# Product Note, PN 423, Rev 2
# AP74 and AP74B Application Guide

July 30, 2013

**Excess Flow Switch (EFS)**

An EFS is a device used to signal when fluid flow has exceeded a trip point. The signal is transmitted by a closed or open electrical contact and is typically monitored by a controller which closes an isolation valve when an 'excess flow' signal is received. It should not be confused with a device with the ability to stop media flow, excess flow valve (EFV).

The AP Tech EFS's, AP74 and AP74B, are pressure drop devices designed for gas service. An encapsulated magnet within the flow switch moves upward when the trip point is exceeded to induce a non-wetted, hermetically sealed reed switch to actuate.

**Sizing the EFS**

***Information required to properly size the EFS***

- Application gas
- Maximum gas system flow rate
- Operating pressure of the EFS
    - If the EFS is installed downstream of the pressure regulator, the operating pressure will be the pressure regulator set point
    - If the EFS is installed upstream of the pressure regulator, the operating pressure will be lowest pressure obtained in the gas cylinder prior to cylinder change (though the EFS must also be rated to maximum pressure, lowest pressure is used for sizing).

***Determining the minimum EFS trip point for your application***

When sizing the EFS for an application, the trip point needs to be above the maximum application flow rate at the minimum system pressure. If the flow switch is sized too close to the application flow rate there is a chance of false trip, also referred to as a nuisance trip. A false trip can be caused by the flow momentarily exceeding the trip point. This commonly happens during start up or maintenance when a gas line is pressurized or during operation if gas lines are vented or pressures dropped as part of a given recipe. In order to avoid these nuisance trips the switch needs to be oversized to more than the maximum application flow rate.

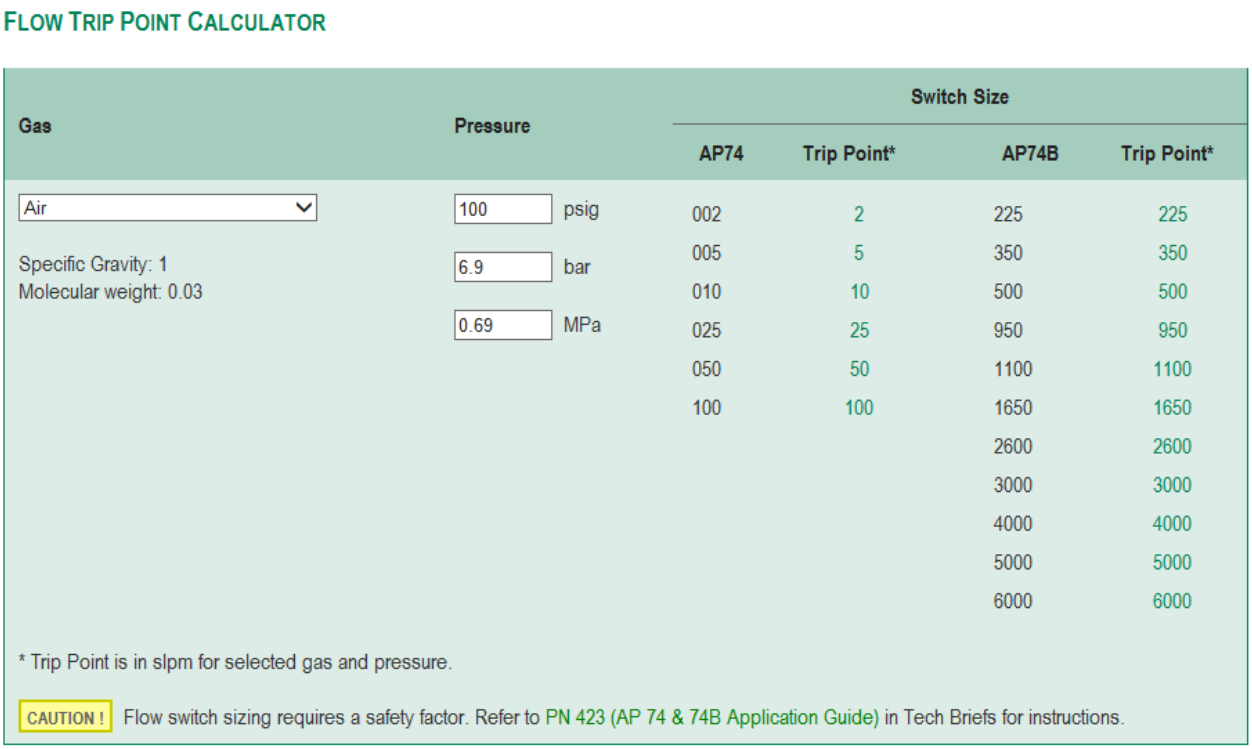
The table below provides trip point oversize recommendations for the AP74 and AP74B flow switches.

| Application Flow Rate | Minimum Percentage Over Application Flow Rate Recommended When Sizing EFS | Multiply Maximum Application Flow Rate X |
|---|---|---|
| Up to 1 slpm | 200% | 3.0 |
| 1-4 slpm | 100% | 2.0 |
| 4-15 slpm | 50% | 1.5 |
| 15-75 slpm | 35% | 1.35 |
| 75-6000 slpm | 35% | 1.35 |

***Online calculator to size the AP 74 and AP74B EFS***

Go to www.aptech-online.com

Click on "Flow Trip Point Calculator" button found on the lower left hand corner of home page.



FLOW TRIP POINT CALCULATOR

| Gas | Pressure | Switch Size | | | |
|---|---|---|---|---|---|
| | | AP74 | Trip Point* | AP74B | Trip Point* |
| Air | 100 psig | 002 | 2 | 225 | 225 |
| Specific Gravity: 1 | 6.9 bar | 005 | 5 | 350 | 350 |
| Molecular weight: 0.03 | | 010 | 10 | 500 | 500 |
| | 0.69 MPa | 025 | 25 | 950 | 950 |
| | | 050 | 50 | 1100 | 1100 |
| | | 100 | 100 | 1650 | 1650 |
| | | | | 2600 | 2600 |
| | | | | 3000 | 3000 |
| | | | | 4000 | 4000 |
| | | | | 5000 | 5000 |
| | | | | 6000 | 6000 |

* Trip Point is in slpm for selected gas and pressure.

CAUTION ! Flow switch sizing requires a safety factor. Refer to PN 423 (AP 74 & 74B Application Guide) in Tech Briefs for instructions.

1. Select application gas from pull down gas menu.
2. Input the EFS operating pressure in units of psig, bar or MPa
3. Trip points for the AP74 and AP74B are displayed automatically
4. Select proper switch size based upon the minimum trip point recommendations table on page 2 above.

***Sizing the AP74 EFS (excess flow switch) without the online calculator***

The trip points that are published in the data sheets are based upon nitrogen at 100 psig. Unless your application is at 100 psig and nitrogen gas, the EFS size will need to be corrected for your specific application.

It is easy to manually calculate the correction factors, if one does not have access to the online flow switch calculator. The formulas enable one to convert the published nitrogen trip point to the trip point for your specific gas and operating pressure. The same formulas are used for the online calculator, so the end result will be the same whether it is done manually or online.

***Gas correction factor***

If your application gas is something other than nitrogen, a gas correction factor will need to be calculated.

This calculation requires the molecular weight (MW) of the application gas. The MW of gases can be found at your gas suppliers catalog or online.

Gas correction factor formula= Fg = square root of (28/MW of application gas)

***Pressure correction factor***

If your application is at a pressure other than 100 psig, a pressure correction factor will need to be calculated.

Pressure correction factor formula = Fp = square root of (OP/114.7)
OP = operating pressure of EFS in psia (add 14.7 to the operating pressure psig).

***AP74 sizing example***

*Example application*

| | |
|---|---|
| Gas: | Silane |
| Flow switch operating pressure: | 50 psig (flow switch installed downstream of regulator, set at 50 psig outlet) |
| Application maximum flow rate: | 3.0 slpm |

*Gas correction factor*

Gas correction factor = Fg = square root of (28/MW of application gas)
The MW of silane is 32.1
Gas correction factor for silane = square root of (28/32.1) = .93

*Pressure correction factor*

Pressure correction factor = Fp = square root of (OP/114.7)
OP = operating pressure of EFS in psia = 50 + 14.7 = 64.7 psia
Pressure correction factor = square root of (64.7/114.7) = .75

The gas correction factor and the pressure correction factor can be applied to any AP74 or AP74B trip point to determine the trip point in silane at 50 psig by using the following formula. .93 (Fg) X .75 (Fp) X published nitrogen trip point.

AP74005 trip point in silane at 50 psig = .93 X .75 X 5 = 3.49 slpm
AP74010 trip point in silane at 50 psig = .93 X .75 X 10 = 6.97 slpm
AP74025 trip point in silane at 50 psig = .93 X .75 X 25 = 17.44 slpm

The correct selection for this application is the AP74010. It has a trip point in silane of 6.97 slpm which is 132% over the application flow rate. The AP 74005 trip point is above the maximum flow rate but does not have an adequate safety margin.

**AP74B sizing example**

*Example application*

| | |
|---|---|
| Gas: | HCl |
| Flow switch operating pressure: | 613 psig (flow switch installed upstream of regulator, gas is liquid phase with constant pressure) |
| Application maximum flow rate: | 500 slpm |

*Gas correction factor*

Gas correction factor = Fg = square root of (28/MW of application gas)
MW for HCl is 36.5
Gas correction factor for HCl = square root of (28/36.5) = .88

*Pressure correction factor*

Pressure correction factor = Fp = square root of (OP/114.7)
OP = operating pressure of EFS in psia = 613 + 14.7 = 627.7 psia
Pressure correction factor = square root of (627.7/114.7) = 2.34

The gas correction factor and the pressure correction factor can be applied to any AP74 or AP74B trip point to determine the trip point in HCl at 613 psig by using the following formula. .88 (Fg) X 2.34 (Fp) X published nitrogen trip point.

To determine the right switch for this application, calculate trip points for the AP74BV225, AP74BV350 and the AP74BV500.

AP74BV225 trip point in HCl at 613 psig = .88 X .2.34 X 225 = 463
AP74BV350 trip point in HCl at 613 psig = .88 X 2.34 X 350 = 720
AP74BV500 trip point in HCl at 613 psig = .88 X 2.34 X 500 = 1030

Based on these results, the AP74BV350 with an HCl trip point of 720 slpm at 613 psig is the correct choice. The trip point of 720 slpm exceeds the recommended minimum 35% over application flow rate requirement whereas the AP 74BV225 is less than the maximum flow rate.

## Installation of the EFS

Excess flow switches can be installed in the gas system either upstream or downstream of the source pressure regulator. The inherent advantages and disadvantages of either choice are:

### *Installing the EFS upstream of source pressure regulator*

Some gas systems designers want to locate the EFS as close as possible to the gas source and install the EFS between the gas cylinder and the pressure regulator. The issues to consider are:

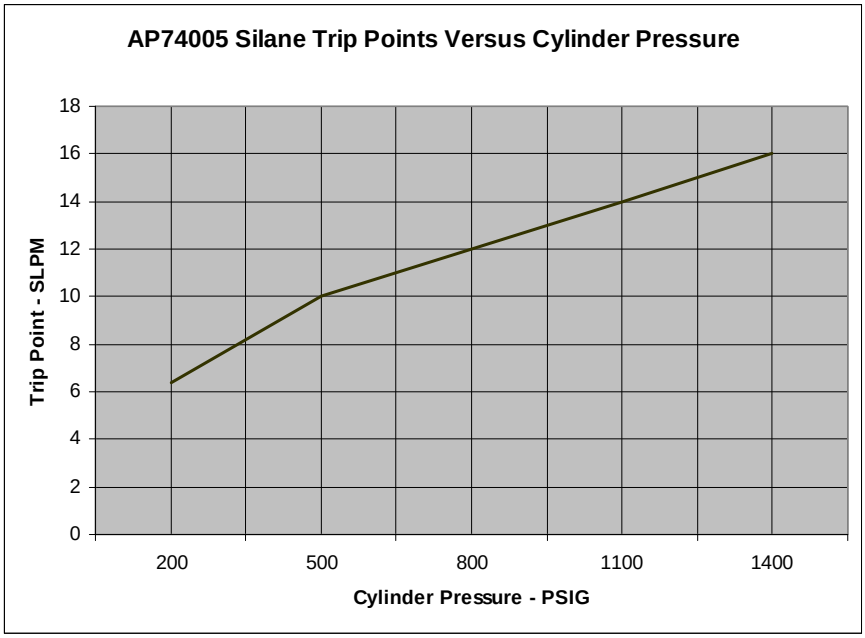
*Potential exposure to atmosphere and contamination*

With the EFS installed in this location there is a greater chance of contamination to the internal orifices or float inside the EFS. During each cylinder change the EFS will be opened to atmosphere and subjected to the purge procedure incorporated by the gas cabinet manufacture. During the purge cycle the EFS could be subjected to moisture and contamination that it would not be exposed to if installed downstream of the pressure regulator. The float in the EFS is susceptible to sticking if there is contamination or corrosion in the EFS.

*Changing trip points due to supply pressure effect*

The AP74 and AP74B excess flow switches are pressure based devices that require a constant operating pressure in order to provide consistent excess flow protection. If the operating pressure varies, the excess flow trip point can vary significantly.

The graph below depicts an AP74005 EFS installed in silane with a full cylinder pressure of 1,400 psig. The cylinder will be changed once the gas cylinder is depleted to 200 psig, therefore the EFS will need to operate between 200 and 1400 psig with the switch being sized at the lowest cylinder pressure of 200 psig. Because of the varying cylinder pressure, the EFS trip point varies from just over 6 slpm to a maximum of 16 slpm.



This situation can be avoided by installing the EFS downstream of the pressure regulator as discussed in the next example. In the case of liquefied gases where the cylinder pressure remains constant while the gas is consumed, the trip point will stay consistent if installed between the gas cylinder and the pressure regulator.

*Installing the EFS downstream of the pressure regulator*

**This is the recommended location for installation of the EFS by AP Tech**.

There are advantages of installing the EFS downstream of the pressure regulator in the gas system.

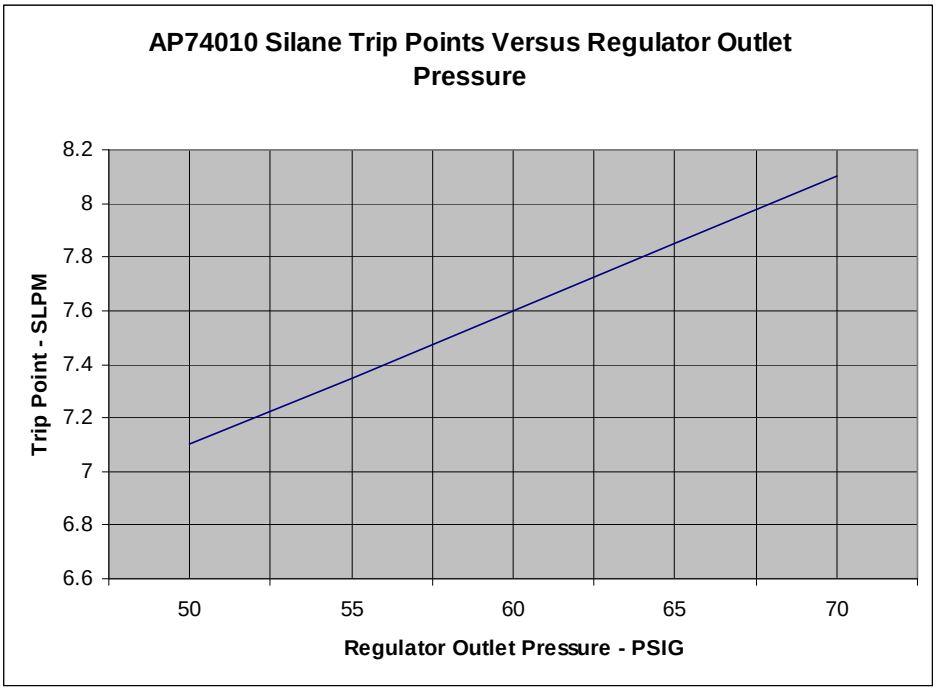
- EFS is not exposed to atmosphere and potential contamination during cylinder changes.
- EFS provides a constant trip point due to the constant. Inlet pressure.

The EFS is not exposed to atmosphere and potential contamination during cylinder changes

If the EFS is installed downstream of the regulator it is isolated from the majority of the cylinder change purge procedures and has very little risk of being subjected to atmosphere and moisture during cylinder changes.

The EFS provides constant trip point due to the regulator's outlet pressure being constant

The graph below depicts an AP74010 EFS installed in a silane application downstream of the pressure regulator. The pressure regulator is an AP1410 with an outlet pressure setting of 50 psig with a full cylinder pressure of 1400 psig. The 50 psig regulator set point becomes the initial operating pressure of the EFS. As the silane cylinder is consumed and the pressure of the cylinder decreases, the regulator outlet pressure rises a published 1.6 psig per 100 psig cylinder decay. If the cylinder is to be changed at 200 psig, the total cylinder pressure decay is 1200 psig or 12 hundreds. Therefore, the outlet pressure change at the regulator can be calculated at 12 X 1.6 (delivery pressure rise per 100 psig cylinder decay) = 19.2 psig change in delivery pressure. Base on this calculation the operating pressure for the EFS changes from the initial 50 psig at 1400 psig cylinder pressure to 69.2 psig when the cylinder is due to be changed at 200 psig.




As demonstrated by the graph above, the trip point of the EFS rises only 14% when installed downstream of the regulator in comparison to nearly 200% if the EFS is installed before the pressure regulator.

**EFS precautions**

- The actual trip point varies as the pressure changes, decreasing pressure lowers the trip point. It is recommended to select an actual trip point for the lowest system pressure of switch operation.
- The switch contains a strong magnet which may affect the function of other devices sensitive to such if located too closely.
- Do not locate ferrous metals and other magnets within one inch of the switch
- Switch performance is attitude sensitive. It must be mounted within 8 degrees of vertical with the inlet at the bottom.
- The flow switch is strictly intended for gas applications
- Switch must be properly installed and connected for proper function.

**EFS common issues**

There are a number of common issues with EFS that may be experienced in the field. The following is a list of the most common issues.

- Switch contamination
- False or nuisance trips
- Switch wired incorrectly
- Wires pulled from contacts

*Switch contamination*

The AP74 and AP74B have an internal float that slides within the body of the switch. In gases such as silane that can become gummy, the float can stick in the body and prevent the reset after it has tripped.

*False trips*

False trips are caused by a sudden surge of flow causing the switch to trip. This is very common with flow switches during the initial start up of the gas system while filling the gas lines downstream of the gas cabinet or after maintenance of a gas system has been completed. It is recommended that the controller be programmed to only consider the excess flow alarm after the excess flow signal has registered for seven seconds or greater. This delay will eliminate the excess flow issues that arise during start up and gas system maintenance.

*Switch wired incorrectly*

The switch must be wired correctly for proper function. The blue wire is common and will always be used whether you select to operate the switch in the normally closed or open configuration. The blue and the brown wires will be used for the normally closed configuration and the blue and the black wires will be used in the normally open configuration. Never use the brown and black wires together.

*Wires pulled out of the switch*

Even though the wires are potted into the switch, the connections can be damaged if the wires are pulled. Be careful to never tension the wires while the switch is being installed or in use.

**Wiring Recommendations**

When wiring the AP74 and AP74B it is recommended that the normally closed contacts are used. This way if the circuit is interrupted due to a cut wire or short to ground, the flow switch will signal an alarm (even though there is no excess flow condition). If the normally open contacts are used, a cut wire would prevent the switch from signaling an excess flow condition.