

HYDAC Technology GmbH
Postfach 1251
D-66273 Sulzbach/Saar
Industriegebiet
D-66280 Sulzbach/Saar

Tel. 06897 509-01
Fax: 06897/509-464 (Accumulator Technology)
eMail: speichertechnik@hydac.com

OPERATING INSTRUCTIONS

ASP*light* Accumulator Simulation Program 5.0



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1. Program description

ASP*light* enables you to calculate the:

- pressures,
- volume,
- temperature as well as
- pressure and flow ratios of an accumulator, simply by entering a few accumulator parameters.

The calculation is similar to that done on a pocket calculator.

Basic knowledge of the operating characteristics of hydraulic accumulators is required.

2. System requirements

- Microsoft® Windows® XP, Windows® Vista, Windows® 7
- Microsoft® .NET Framework 3.5 or higher
(further information is available at <http://www.microsoft.com/downloads>)
- Screen resolution: 800 x 600 Pixels or higher

3. Program installation

Download **ASP*light*** from the HYDAC website (www.hydac.com / Downloads / Software / Accumulator Division).

Now open the file "ASPlight.zip" and run the application (Dateiformat/-endung: *.msi).

Follow the instructions on the installation screen.

A link to **ASP*light*** will be created automatically on your desktop.

Symbol for the desktop link: 

4. Program start

4.1. Local application

- Double-click on the desktop link: 
or follow the path Start / Programs / HYDAC International / ASP light.
- The program opens in a separate window.

4.2. Web application

ASPlight can also be run without installing locally, as a web application on the HYDAC website.

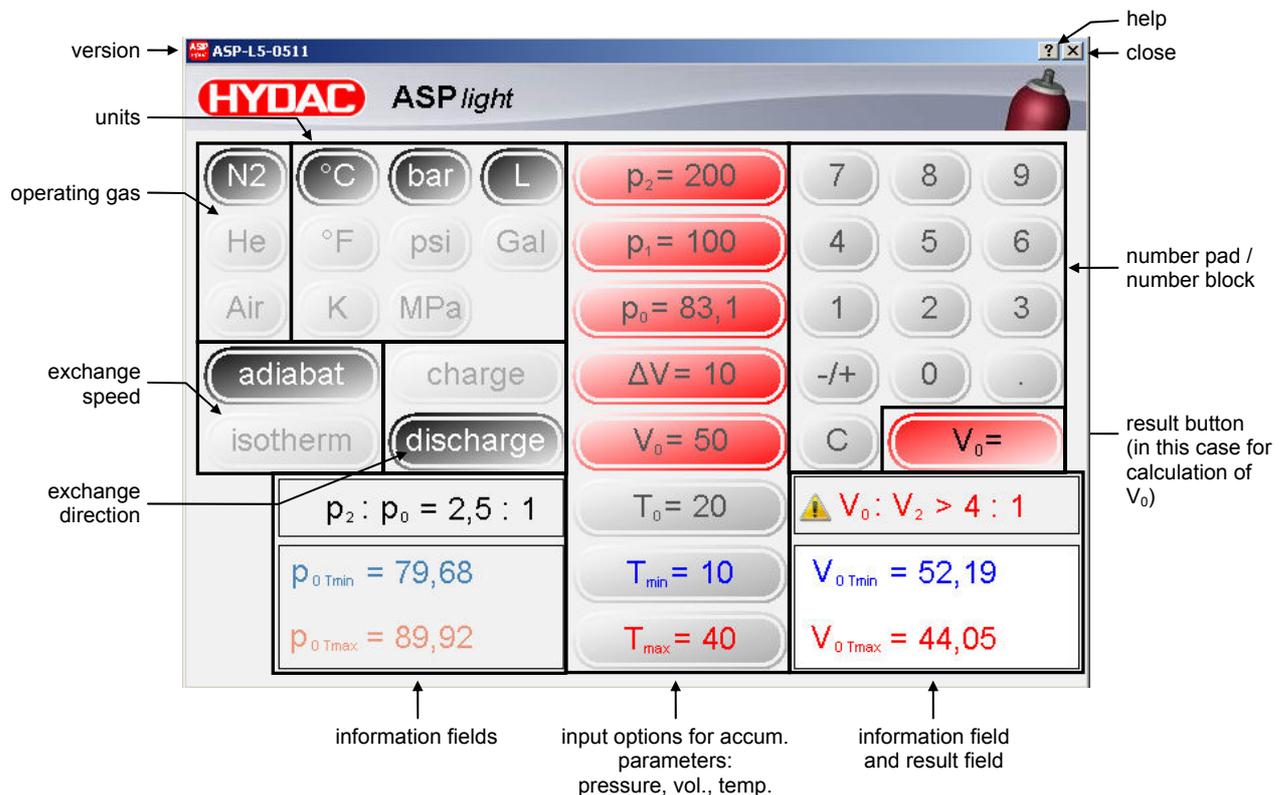
The application can be accessed via the accumulator product pages wherever the ASPlight symbol is displayed.

By clicking on the symbol, the web application will open in a separate window.

5. Operating instructions

5.1. User interface

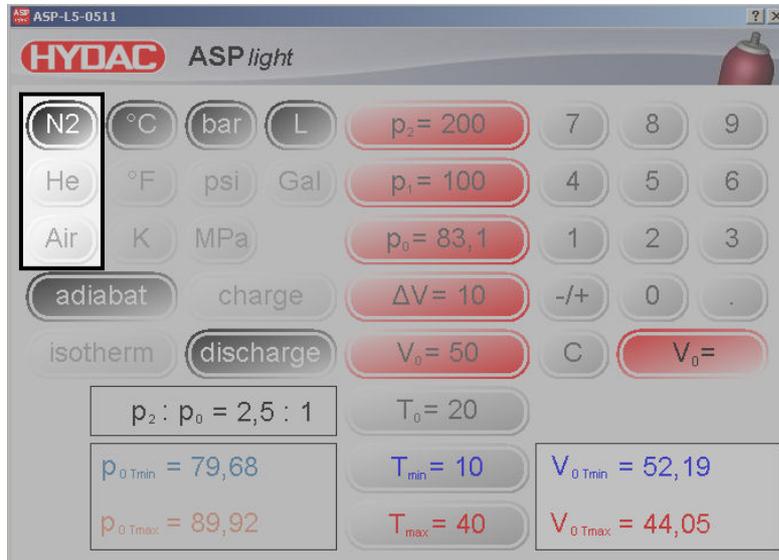
As you can see from the picture below, the user interface for ASPlight is divided into different fields and consists of: selection fields, function and input fields, as well as result and information fields. These will be described in more detail in the following pages.



As this is a *light*-version of the application, i.e. an "interim accumulator sizing" program, all the calculations are carried out in this window.

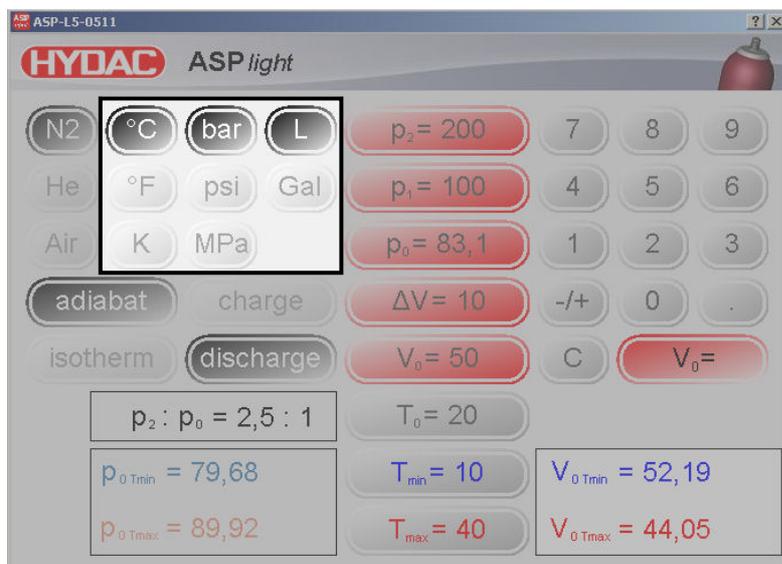
5.2. Operating gas

Within the "operating gas" selection field, in addition to nitrogen (N2), which is the usual default gas type, helium (He) and compressed air (Air) are also permitted. You can select the required gas type here.



Selection field "operating gas"

5.3. Units of measurement



Selection field "Units"

The physical units for temperature, pressure and volume can be selected as follows:

- Temperature in degrees Celsius (°C), Fahrenheit (°F) or Kelvin (K).
- Pressure in bar, psi or Mega Pascal (MPa).
- Volume in litres (L) or gallons (Gal (US)).

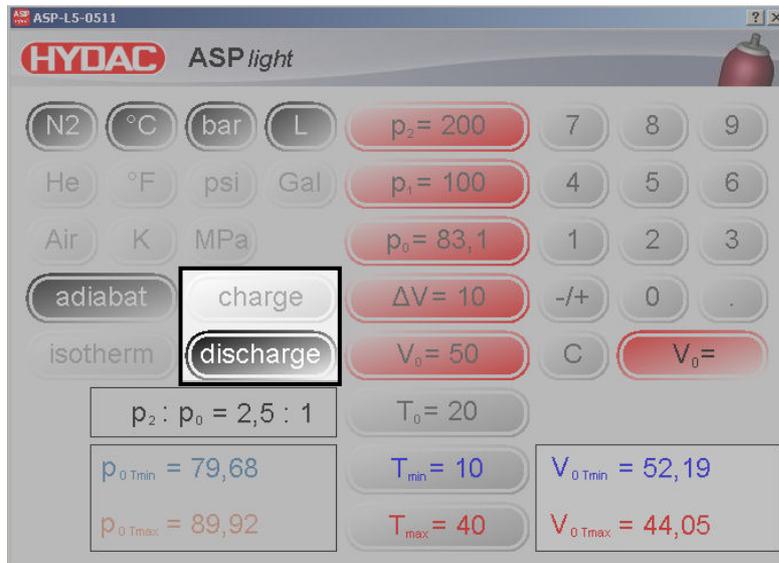
By clicking on the relevant button, the required unit is activated.

Any value subsequently input or displayed will be in the pre-set unit.

The following summary shows the association between physical unit and calculation parameter.

Physical units	Calculation parameters		
Temperature [°C, °F, K]	T_{max}	T_{min}	T_0
Pressure [bar, psi, MPa]	p_2	p_1	p_0
			p_{0Tmin}
Volume [L, Gal (US)]	ΔV		V_0

5.4. Exchange direction



Selection field "exchange direction"

Hydraulic accumulators are generally used to store energy.



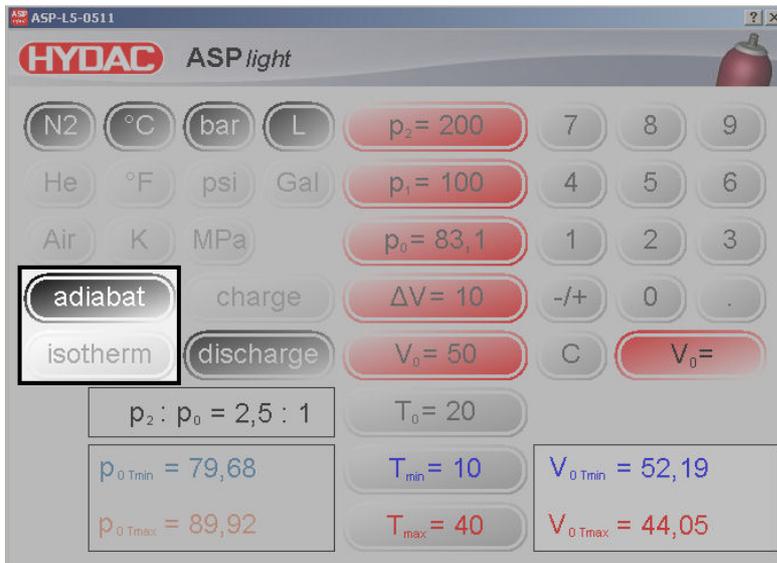
At a certain time the accumulator is required to provide a certain quantity of energy/fluid.
In other words, it will **discharge**.



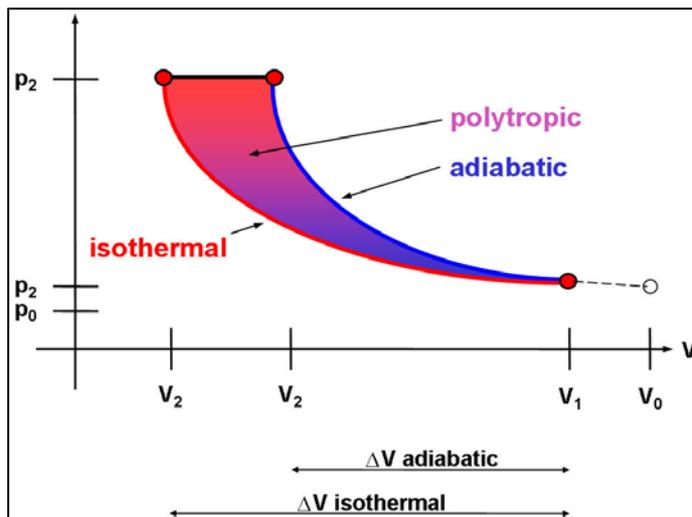
Conversely, select **charge** if the accumulator is to be charged in its application.

Both exchange directions, both charge and discharge, can take place quickly or slowly; see Point 5.5. Exchange speed.

5.5. Exchange speed



Selection field "Exchange speed"



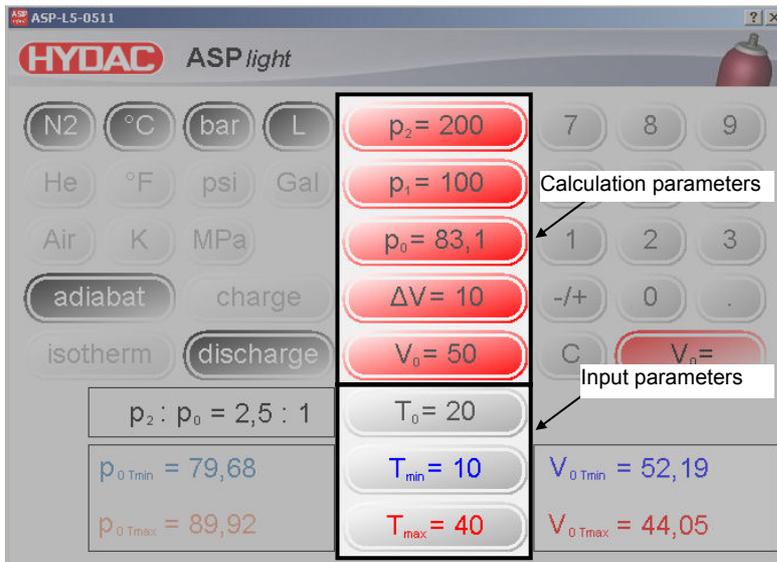
Exchange speed in the p-V graph

In thermodynamics, different changes of state exist for gases.

ASPlight is limited to the two extremes for the calculation:

- **adiabatic (= isentropic) change of state = no heat exchange**
 With this option, the program is based on very rapid accumulator charging or discharging processes. In this case, thermal compensation to the outside is not possible.
 This option results in large accumulator volumes or in small ΔV values.
- **isothermal change of state = complete heat exchange**
 With this option the program is based on very slow accumulator charging or discharging processes. In this case, complete thermal compensation to the outside is possible.
 This results in smaller accumulator volumes, comparatively, or large ΔV values.

5.6. Calculation parameters



Function or input fields "Calculation parameters"

The outlined section consists of the calculation parameters (p_2 , p_1 , p_0 , ΔV , V_0), and the input parameters (T_0 , T_{\min} and T_{\max}).

The calculation parameters are the input values and calculated values which are required to determine the size of an accumulator. They can be understood as a mathematical equation which can be converted according to the required size.

A value cannot be calculated then until all other calculation parameters have been entered.


Caution

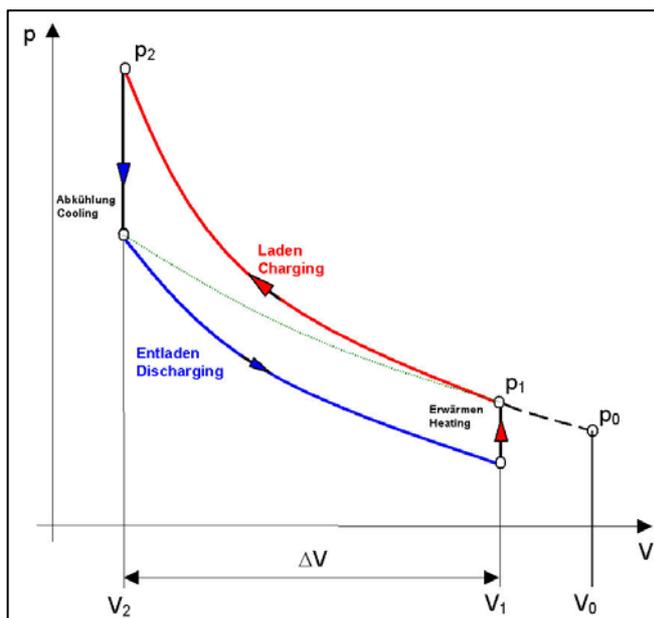
The p_0 value is suggested depending on T_0 , T_{\max} , and p_1 .
 If an input value for p_0 is to be pre-determined, i.e. forced by the user, it must be changed manually **after** the temperature has been input and also after the p_1 has been entered.

The following table shows the input and display options for the parameters:

Input parameters		Input option	
Abbreviation	Description	Input value	Output value (calculation possible)
p_2	Max. operating pressure	x	x
p_1	Min. operating pressure	x	x
p_0	Pre-charge pressure	x	
ΔV	Sampling volume	x	x
V_0	Effective gas volume	x	x
T_0	Gas charging temperature	x	
T_{min}	Min. operating temperature	x	
T_{max}	Max. operating temperature	x	
p_{0Tmin}	Pre-charge pressure at T_{min}		x
p_{0Tmax}	Pre-charge pressure at T_{max}		x
$p_2 : p_0$	Pressure ratio		x
$V_0 : V_2$	Volume ratio		x



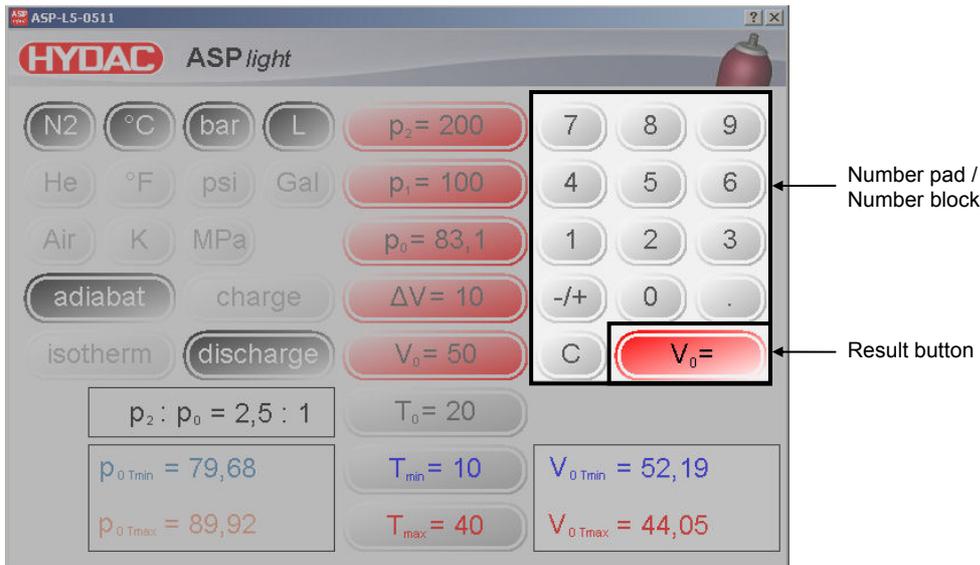
If the value for p_0 is to be pre-determined, i.e. forced, it must be changed manually **after** the temperature has been input and **after** p_1 has been entered.



For a graphic representation, see the p-V graph of an accumulator cycle. This contains all the parameters of the accumulator calculation.

Exchange direction in the p-V graph

5.7. Number pad / Number block



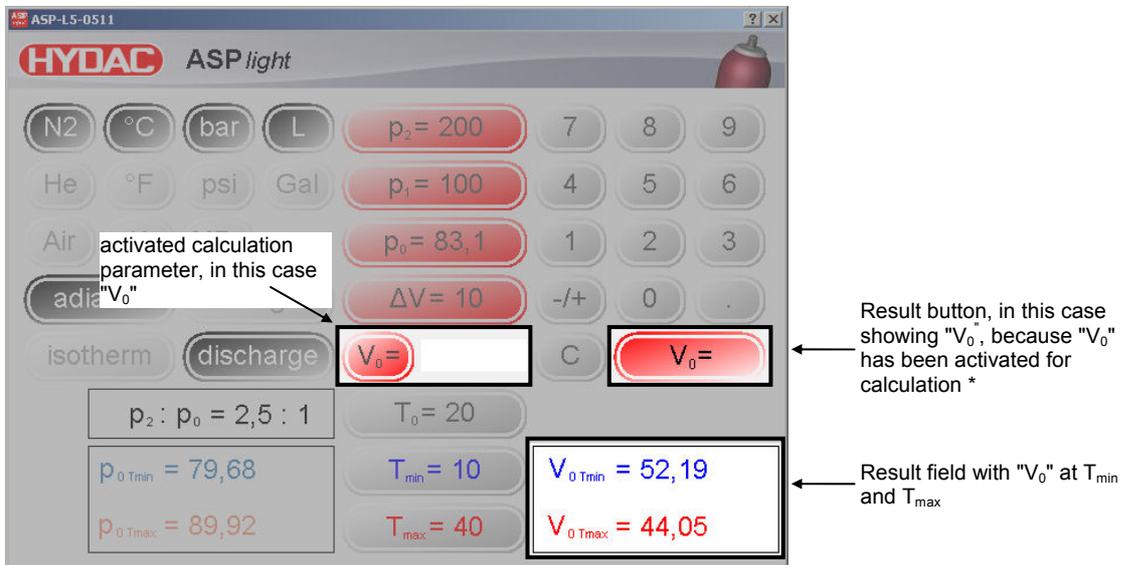
Function field "Number pad/Number block"

The number block is designed like a pocket calculator.

As an alternative to entering the calculation parameters via the keyboard, they can also be selected using the mouse/touchpad.

The label on the result button will change depending on the calculation parameter activated (e.g. p₂ =, p₁ =, ΔV =, V₀ =).

It corresponds to the "equals" button on a pocket calculator.



Function field "Result button"

* i.e. all other parameters have been entered.

5.8. Information and Results Fields

Once the result button is pressed, the following information and results fields are shown, on both the left and right.

Information field

Pressure ratio

Information field: Volume ratio
Caution sign is only displayed if the critical condition is reached.

Results field
The information given here changes according to the calculation parameters selected

Information and Results Fields

Pre-charge pressure at T_{min} and T_{max}

Results field

To select which calculation parameter is shown in the result field at T_{min} and T_{max} , click in the calculation parameter area (in this case V_{0Tmin} and V_{0Tmax}).

Information fields

In addition to the actual result field, **ASPlight** provides important information which suggests an accumulator type (bladder, piston or diaphragm accumulator).

$p_2 : p_0$ = Max. pressure ratio, in this case $p_2 : p_0 = 2.5 : 1$

$V_0 : V_2$ = Volume ratio

is only displayed when the critical condition is reached.

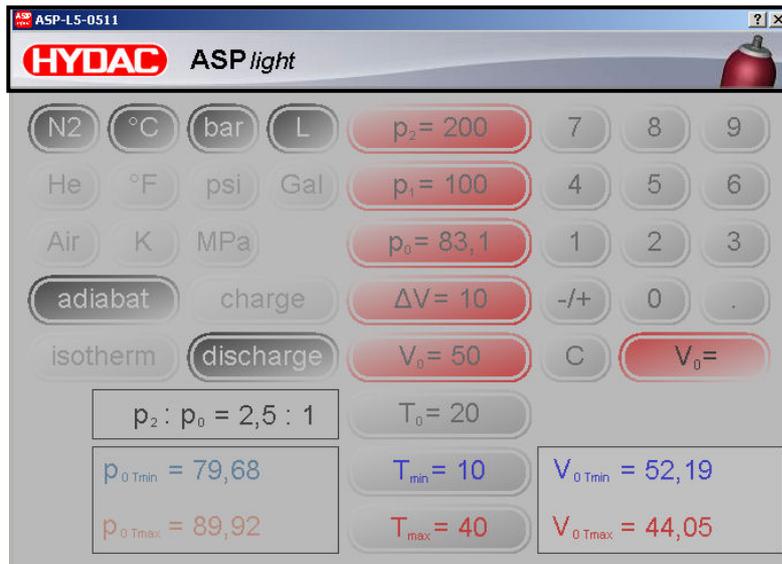
The critical condition is when $V_0 : V_2 > 4 : 1$ or $V_0 : V_2 > 10 : 1$.

In the above example, a piston accumulator is recommended, but depending on the application, diaphragm accumulators can also be used.

This must be agreed with HYDAC.

p_{0Tmin} and p_{0Tmax} = Before commissioning, hydraulic accumulators must be pressurized to a pre-charge pressure (p_0 at T_0). These values indicate the level of the pre-charge pressure at min. or max. ambient temperature, in this case:
 $p_{0Tmin} = 79.68$ bar, i.e. the pre-charge pressure of an accumulator reaches the value of 79.68 bar at an ambient temperature of 10 °C
 $p_{0Tmax} = 89.92$ bar, i.e. the pre-charge pressure of an accumulator reaches the value of 89.92 bar at an ambient temperature of 40 °C.
 The pre-charge pressure will change as a result of a change in operating temperature.

5.9. Header section

Header section of the **ASPlight** program

ASP-L5-0511 = Version of **ASPlight** program

 = Exit program

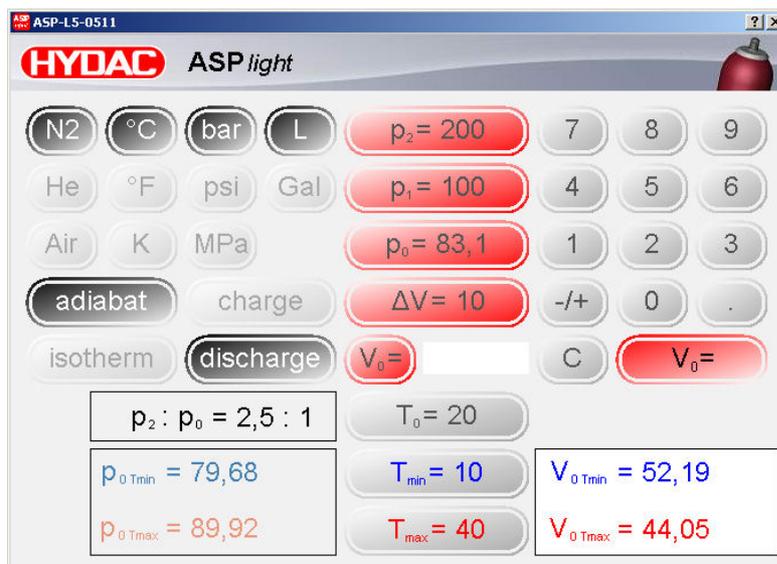
 = This button opens the operating instructions as a pdf document

6. Calculation sequence

The calculation using **ASPlight** is similar to that of a pocket calculator.

The following table shows the sequence of a calculation:

1.	Select gas type	
2.	Select units	 (default is accepted)
3.	Select exchange speed	
4.	Select exchange direction	
5.	Enter known calculation parameters	 (p ₀ is suggested by program depending on T and p ₁)
6.	Activate target calculation parameter (in this case V ₀)	
7.	Press result button	 (Label can change depending on the calculation parameter selected)
8.	Read off and evaluate the result and information fields	



Result display of the effective gas volume of an accumulator

7. Examples

Example task 1 and calculation

A consumer requires 2.5 litres hydraulic fluid within a very short time. The minimum pressure should not fall below 180 bar. The pump charges the accumulator to a maximum of 350 bar. The accumulator is pre-charged at 20°C.

What is the required accumulator gas volume if the system is working between 0 °C and 60 °C? Evaluate the result.

Given parameters:

p_2 = 350 bar
 p_1 = 180 bar
 p_0 = approx. 90% of p_1 at T_{max}
 T_0 = 20 °C
 T_{min} = 0 °C
 T_{max} = 60 °C
 ΔV = 2.5 L

Time/Direction= very short time (isentropic / adiabatic) / discharge process

Required:

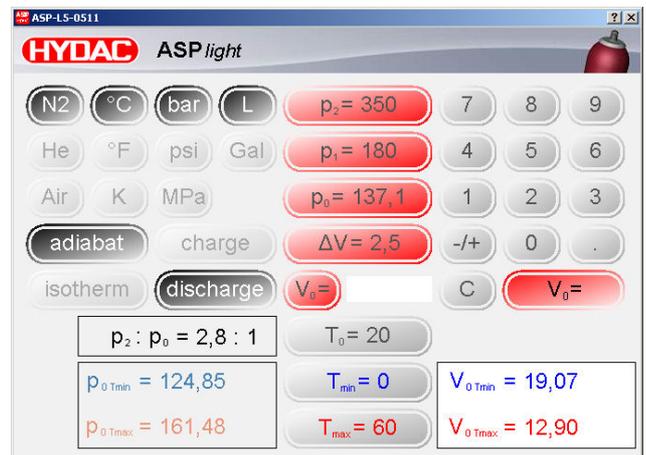
Accumulator nominal volume = V_0

Result:

V_0 at T_{min} = 19.07 L
 V_0 at T_{max} = 12.90 L

Additional information:

$p_2 : p_0$ = 2.8 : 1
 p_{0Tmin} = 124.85 bar
 p_{0Tmax} = 161.48 bar



Evaluation:

The pressure ratio of 2.8 : 1 means that bladder, piston and diaphragm accumulators can be used. However, because the V_0 result is between 12.9 and 19.07 litres, a bladder or piston accumulator is recommended. Diaphragm accumulators are only available up to 4 litres nominal volume.

Example task 2 and calculation

A 20 litres (18.2 litres effective gas volume) accumulator is charged with 5 litres fluid within 10 minutes. The minimum operational pressure (p_1) is 250 bar. The accumulator is operated in a factory where the temperature ranges between 10 °C and 50 °C.

What is the maximum operational pressure (p_2) that could arise if the accumulator is pre-charged to 150 bar (p_0) at a temperature of 15 °C?

Which type of accumulator will you select?

Given parameters:

p_1 = 250 bar
 p_0 = 150 bar
 T_0 = 15 °C
 T_{min} = 10 °C
 T_{max} = 50 °C
 ΔV = 5 L
 V_0 = 18.2 L effective volume (20 L)
 Time/Direction = 10 minutes (isothermic accepted) / charging process

Required:

p_2 at 10°C and at 50°C

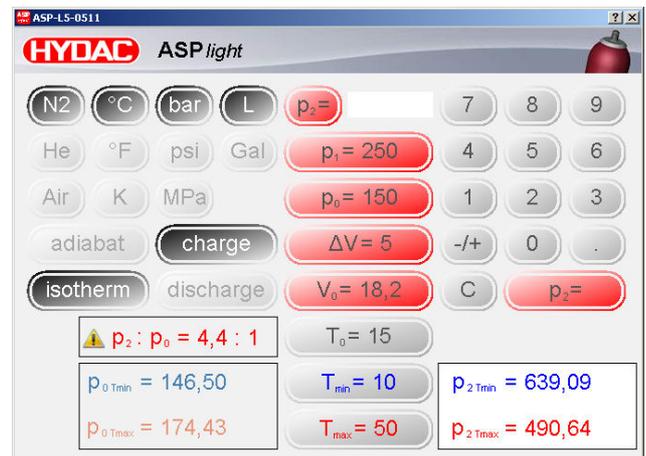
Result:

p_2 at T_{min} = 639.09 bar
 p_2 at T_{max} = 490.64 bar

Additional information:

$p_2 : p_0$ = 4.4 : 1 *
 p_0 at T_{min} = 146.50 bar
 p_0 at T_{max} = 174.43 bar

* too high for bladder accumulators



Evaluation:

Given the high pressure ratio of 4.4 : 1, a bladder accumulator cannot be used. The calculated pressures p_2 at T_{min} and p_2 at T_{max} require that a piston accumulator (SK) is used. The diaphragm accumulator is excluded from consideration because the stated gas volume is over 4 litres.

Example task 3 and calculation

A 10 litres piston accumulator is discharged within 2 seconds. 1 litre of hydraulic fluid is taken. The maximum operational pressure (p_2) is 1000 bar. The pre-charge pressure (p_0) is 100 bar at 10 °C.

What will pressure p_1 be if the accumulator is discharged at 0 °C and also at 40 °C?

Given parameters:

p_2 = 1000 bar
 p_0 = 100 bar
 ΔV = 1 L
 V_0 = 10 L effective volume (10 L)
 T_0 = 10 °C
 T_{min} = 0 °C
 T_{max} = 40 °C
 Time/Direction = 2 seconds (adiabatic accepted) / discharge process

Required:

p_1 at 0 °C and at 40 °C

Result:

p_1 at T_{min} = 196.14 bar
 p_1 at T_{max} = 263.21 bar

Additional information:

$p_2 : p_0$ = 10.5 : 1 *
 p_0 at T_{min} = 95.55 bar
 p_0 at T_{max} = 113.32 bar
 $V_0 : V_2$ > 4:1 *

* too high for bladder accumulator, but OK for piston accumulator

