XTRALIS OPEN-FLOW IN-LINE COMPONENTS APPLICATION NOTE

August 2020

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Preface

This Application Note outlines the use of additional optional components in the pipe network arrangement for Aspirating Smoke Detectors (ASD) supplied by Xtralis. This includes components such as simple water traps, isolation valves, intumescent seals or any other specialist components which may be needed to realise a practical and effective aspirating smoke detection system in a particular environment.

The objective of this Application Note is to define the limitation of use of such components within the context EN54-20:2006 which requires (clause 5.8) that such "optional components" are described in the documentation.

One of the significant advantages of Aspirating Smoke Detectors (ASD) is that they offer huge flexibility in the pipe arrangements possible and allow for special components to be used to solve specific problems. For example, where the sampled air has high humidity there may be a risk of condensation occurring in the pipe and a simple water trap arrangement can be used to ensure the condensate does not enter the detection unit.

It is the intention of this application note to provide guidance to designers and users of Xtralis ASD systems on the considerations and use of such low-risk optional components and more specifically, to define a safe "Code of Practice" for their use – without the need to individually list specific components within the approvals documentation and certificates.

This application note also considers in-line filters or other such devices which may inhibit the free passage of smoke. Such devices shall be tested and approved for use as optional components on an Xtralis ASD system. Refer to application notes:

- 17785 Xtralis In-Line Filter Application Note (VSP-805 inline filter).

In cases where the flow characteristic of such filters are not available in ASPIRE, this application note includes some guidance on how they can be used.

Contents

1 Background

EN54-20:2006 clause 5.8 states:

5.8 Hardware components and additional sensing elements in the sampling device

Components, including optional components (box, filter, sensor, valve etc.) in the sampling device shall be described in the documentation. The ASD, including the hardware components listed (i.e. the worst case combination in accordance with the manufacturer's documentation), shall meet the requirements of this standard. If the component incorporates a sensing element which participates in the signal output of the ASD (e.g. for localization information) then the performance of the ASD, including these sensing elements shall meet the requirements of this standard.

EN54-20 is easy to understand in that it requires that the fire detection performance of an ASD be demonstrated by the successful detection of a series of standard test fires. In addition, it specifies a series of environmental tests to check the robustness of a product. However, while the requirements are easy to understand, the complexity of approving an almost infinite variety of pipe networks and hole configurations is challenging. For Xtralis ASD systems the underlying philosophy is that as long as; each hole is drawing a sufficient proportion of the flow, that the transport time from each hole is sufficiently fast, and that the alarm threshold of the detector is configured with sufficient sensitivity, then it is wholly reasonable to conclude that the system will detect a fire within the prescribed performance requirements – as defined by the standard test fires.

ASPIRE is the PC tool used for checking that any particular Xtralis ASD system is designed within the agreed performance limits. This tool simplifies the assessment of any particular pipe/hole configuration and actually combines two of the underlying philosophical points outlined above – by calculating the effective sensitivity of each individual hole based on the flow through each and the sensitivity of the detector itself.

As a simple example, an VESDA-E VEP detector configured with an alarm threshold of 0.16%obsc/m with 50 holes (each drawing exactly equal flow) has an effective sensitivity at each hole of 8%obsc/m. Such a system detects the EN54-20 Class C test fires as long as the predicted transport time from the furthest hole is less than 110 seconds.

Table 1 provides a concise summary of the configuration limits for each Xtralis detector; performance limits as expressed in each individual product guide. These limits have been approved during the assessment of the products to EN54-20:2006.

Table 1: Summary of configuration limits for Xtralis Detectors

Detector	Class	Hole sensitivity	Max transport time (predicted)
VLI	A	1.5 %obs/m	60 seconds
	B	4.5 %obs/m	90 seconds
	C	10 %obs/m	120 seconds
VLF-500	A	1.5 %obs/m	90 seconds
	B	4.5 %obs/m	90 seconds
	C	10 %obs/m	90 seconds
VEP-1	A	1.5%obs/m	60 seconds
	B	3 %obs/m	90 seconds
	C	8 %obs/m	110 seconds
VEP	A	1.5%obs/m	60 seconds
	B	3 %obs/m	90 seconds
	C	8 %obs/m	110 seconds
VEU	A	1.5 %obs/m	70 seconds
	B	3 %obs/m	85 seconds
	C	10 %obs/m	110 seconds
VES	A	1.5%obs/m	60 seconds
	B	3 %obs/m	90 seconds
	C	8 %obs/m	90 seconds
IAS	C	See product guide	pipe length[1]
ILS[2]	A&B	See product guide	60 seconds
	C	See product guide	120 seconds
IFT-P	A	0.6%obs/m	60 seconds
	B	1.6%obs/m	60 seconds
	C	3.6%obs/m	60 seconds

The limits given in table 1 (with the exception of IAS/ILS– see the notes to the table) are embedded into the relevant ASPIRE programme and when exceeded, the relevant results are highlighted in red and thus clearly indicating that the system design does not comply with EN54-20. If this occurs, the pipe and hole configuration should be adjusted until there are no red results.

1 Where the product guides specify the maximum pipe length not transport time it is recommended that the 5% and 10% margins given in this Application Note should be applied four-fold to the to the pipe length limits; e.g. a 50m limit is reduced to 40m or 30m where an in-line component is used.

2 For the Xtralis ICAM ILS detectors (and IAS units with high sensitive detectors which provide Class A&B performance), the EN54-20 limits are formally expressed as the pipe length however for the purposes of this Application Note a maximum transport time of 60 seconds (class A&B) and 120 (Class C) are considered to be the limiting factor. This being the limit embedded into ASPIRE for these detectors.

2 Summary of the Xtralis Approach to In-Line Components

It is important to note that the figures presented in Table 1 are the limits agreed for any Xtralis ASD detector according to the sensitivity Class. Clearly a VEP operating with a hole sensitivity of 7.9%obsc/m and a predicted transport time of 109 seconds will be operating very close to the limits. However, a VEP detector operating with 6%obsc/m at the holes and a predicted transport time of 90 seconds can be assumed to comfortably detect the EN54-20 Class C test fires. As such it is not unreasonable to add additional in-line components to such a pipe network as long as they do not restrict the passages of smoke or slow the flow rate appreciably.

The objective of this Application Note is to provide recommendations on how to assess in-line components and the pipe network into which they are to be installed to achieve a reasonable safety margin and thereby have confidence that the installed system is in compliance with EN54-20.

3 Potential Effect of Using Additional Components

An Xtralis ASD system is reliant on the effective transportation of smoke samples from the sampling holes to the detection unit. Unrestricted pipes and fittings are clearly the preferred media for this task. Where an additional component restricts the flow as a result of it having a smaller cross section than an unrestricted pipe then the primary consequence is that the transport time is longer. As long as the component does not include any filtering elements or sharp changes in the flow (which might separate/trap the smoke particles carried in the flow and so attenuate the smoke reading measured by the system) then an increased transport time will be the only consequence.

For any particular component it is possible to predict its effect on the transport time if there is assessment undertaken of its pressure-flow (PQ) characteristic. Generally pressure losses are proportional to the square of the flow rate ($P \sim Q^2$) with laminar pipe flows (<30L/min). For fully turbulent flows the pressure loss is proportional to flow rate ($P \sim Q$). However, while flow theory can provide an indication of the characteristic, the actual PQ characteristic of a particular component is most usually determined empirically (i.e. by testing it).

Once the PQ characteristic of a particular component is determined it can be included into the ASPIRE PC tool as a standard component. Alternatively, assuming the component is positioned between the detector and the first hole, the pressure drop due to the component can be included manually into the ASPIRE model by altering the ambient pressure[3].

However, due to the variety of reasons for using additional in-line components it is impractical to assess the PQ characteristic of each and every component that may be used. Such an approach is detrimental to the practical application of ASD systems and restricts the use of relatively benign components to realise a practical solution to detection of smoke in a particular application. Unfortunately, some ASD manufacturers choose to take this approach in order to ensure that only in-line components manufactured by them and listed in their approved documentation may be used. Such restrictive practises are not supported or pursued by Xtralis.

Hence, where an additional in-line component is proposed for use in an Xtralis ASD system, it is important this it is assessed according to the recommendations given in this Application Note to ensure that it is not detrimental to the smoke detector's ability to detect smoke in a timely and reliable fashion – specifically its ability to detect the standard EN54-20 test fires for the relevant Class of detector.

3 The ASPIRE model can take account of an "ambient pressure" difference between the sampling holes and the detector exhaust. This ambient pressure correction is provided to accommodate pressure differences when the detector is located in a different room to the sampling holes. However it can also be used to include other pressure drops into the model. As such it can be used to account for the pressure drop associated with an in-line component. Practically this is done by simply entering the pressure drop of the component at the flow rate predicted by ASPIRE without the in-line component. Of course, this results in a predicted lower flow rate so it is possible to iterate to a more accurate solution by revising pressure drop entered for the in-line component to match the new flow rate (and so on). However the first result provides a conservative result (lowest flow rate and longest transport time) so can be used with confidence without iteration.

4 Recommendations for the use of additional in-line components

The following recommendations are conservative and result in a good safety margin and low level of risk when using additional in-line components. The same recommendations are expressed in a flowchart format on page 7.

1. The use of addition in-line components is not recommended when an Xtralis ASD system is designed to operate very close to the limits defined in Table 1 unless the component is approved *and* included in ASPIRE.
2. Any additional in-line component must be assessed to identify any risk that it will impede the passage of smoke through it. Where there is zero risk of smoke attenuation because; the component has open flow paths, no sharp changes in the direction of flow and no filtering element[4], it is very likely that it will be suitable for use on an Xtralis ASD system (proceed to recommendation #3).
   If the component includes a filter or similar it should not be used without particular consideration of its smoke attenuation characteristic. This will require formal assessment and approval of the component within a system tested to EN54-20. Components that have been tested but are not yet included in ASPIRE can be used in without further assessment on systems with a 10% safety margin in terms of sensitivity and transport time as predicted by ASPIRE.
3. The effective internal cross section of any additional open-flow in-line component (Ac) should be determined by inspection and compared with the cross sectional area of the pipe (Ap).
   - Where the effective internal cross sectional area of the component (Ac) is equal to or more than the internal cross sectional area of the sampling pipe (Ap) then it can be used without further assessment on systems with a 5% safety margin in terms of sensitivity and transport time as predicted by ASPIRE.

     Example 1: A manual ball valve with a larger internal diameter than the sampling pipe can be used on a Class C VEP system with a predicted hole sensitivity better than 7.6%obsc/m and a predicted transport time of less 105 seconds.

     Example 2: A water trap with the same internal diameter as the sampling pipe can be used on a Class A VLC with a predicted hole sensitivity better than 1.425%obsc/m and a predicted transport time of less than 57 seconds.
   - Where the effective internal cross section of the component is at least 58% of the internal cross section of the sampling pipe then it can be used without further assessment on systems with a 10% safety margin in terms of sensitivity and transport time as predicted by ASPIRE.

     Example: A manual valve with a internal diameter (ID) of 16mm (Ac=201mm²) can be used on a sampling pipe of 21mm ID (Ap=346mm²) (201/346=58%) connected to a Class B VLF-500 with a predicted hole sensitivity better than 4.05%obsc/m and a predicted transport time of less than 81 seconds.
4. Where a component has a length greater than 10 diameters it should be included into the ASPIRE model as an equivalent length of smaller diameter pipe using two reducers. Such a component can be used without further assessment on systems with a 5% safety margin in terms of sensitivity and transport time as predicted by ASPIRE (with the length of pipe in the model). It is not required to allow a 10% safety margin for such modelled components.

   Example: A 300mm long component with an effective diameter of 16mm is longer than 10 diameters. When it is modelled in ASPIRE it gives a small reduction in TT and alters the "balance"[5] of the system slightly. In accordance with this document such a component can be used on a Class B IFT-1 if the hole sensitivity is better than 3.24%obsc/m and the transport time is less than 57 seconds as predicted by an ASPIRE model incorporating a 300mm long length of 16mm ID pipe.

4 See appendix 1 for examples of how to assess whether a component can be considered to have an open flow path.

5 The "balance" of a system expresses the relative proportion of flow into each sampling hole – see ASPIRE help for more details.

5. The material and construction of any in-line components must be assessed to ensure it is suitably robust for use in an EN54-20 ASD system. In summary any component should be specified to operate reliably within a temperature range of at least -10°C to +55°C at 95% RH be chemically stable (to SO2 in particular) and be resistant to shock, impact and vibration. Additionally, the component must resist crushing in accordance with clause 5.7 of EN54-20. As such, only high-quality components should be specified and where there is any suspicion that they do not comfortably exceed the requirements of EN54-20 a statement of conformity should be obtained from the manufacturer of the component.
6. The use of more than one additional in-line component is not recommended *unless* either:
   - The flow from each sampling hole on the system only passes through one additional component;

     Example: an isolation valve for blow out purposes can be introduced into each final branch of a pipe (i.e. the valves are all in parallel and flow from any one hole only passes through one valve).
     Or
   - There is addition safety margin applied pro-rata for each in-line component installed in series.

     Example: a large water trap (5% safety margin) and *two* 19mm valves (10% safety margin) can be installed on an ASD system with 25% safety margin in terms of sensitivity and transport time as predicted by ASPIRE.
7. Where there is any ambiguity in the assessment of the effective cross sectional area or effective length then it is recommended that the pressure drop across the component is measured at the operational flow rate (as predicted by ASPIRE) using a digital manometer[6]. This pressure loss can then be included into ASPIRE as a negative "ambient pressure" and thus provide a more accurate estimating of the predicted sensitivities and transport time.
8. IN ALL CASES WHERE ADDITIONAL IN-LINE COMPONENTS ARE USED, THE ACTUAL TRANSPORT TIME SHOULD BE MEASURED AT INSTALLATION AND CONFIRMED TO BE WITHIN THE RELEVANT LIMIT PRESENTED IN TABLE 1[7].

6 A (digital) manometer (or similar instrument) is be used to measure the pressure difference between pressure tappings/ports upstream and downstream of the component. (e.g. the DP-Calc 5815 from TSI).

7 Guidance on how to measure transport time and compare it with the limits in Table 1 are given in Appendix 2.

5 Further Recommendations for the Use Of Additional In-Line Components with Variable Characteristics and/or Automatic Control

Some additional in-line components are specifically introduced to control the flow through the pipe. The most obvious example is where a valve is introduced which is open in normal operation but is closed during a short maintenance period to facilitate "blow-back" of the pipework. As such the PQ characteristics of the component are not constant – i.e. they depend on the position of the valve; whether open, closed or, more significantly, if they are only partially open due to an operational fault.

In some cases the valve can be automatically controlled (e.g. in the case of an automatic blow-back system) while in others they can be controlled and operated manually. In either case, if the valve is left closed then the ASD system should indicate an Air Flow Fault within 300 seconds.

At commissioning, it is recommended a flow fault is confirmed to be reported if a valve in the pipework is inadvertent left closed for longer than 300 seconds.

Full monitoring of partial closure of such in-line components is not practical and is not generally necessary in the majority of applications. In practise, if partial blockage occurs which; is sufficient to impair the system to the extent that it is unable to detect the standard EN54-20 test fires, but is not sufficient to invoke a flow fault in the ASD, then it is reasonable to conclude that the ASD is still drawing sufficient air to pull samples from the protected area as so *will* report a fire within a reasonable period.

In practical terms it may be desirable to include a test at commissioning to confirm that partial closure of the valve - which is just sufficient to invoke a flow fault – does not lead to an unacceptably high transport time.

When valves are controlled automatically the control system and actuators should be robust, reliable and appropriate to the task. It is recommended that de-energise state of any valve is such that, when power fails, the valve does not interfere with the correct operation of the ASD[8]. The organisation supplying the system should be able to provide clear evidence of validation and/or details of reference sites where their particular system has been installed and operated successfully.

In some territories there are local requirements that such systems are inspected and approved by the Authority Having Jurisdiction (AHJ) but where this is the case, such an approval is related to the robustness, operation and reliability of the automatic system rather than its effect on the performance of the ASD system in accordance with EN54-20.

Some particular points to consider when assessing the suitability of a blow back system are:

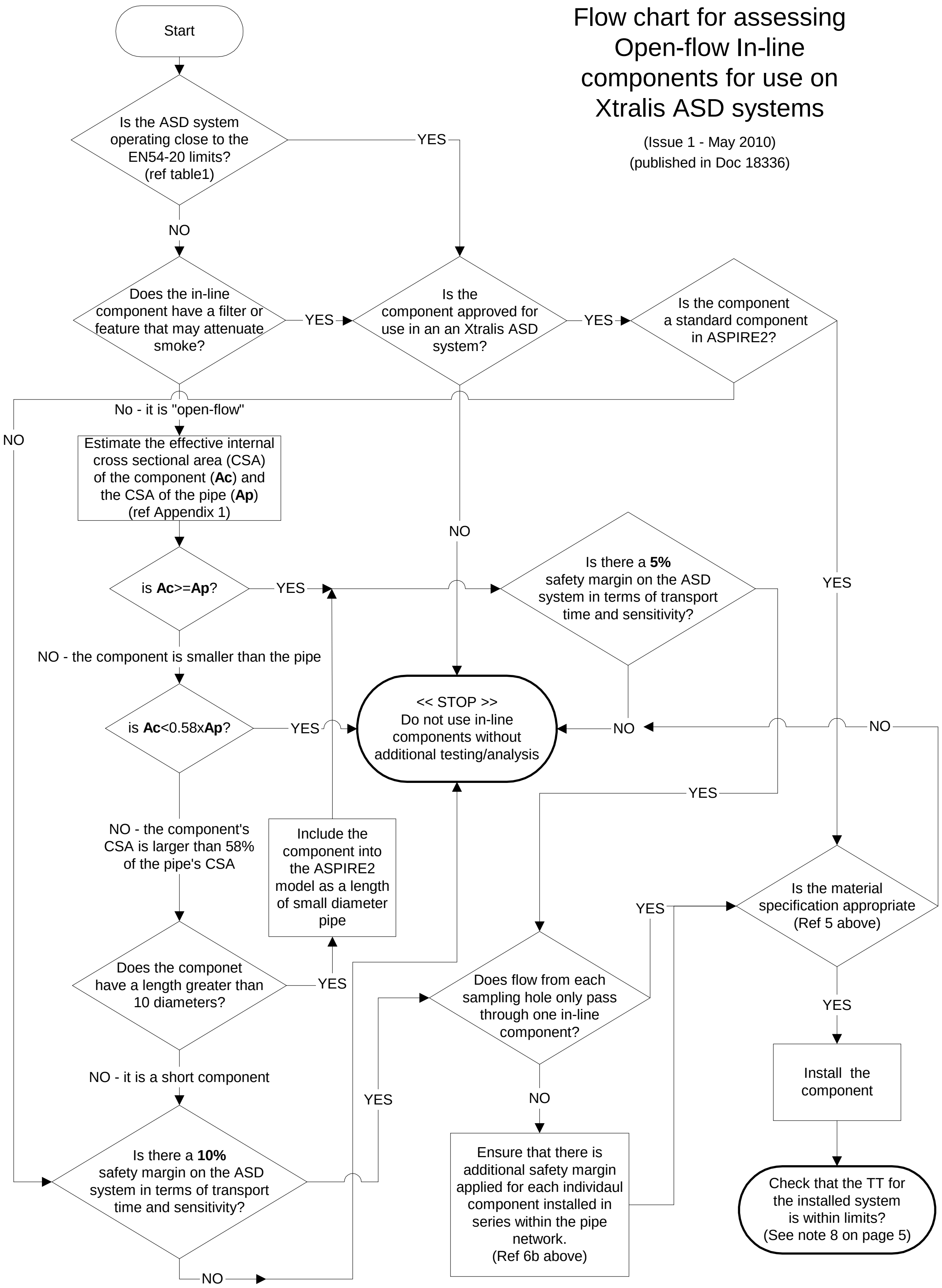
1. Are the timings appropriate (and configurable) to the application?
   - Is the blow back frequency appropriate?
   - Is the blow back period short enough to avoid a flow fault on the ASD?
   - Do the valve timings/controls ensure that there is little risk of blow back pressures being applied before the isolation valve has closed?
2. Is the pipework suitable to withstand the pressures associated with the blow back system?
   - Is the pipe rated for the maximum design pressure?
   - Are all pipe fitting securely installed?
   - Are all sampling holes and capillary fitting suitable for use with a bow back system?

   > **Note!**
   >
   > The use of pre-drilled self-adhesive "foils" at the sampling points may not be appropriate as they may not be able to withstand the blowback pressures during prolonged service.
3. What are the consequences/risks of the blow back system in normal operation and in fault?
   - What happens to the dirt or particles expelled during the blow back?
   - Are there safety devices to prevent overpressure in the pipework?
   - What are the failure modes if a valve fails to open/close?

8 In France, NF S 61-970 makes this a mandatory requirement for NF approval.

Flow chart for assessing Open-flow In-line components for use on Xtralis ASD systems

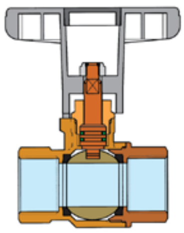
(Issue 1 - May 2010)
(published in Doc 18336)

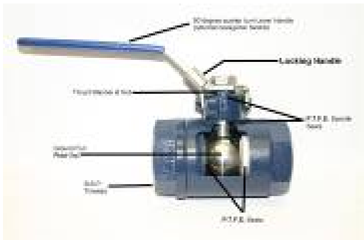


Appendix 1: Examples Illustrating How to Assess Whether a Component Has Open Flow Paths

The examples contained within this appendix provide practical illustrations of how to assess any particular component to determine if the flow path can be considered to be open. It also provides some guidance on how to estimate the internal cross sectional area.

Example 1 – Isolation Valve





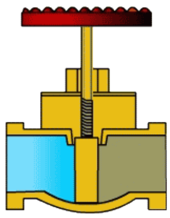
There are many types of isolation valves but the most common used with aspirating smoke detectors are ball type valves. These can be identified very quickly as open flow components because it is possible to look straight through them when the valve is open and the ball is clearly visible when they are closed.

Furthermore it is very easy to determine the internal cross sectional area by simply measuring the internal diameter (ID). For example a particular ball valve may have an ID of 19mm.

Using the formula Area = Π* radius² this equates to a Cross Sectional Area (CSA) of 283mm².

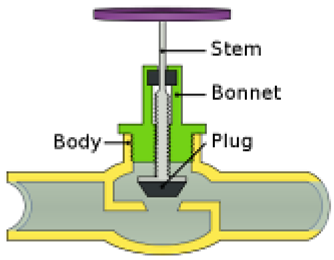
In most cases the internal diameter (ID) of the pipe is 21mm or more. The CSA of the pipe is thus 346mm² so the CSA of the valve is about 81.9% compared to the CSA of the pipe. As this is greater than the 58% limit recommended in this Application Note, such a valve can be used with confidence on an Xtralis ASD system designed to have a 10% safety margin in terms of sensitivity and transport time.

Note: Other types of isolation valve with a similar open section (such as a gate valve) can be assessed in a similar fashion as they offer little impedance to the flow when open.



Gate Valve Closed

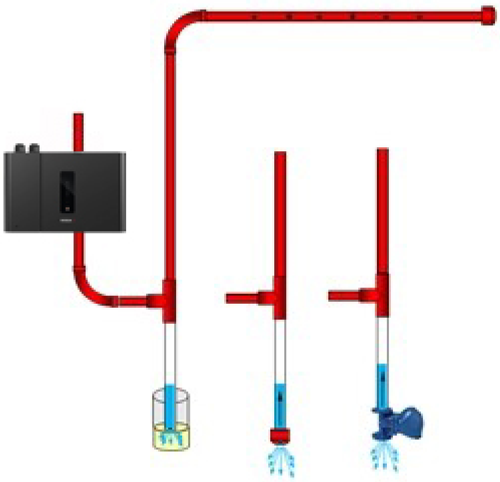
Gate Valve Opened



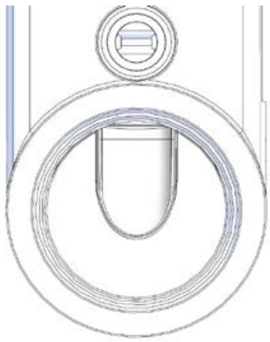
Assessing more complex isolation valves (such as the globe valve illustrated above) requires knowledge of the valve seat and the effective CSA when the valve is open. While such information can be obtained from the manufacturer of such valves there is a small risk that smoke attenuation will occur due to separation of smoke as the flow changes direction through the component. However, as such valves are generally intended for flow *control* as opposed to *isolation* it would be rare to use them when alternative, more appropriate valves designs are available.

Example 2 – Sample Water Trap

In some ASD applications there is a small risk of condensate building up inside the pipework and entering the detector. Generally this is a risk where the air samples are drawn from a warm & humid environment and in some applications the risk is sufficient to justify including a simple water trap arrangement. While it is possible to purchase commercial water traps designed for pneumatic systems these are not generally suitable for ASD systems and a simple arrangement using appropriate bends and lengths of transparent pipe often provide the most appropriate and cost effective solution.



Some possible arrangements are shown above. In terms of flow restriction the elements that make up such simple water traps are normal pipe components. If condensate builds up to the point that flow is restricted then ASD detector will signal a flow fault.



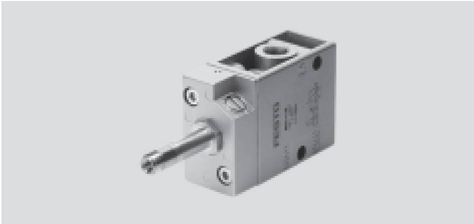
Example 3 – In-line Gas (or Smoke) Detectors

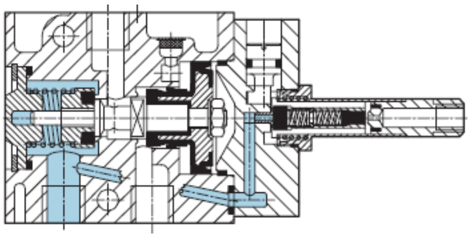
Additional components containing gas or smoke detectors may be inserted in the pipework. Such components may be assessed in accordance with this Application Note[9]. The example shown above consists of the sampling "scoop" in the pipework with diverts a small proportion of the main flow over one or two gas sensors. The CSA of the 20.5mm pipe is pipe 330mm² and this is reduced to 202mm² - as this is a reduction to 61.2% the component can be used with confidence on an Xtralis ASD system designed to have a 10% safety margin in terms of sensitivity and transport time.

> **Note!**
>
> Where the flow characteristics of a component are provided in ASPIRE, the generous safety margins provided by this Application Note are not applicable and the ASPIRE predictions can take precedence.

9 This Application Note does not consider the interconnection of such devices into the monitoring host. Direct connection to a fire system may require approval depending of the territory.

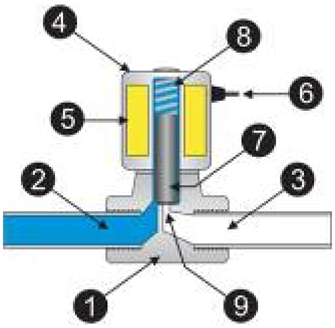
Example 4 – Automatic Isolation Valve





Automatic isolation valves are often more complex than manually operated valves but in general there is no deliberate filtration and flow paths are designed to minimise the pressure drop. In most applications, as long as the valve is sized to match the pipework then the pressure drop will be relatively small.

However, when assessing the effective internal diameter of the valve it is important to consider the minimum CSA. For example, in the diagram below the inlet and exhaust ports (2&3) appear to be similar to the pipe diameter but the valve seat (9) is significantly smaller. Therefore, when assessing such valves it is important to determine the minimum CSA that occurs as the flow passes through it. Unfortunately, in many valves this is not possible by simple inspection and the information must be obtained from the manufacturer. Where such information is not availbe then the component should not be used.



With regard to the smoke attenuation risks associated with such valves it is important that the flow paths are as simple and smooth as possible. A valve that offers almost straight-through flow paths (such as the type illustrated above-right) is unlikely to introduce any risk of smoke attenuation. However, the valves must be suitable for the purpose, robust and controlled in a manner which cannot inhibit the correct operation of the ASD system (see discussion on page 6 – Further recommendations for the use of additional in-line components with variable characteristics and/or automatic control).

Exemple 5 – Flexible Coupling and Expansion Joints

Such in-line components are easy to assess to confirm that they are open-flow. Furthermore, measuring the internal diameter and length is straightforward. Where the component's walls are corrugated it is recommended to estimate the effective cross section as 90% of the minimum cross section within the component for the purposes of this Application Note.

Appendix 2: Guidance for Persons Involved in the Inspection of ASD Systems

The recommendations contained within this appendix provide a practical guidance for persons involved in the assessment and inspection of ASD systems which include optional in-line components to confirm that they are installed in compliance of EN54-20.

There are two simple aspects to assessing the suitability of any in-line component:

1. Confirm that there is no filtering element or complex flow paths that introduce a risk that the component will attenuate smoke.

   In general it is easy to confirm that there is no filtering element.

   In components with fewer than 2 changes of direction of flow within the component and a cross-sectional area of at least 58% of the native pipe, it is reasonable to accept that the risk of smoke attenuation is negligible.
2. Confirm that component (or components if more than one) has not increased the maximum Transport Time beyond the allowable limits for the particular product (see Table 1 above).

   The maximum Transport Time is measured by introducing smoke at the furthest sampling point (or end cap) and measuring the time it takes for the first indication of smoke to appear at the detector. In many detectors this can be observed on the bargraph or on a PC connected for the purpose of observing the smoke reading. However, on detectors where there is no such bargraph or analogue signal, the moment that the detector signals an alarm is taken as the “first indication of smoke”. When assessing maximum transport time using the alarm signal, allowance shall be made (and recorded) for any alarm delays that are configured (default is typically 10 seconds).

   Having measured the maximum transport time it can be checked to be in compliance with the limits for the particular detector (see Table 1).

In summary, as long as the component used is “open” (i.e. the risk of it attenuating smoke is negligible) and the maximum transport (as given in Table 1) are not exceeded then the operation of the system in accordance with EN54-20 is NOT impaired by the in-line component.

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