea, and Options tabs. Save the new project after filling in each tabbed page (Menu: File / Save).
- Click the BOP Stack tab and add elements to the stack in the order that they will be operated (order is not important for API stacks, only for rapid charge or discharge).
- Save the project (Menu: File / Save).
- Press the F9 key or click the Summary, Notes, or Performance Tabs to calculate the results.

3.3.4 Entering or Changing the BOP Stack Components

Click the “BOP Stack” tab of an open project. This shows the list of components in the stack and some buttons to use for modifying the list. Common actions are described below.

3.3.4.1 Enter New Stack Components

- Click the Add button.
- In the resulting dialog box, type in the description of the component (like Upper Pipe Ram or Upper Outer Kill Valve).
- Use the pull down list to select the equipment to be used for this component. The equipment must have already been entered into the project equipment list.
- Press OK to enter the new component into the stack or press Cancel to abandon the new component without putting it into the stack.

3.3.4.2 Change One That Is Already There

- Double click the stack component you want to change.
- Enter a new description and/or select a different piece of equipment.
- Press OK to save the new component description or press Cancel to leave the component unchanged.

3.3.4.3 Delete a Component from the Stack

- Click a stack component to highlight it.
- Click the Delete button. Be careful. No confirmation will appear; it just goes away.

3.3.4.4 Change the Order of the Components

- Click a stack component to highlight it.
- Click the up or down arrows (Illustrated at the right) to move the component up or down in the stack.



3.4 Setting Default Units of Measure

3.4.1 English vs. Metric

New projects start out with English units for all quantities. You may convert all units of measure in a project to English or metric with a single mouse click. The buttons to do this are found in the lower left corner of the “Project” tab of an open project window. When you press one of the buttons, a warning message is displayed, giving you the chance to change your mind.

Using this feature will affect every numeric field. Afterward, you will still probably need to set the units of some fields since it may not pick the unit you actually want. Also, manually setting the units of specific fields is the only way to use mixed units.

3.4.2 Mixed Units

If you have a specific set of mixed units that you like to use, make a project containing typical but junk data with the units of measure and display format that you prefer. Then, to make a new project, use the dummy project as detailed in “Create a new project starting with another project,” above.

4 EQUIPMENT LIBRARIES

Equipment libraries are stored in files with names in the form *.16DLIB. Each file contains one or more pieces of equipment (valve, ram, etc.) that can be used in a BOP stack. You may make your own libraries, or you may use libraries created by equipment manufacturers (ask them) or others. An example generic library is provided with the program.

4.1 Equipment Library Window

The Equipment Library window consists of tabbed pages on the left, display-only fields on the right, and command buttons at the bottom. These parts are described in the following sections.

The Equipment window has several command buttons that may appear, depending on the context. The Help? button is always there. Clicking this button brings up a dialog with brief reminders of how to use the library.

4.1.1 Comments

The Comments tab allows you to describe the library in any way you wish. Things like where the data came from, who compiled it, how, when, special considerations or warnings, etc., should all be in this comments section.

4.1.2 Equipment

The Equipment tab shows the pieces of equipment contained in the library. Click on a piece of equipment, and its data will appear in the field to the right. To change any of that data, double click the piece of equipment.

Note: See the *Edit or Input by Hand* section for the effect of changing descriptive data.

4.1.3 History

Each time you save a library file, you will be asked for a new version number and date, and a description of what was changed. This information is stored with the library, and the descriptions—along with the version numbers—appear in the list under the History tab. Over time, the History tab will build up a listing of all changes made to the library so that you can associate a version number with a specific set of changes.

4.2 Importing

To combine equipment libraries, there is a provision for copying the entire contents of a library into another library or a project equipment list. This is referred to as “importing” a library.

To import an equipment library, the library (or project equipment list) that is to receive the imported equipment must be open and highlighted. You then will be able to select Import Eqpt from Library from the Equipment menu.

4.2.1 Import into a Library

- Open the destination library for editing (Menu: Equipment / Edit Library or Equipment / New Library).
- Import equipment from the library (Menu: Equipment / Import Eqpt from Library). When you choose the library you want to import from, it will be opened, all equipment copied to the destination library, and then closed, leaving the destination library open for further editing.
- Edit or import another library, as desired, and then save the destination library (click the Save or Save As button).
- Close the window.

4.2.2 Import into a Project Equipment List

- Open a project (Menu: File / Open Project).
- Click the title bar of the project so that it is highlighted.
- Open the equipment list for the project (Menu: Equipment / Edit Project Equipment).

- Import equipment from the library (Menu: Equipment / Import Eqpt from Library). When you choose the library you want to import from, it will be opened, all equipment copied to the project, and then closed, leaving the project and project equipment list open.
- Close the Project equipment list window.
- Save the project (Menu: File / Save).

4.3 Edit or Input by Hand

To create your own library from scratch, select Equipment from the main menu and then New Library. A blank Equipment Library window will appear, in which you can enter equipment as you wish, or import another library as described above. Be sure to use the “Save” and “Save As” buttons on the window periodically and when you have finished entering data.

You may edit the equipment data in any library. Simply select Equipment from the main menu and then Edit Library. A dialog box allowing you to select the desired file will appear. Once you select the file, it will be opened and the contents displayed in an Equipment Library window. Double click a piece of equipment to change its parameters.

Important Note: If you edit a piece of equipment and change any item in the description section, you are creating a new piece of equipment, not editing an existing one. After changing all or part of the description, a piece of equipment containing the new description appears in the Equipment list. This is not the case with the items in the technical data section, which are treated as changes to the same piece of equipment.

Example: You begin with an Acme 5" valve with a 1 gallon actuator. Suppose you edit the valve and change Acme to "Pinnacle". Pinnacle and Acme are not the same... you have created a new valve called a Pinnacle 5" valve with a volume of 1 gal. Suppose instead that you edit the Acme 5" valve and change the volume to 1.3 gal. It is still an Acme 5" valve, since you made no changes to the Description and only updated the volume.

4.4 Copy from Another Library

Individual items of equipment can be moved easily back and forth between equipment libraries and project equipment lists. These instructions are written for copying equipment from a library to a project equipment list, but they will work just fine when used to copy between two libraries, two project equipment lists, or from a project equipment list to a library.

4.4.1 Copy and Paste

Copy and paste is most useful when your screen is crowded and it is not easy to see both the source library and destination equipment list at the same time.

- Open the destination project (Menu: File / Open Project) or open a destination library for editing (Menu: Equipment / Edit Library).
- In the case of a destination project, open its Equipment list (Menu: Equipment / Edit Project Equipment).
- Open the source library (Menu: Equipment / Open).
- Click on the source Equipment list so that its title bar is highlighted.
- Click on the Equipment tab.
- Click on the desired piece of equipment so that it is highlighted.
- Press Ctrl-C to copy.
- Click on the destination Equipment list so that its title bar is highlighted.
- Click on the Equipment tab.
- Click in the white equipment list area underneath the Equipment tab. It is OK if an existing piece of equipment is highlighted. It will not be replaced.
- Press Ctrl-V to paste.

- Repeat as necessary.

4.4.2 Drag and Drop

- Open the destination project (Menu: File / Open Project) or open a destination library for editing (Menu: Equipment / Edit Library).
- In the case of a destination project, open its Equipment list (Menu: Equipment / Edit Project Equipment) and click on the Equipment tab, so that the Equipment list is visible.
- Open the source library (Menu: Equipment / Open) and click on its Equipment tab, so that the Equipment list is visible.
- Position the two Equipment list windows so that both are visible at the same time.
- Click on the desired piece of equipment in the source list and hold the left mouse button down.
- Move the cursor over the destination list. The cursor will change from a circle with a bar to an arrow with a square. Release the mouse button to drop a copy of the equipment in the destination.
- Repeat as necessary.

5 PROJECTS

5.1 Project Data

Project data includes all data except the list of equipment. This section contains comments on some of the data fields.

5.1.1 Project Tab

5.1.1.1 Project Has Subsea Equipment

Check this box if the stack is subsea. This box controls the visibility of the Subsea and Fluids/Depths tabs.

5.1.1.2 Type of System

“Full API stack...” means a stack subject to the volumetric capacity requirements of section 5 of API 16D. It may have accumulators on the surface, subsea, or both. There is no provision for rapid charge cases.

“Other Design” means a system in which the user specifies the equipment to be operated. The program verifies sufficient fluid volume for each step in the stack sequence. It may have accumulators on the surface or subsea, but not both. Rapid discharge systems also give the option of using rapid charge.

5.1.1.3 Convert All Quantities to...

These buttons allow you to convert all data fields in the whole project to standard English or metric units of measure. The section “Setting Default Units of Measure” above has more information on these buttons.

5.1.1.4 Accumulators Are Isolated...

This box controls the selection of pressure at the start of the discharge. If it is checked, then the discharge starts at the pump stop pressure. Otherwise, the discharge starts at the pump start pressure.

5.1.2 Surface and Subsea Tabs

Input data fields for pump start and stop pressures (Surface tab), accumulator bottle properties (including precharge gas—nitrogen or helium), environmental temperatures, and any user determined minimum functional volume requirement for subsea accumulators.

Select options for calculation method (A, B, or C) and for precharge and number of bottles (calculated or user input).

Calculation Methods (per Specification 16D): A—Ideal Gas Isothermal; B—Real Gas Isothermal; and C—Real Gas Adiabatic.

5.1.3 BOP Stack Tab

5.1.3.1 Override Wellbore Pressure

The Wellbore Pressure for all design cases will be based on the rated working pressure of the rams unless the user overrides it with another entry. There is no API guidance on what the optional override pressure entry can be, but the intent is for a user to be able to impose a lower Wellbore Pressure for a specific application. In accordance with the definition in 16D section 3.16, the Wellbore Pressure used in the calculations is the lowest of:

- Lowest rated ram BOP pressure
- Lowest rated BOP pressure (if there are no rams)
- Operator entered wellbore override pressure

For all cases (API Stack and Other), the Wellbore Pressure value is used with the ram Closing Ratio to determine Minimum Operating Pressure (MOP) of rams.

5.1.3.2 User Specified Minimum Operating Pressure

Entering a pressure greater than 0 here will specify a lower limit on the MOP that the program uses, even if the equipment does not require that much pressure. The MOP used by the program will always be the greater of the highest equipment MOP requirement or the user specified value.

5.1.3.3 Stack Components

The section “Entering or Changing the BOP Stack components” above has details on how to enter the stack components.

5.1.3.4 Minimum Operating Pressure for Shear Rams

Shear rams present a special case in that the shearing pressure depends on the tubular to be sheared. These operating pressure values, like other properties, are generally obtained from the ram manufacturer.

For an “Other design” Type of System, this is handled by creating a separate equipment item for each drill pipe/tubular shear data case of the shear ram and entering the required shearing pressure in its “Minimum Component Operating Pressure” field and entering an appropriate description under the “Submodel” data field.

The different descriptions (i.e., in Submodel) will force the library editor to create different pieces of ram equipment for each tubular entered. An example follows:

- Enter a shear ram shearing on tubular X.
- Edit that shear ram, changing the description and changing the pressure to that for shearing on tubular Y. This creates another shear ram with a different shear pressure.
- Repeat as many times as you want for tubulars X, Y, Z, T, etc.

- In the BOP stack list, add a stack component called Shear Ram (if it is not already there), and select equipment X for it.
- Run your calculation.
- To see what it would do with tubular Y, double click the shear ram and change the equipment field to Y.
- Run your calculation again.

For an “API Stack” Type of System, Specification 16D does not require that the shearing pressure be considered and therefore the Minimum Component Operating Pressure (which may contain shear pressures) of all ram-type of equipment is not considered by the program for such designs. However, if the user wishes to have the shearing pressure also considered in setting the MOP, enter the required shearing pressure in the “User specified minimum operating pressure” data field on the BOP Stack tab.

5.1.4 Options Tab

5.1.4.1 Additional Volumes

In the case of API stacks, the program will always use at least the minimum volume criteria specified in 16D. If you want to include additional volumes, place the appropriate check marks in this section.

In the case of non-API stacks, you must place check marks in this section for the equipment that you want to operate. If you want to open and close a piece of equipment but at different places in the specified sequence, it will be necessary to define two different pieces of equipment: one with only an opening volume and another with only a closing volume. Enter a descriptive phrase (i.e., “Open only” and “Close only”) in the Submodel description to keep the two equipment pieces separate.

5.1.4.2 Units and Formatting for Use with Computed Output

Specify units of measure and formatting options for all computed quantities that do not have an on screen field dedicated to them.

5.1.5 Summary Tab

All the information on this tab is computed. Clicking the tab automatically causes a recalculation of the results, if needed.

5.1.6 Notes Tab

5.1.6.1 Technical Notes

The technical notes are included to give additional information on the internal details of the calculations. They can be ignored if you judge them to be acceptable or unimportant for the design case being analyzed.

5.1.6.2 Technical Warnings

Technical warnings are serious errors that possibly invalidate the results of a calculation because of Specification 16D requirements or technical/program issues. If there are any technical warnings, look at them closely and determine how to resolve the problems.

5.1.7 Performance Tab

Displays two tables of volumes, pressures, temperatures, and gas densities for each charging and discharge step. Lower table shows how discharged fluid volume compares to FVR (Functional Volume

Requirement) and whether each FVR is met. An explanation of the information in each column is included here.

5.1.7.1 Performance Table

Clicking the help button near the upper right corner of the Performance Table brings up a window containing a summary of the following information. Note: Surface and subsea bottles are listed separately in this table, not combined.

- **Functional Step**—This column indicates the state of the accumulator. For any line starting with “Condx 2;” this is the condition of the accumulator associated with operating the named stack equipment item (see Bottle Press for more detail).
- **Temp**—This is the average temperature in the accumulator at the end of this step, when the accumulator has been discharged to *Bottle Pres*.
- **Bottle Pres**—These two columns indicate the absolute and gauge pressure in the accumulator at the end of this step. Note that in the case of “Condition 2;” this pressure is normally the MOP for the equipment item. The strategy of the program is to drain the accumulator to the MOP (or until empty) and then see if enough fluid was supplied. The only place that cumulative required volume is listed is in the Liquid Volumes table, FVR column.
The psig column shows surface equivalent pressure relative to the control fluid head for a subsea accumulator and relative to 1 atm for surface accumulator.
- **Gas Vol**—The volume of gas present in the accumulator (total of all bottles) after being discharged to *Bottle Pres*.³
- **Liq Vol**—The amount of liquid actually remaining in the accumulator (total of all bottles) after being discharged to *Bottle Pres*.³
- **Gas Dens**—The density of the gas when the accumulator is discharged to *Bottle Pres* and is at the listed *Temp*.

5.1.7.2 Liquid Volumes

All numbers in the table have the unit listed after the “Liquid Volumes” heading. Clicking the help button near the upper right corner of the Liquid Volumes Table brings up a window containing a summary of the following information.

- **Condition 1**—This row contains the actual volume of fluid in the accumulators when fully charged.
- **F_p, F_v**—These are the pressure and volume design factors as defined in API 16D. Actual fluid volumes delivered by the bottles are divided by these factors to get the permissible design volume.
- **Condition 2 (MOP)**—This row contains the actual fluid volume remaining in the accumulators when discharged to the MOP. Also listed on this line is the pressure limited design factor (Fp) to be applied to the actual volume.³
- **dV 1 to 2**—This row is associated with the row immediately above it and gives the volume of fluid delivered by the accumulators when discharging from fully charged (condition 1) to the MOP (condition 2). This is called the pressure limited volume.³
- **Condition 3**—This row contains the actual volume of fluid left in the accumulators when discharged. This is usually 0.0, but does not have to be. The accumulator is “discharged” when its pressure reaches the hydrostatic pressure of the sea, even if there is fluid left in the accumulator.

Also listed on this line is the volume limited design factor (Fv) to be applied to the actual volumes.

³ Prior to Revision 1.12 some cases would blindly calculate the pressure limited volume even if that drained the accumulator past empty. This would result in Gas Vol > total accumulator volume, Liq Vol negative, and dV1 to 2 too large. This was corrected in Version 1.12.

- **dV 1 to 3**—This row is associated with the row immediately above it and gives the volume of fluid delivered by the accumulators when completely discharged (condition 1 to 3). (See Surface and Subsea Actual and Surface and Subsea Adjusted below for more details).
- **Functional Step**—This column indicates the state of the accumulator. Each equipment item in the sequence gets two lines. The content of the two lines is given under the appropriate column heading.
- **Surface and Subsea Actual**—For Condition 1, these columns show the amount of fluid left in the accumulator at the end of the step and occupy a single line. However, each equipment item in the stack sequence and also the discharged condition (Condition 3) have two lines associated with them.
 - The first line is the amount of fluid left in the accumulator at the end of the step (see Condition 2 and 3 above).
 - The second line always begins with “dV 1 to ” and it always shows the change in fluid volume between Condition 1 and Condition 2 (see dV 1 to 2 and 3 above). Remember that Condition 2 is when the accumulator has been discharged all the way to the MOP for the equipment item.
- **Surface and Subsea Adjusted**—These two columns indicate the *Surface and Subsea Actual* delivered volume (dV, the volume change from condition 1 to condition 2 or 3) after being divided by the volume factors, F_p or F_v . This is the delivered volume that API 16D allows you to count in the total of available fluid.
- **Total**—This is the sum of the *Surface and Subsea Adjusted* columns. This is the total delivered volume, counting both surface and subsea accumulators, that API 16D allows you to count as available fluid. This must be greater than or equal to the volume that is actually required by the equipment (*FVR*).
- **FVR**—This is the amount of liquid required to complete this step in the stack sequence. This includes the total amount of fluid needed for this stack equipment item and all of those that precede it in the sequence.
- **OK?** —This will be Yes or No, depending on whether the accumulator supplies enough fluid to complete this step.

5.1.8 Calculator Tab

See the Gas Law Calculator section.

5.2 Project Equipment List

The Project Equipment list is not shown in the project window. It is accessed via the main menu by clicking the project window and then choosing Menu:Equipment / Edit Project Equipment. The Project Equipment list appears in another window similar to an equipment library window.

You must enter project equipment before you can define the BOP stack. The step-by-step instruction section above shows examples of how to enter project equipment items.

6 GAS LAW CALCULATOR

The gas law calculator allows you to do basic gas law calculations on a mass of gas. There is no concept of a “bottle” in the calculator. You simply have a volume of gas that you can compress or expand in various ways.

6.1 Gas Starting Conditions

Begin by entering starting conditions. The type of gas (which can be ideal) and the calculation method will put limits on other choices you can make.

6.2 Desired End Condition

Check the quantity you want to specify as the end condition and enter its value.

6.3 Ending Gas Conditions

This section holds the calculated condition of the gas at the end of the change. Press the Calculate button to fill in the fields.

If you want to use these ending conditions as the starting conditions of another change, then press the Copy To Start button.

6.4 Volume Change Summary

This section translates a gas volume change into a fluid volume change. The two fields list the change that occurred in the last calculation, and also a running total of all changes since the last reset.

7 TECHNICAL TOPICS

7.1 Minimum Operating Pressure (MOP)

MOP is defined and handled differently for Full API stacks as opposed to “other design” systems. You can find information on this in sections 5.1.3.1, 5.1.3.2, and 5.1.3.4. There is a field to allow you to set an MOP independently of the equipment; it is found on the BOP Stack tab.

8 CUSTOM PRINTING

There is a limited facility in the API 16D Sizing program for customized printouts. This section describes the options available.

8.1 Custom Print Formats

The Program has a fixed output format. If you want to have the data printed in a different way, you have two options: manipulate an output file or start with the raw project data.

The Program will send output to a printer, but it also has other destinations, including file output to HTML, RTF (rich text format), and plain text files. These can be modified in a word processor. For a more automated approach that can be applied to multiple output cases, It is possible, although tedious, to write software that will automatically modify these output files, taking out items that you do not want and adding in items (like letterhead or logos) that you do want.

Alternatively, a custom PC application can be written to prepare fully customized output from the project file itself that contains all of the information needed. The project file can even be used to input data to custom software doing other types of calculations. Information that will help in such a program development is in the “Data File Structure” section below.

8.2 “Custom Print” Main Menu Command

On the main menu of a project window, the selection “Custom Print” appears. It is normally greyed out and without function. If you write a customized print program, this menu item allows you to start that program directly from the sizing program.

8.2.1 Enabling the Custom Print Menu Item

The Custom Print menu item is enabled using the Options main menu item. (Menu: Options / Custom Print). This brings up a dialog box allowing you to select the custom printing program.

To enable the Custom Print menu item, you must check the box, select the executable file using the open dialog box that appears, and then press the "Accept" button. To change the name of a program that is already there, uncheck the box and then check it again by clicking it twice. The Program uses the string value as the *lpFile* parameter of a call to the Windows 32 API function ShellExecute.

8.2.2 What Custom Print Does

When you click Custom Print, the sizing program runs a calculation just as if you had pressed the F9 key. It then saves the project. Then it makes a call to the Windows 32 API function ShellExecute to start your custom print program. One parameter is passed to your program via *lpParameters* in ShellExecute. It is the complete path and file name of the project file (Example: c:\projects\API 16D\Example 1.16D).

9 DATA FILE STRUCTURE

9.1 General Comments

Project files, when saved after a calculation (by program version 0.45 and later), contain all the data necessary to do a custom printout of the data in any form you desire. Project file names have the form *.16D and have the structure of a Windows INI file. They are easy to read. Note that since it is an INI file, you cannot depend on the order of the lines in the file. However, there is enough information to tell how to read the file.

Note: A suggested approach to obtaining data from a project file is using the WinAPI GetPrivateProfileString and then processing the returned string to the desired floating point value, including units.

To follow the description below, open a project, press F9 to calculate, and save the project. Then refer to the project, looking at it or printing it with notepad so that you can see the sections, keys, and data. Otherwise, the text below will be difficult to read.

Each of the tabs in the project window has a section in the file, e.g., [Surface], and the section name can be depended upon not to change from project to project (or to only change in a predictable way). Key names always bear a strong resemblance to the prompt for the data field, so it should normally not be a problem telling what data fields go with what keys in the file.

The project equipment list is also found in the file. Its structure is a bit involved, so there is a description below.

Finally, the file may contain information you do not need. For instance, the file will always have a [Subsea] section. However, the project itself may not have a subsea stack and so the [Subsea] section is irrelevant. Similarly, there may be equipment listed that is not used in the stack and that may no longer even be part of the current equipment list.

9.2 How to Use

If you make a custom print routine, you must handle all formatting, page handling, etc. The proper procedure is to open a project file, press F9 to cause it to do the calculations, and then save the project. You may then run your print routine, read the project file and print it as you like.

9.3 Storage of Memo Fields

The Project and Notes tabs both contain memo fields. In the project file, each memo field is written in a section by itself, with each key holding one line of the memo field. The section name is a tab name followed by underscore (_) followed by the name of the memo field.

Example: [Notes_memoTechnical_Warnings]

When reading a memo, the first key to read is LineCount. You must then read LineCount lines using key names of the form LineN, where N is in the range 0..LineCount-1.

Each line has two features you must note. First of all, you must change each instance of “/” (slash space) to “ ” (space). The convention is that any other white space (multiple spaces without slashes) can be collapsed to a single space.

Also, if a line begins with a * then it is the beginning of a paragraph. Lines that do not begin with * are logically continuations of the line above and may be concatenated to the end of the previous line and word wrapped.

9.4 Project Equipment List

The first step in reading the project equipment list is to read the [Eqpt_List] section. The Qty key tells you how many pieces of equipment to read. The Marker key holds a revision number describing the format of the equipment list entries. At this point, there is only one: EL01.

Each equipment item is in a section by itself with the section name [Eqpt_List_Item_N] where N is in the range 1 to Qty. Each section contains data for one equipment item. All of the key names should be relatively easy to follow except perhaps for EqptTag. EqptTag is an identifier for the piece of equipment that is unique within the project. It is used in a stack sequence to identify the piece of equipment associated with a particular stack component (see BOP Stack Sequence, below).

9.5 Project Tab

The section for the Project tab has the name [General].

9.6 BOP Stack Sequence

The fields at the top of the BOP Stack page are stored in the [Stack] section, formatted like everything else and do not need specific comments. However, the sequence of stack components needs some explanation.

The [Seq_] section holds one key, named Qty, which tells you how many components are in the stack. Each of the Qty stack components is in a section of its own named [Seq_DefaultSeq_Item_N] where N is in the range 1 to Qty. The numeric order 1..N is the order in which the components are operated in the case of rapid discharge systems.

Each stack component section has two keys: Desc and EqptTag. The Desc key holds the description of the stack component, such as “Upper Pipe Ram”. The EqptTag key holds a unique identifier that allows you to cross reference this stack component with a particular piece of equipment in the project equipment list.

9.7 Performance

The Performance tab holds two grid controls. Each grid is written in its own section where the section name is in the form [Performance_nameofgrid].

A RowCount key that tells you how many rows to read. Each row is associated with a key of the form RowN where N is in the range 1 to RowCount.

A ColCount key that tells you how many columns there are in each row. The columns are separated by commas. Note that some cells may be blank, but there are always ColCount-1 commas in the row and a comma never appears in the text for a cell, allowing you to blindly use the commas to separate the columns.

9.8 Other Sections

Other sections in the file do not hold project data. Some deserve comments, or will get them anyway so that you know what they are.

9.8.1 File_Integrity_Check_Sum

This is a quantity computed from the data in the file. It is not a simple check sum, but is more akin to a cyclic redundancy check. It is an extremely robust way to detect any changes to a file. It is included to catch corruptions or manual changes to project or library files.

Never write to a project or library file. Otherwise, the program will warn you of the mismatch. However, the program will read the file as best it can. So, if you make changes in a proper way, the data will be read correctly by the program (after it yells in alarm at you) and the check sum will be corrected when the file is saved.

9.8.2 Library_Version

Never used in a project file. Ignore it.

9.8.3 API_16D_Project_File

This section only contains one key that tells you the revision number of the program that wrote the data file.

9.8.4 PageSetup

This contains the data that you input under the File / Page Setup menu item.

10 PROGRAM INI FILE

API_16D_Sizing.exe makes use of a small INI file to store some basic information about the operation of the program. The file is stored in the location specified by the %APPDATA% environment variable. This points to different locations depending on the operating system you are using. In Windows Vista and 7, the whole path is usually:

C:\Users\{username}\AppData\Roaming\Interlink_Systems_ILS\ILS_16D_Tool

In Windows 2000 and XP it is usually

C:\Documents and Settings\{username}\Application Data\Interlink_Systems_ILS\ILS_16D_Tool

If the %APPDATA% environment variable is missing (as it might be in operating systems earlier than Windows 2000) or the program cannot create the APPDATA folder as described above, the INI file is written into the same folder as the executable.

The information in the INI file holds the location and size of the main (parent) window. It keeps track of the folder that was last used to read or save a project. This folder becomes the starting folder for the next project “open” or “save as” operation. It also remembers the most recently opened or edited

library and uses it as the default selection next time a library is called for. Finally, it stores the name of the custom printing program.

The INI file is only a convenience for the user. The program does not depend on it. Deletion of this file will not interfere with the proper functioning of the program. It will be recreated each time the program terminates.