Technical Information

EJX Series
Overview of Impulse Line Blockage Detection Function

DPharp EJX™

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CONTENTS

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1. Objectives

When DP flow measurement is performed with an orifice plate, a blockage in the impulse line may cause a measurement failure, affecting process control. An EJX with an Impulse Line Blockage Detection - ILBD (option code: /DG1 or /DG6) is capable of estimating the blockage condition using a newly developed pressure fluctuation detection function. An alarm on the EJX LCD display or an analog alert, if programmed, will be generated when a certain blockage level / preset is reached. ILBD is performed using statistical values derived from the measured values of pressure fluctuations that exist in a fluid. Since the characteristics of pressure fluctuations vary with the process conditions, the accuracy of blockage detection depends on the process conditions.
This Technical Information (TI) document provides a functional overview that includes a description of the characteristics of ILBD, and explains how ILBD is performed within an EJX differential pressure / pressure transmitter. Furthermore, this TI document describes the process conditions suitable for ILBD and provides a guideline for applying ILBD function to EJX differential pressure/pressure transmitter.

2. Function and Characteristics of ILBD

■ Principles of ILBD

During measurement of the flow of a fluid through a pipeline, the impulse line may be plugged with solids or frozen fluid. The flow is affected by pressure fluctuations produced by pumps and other machinery, and a differential pressure transmitter measures the differential pressure along with process-related fluctuations. The impulse line condition can be detected by extracting the fluctuation component from the differential pressure and static pressure signals. The extracted component of the process fluctuations is used to determine the amount of impulse line blocking. The ILBD function allows an operator to detect a potential blockage condition before it interferes with the control of flow and pressures at a plant. The original objective of a differential pressure transmitter is to accurately measure differential pressure based on the flow conditions. However, a differential pressure transmitter that is also capable of measuring process fluctuations can use this important information to carry out important diagnostics such as ILBD. Figure 1 shows that the transmitted pressure fluctuations are reduced when the high-pressure-side impulse line is plugged. The same is true for level and pressure measurements.

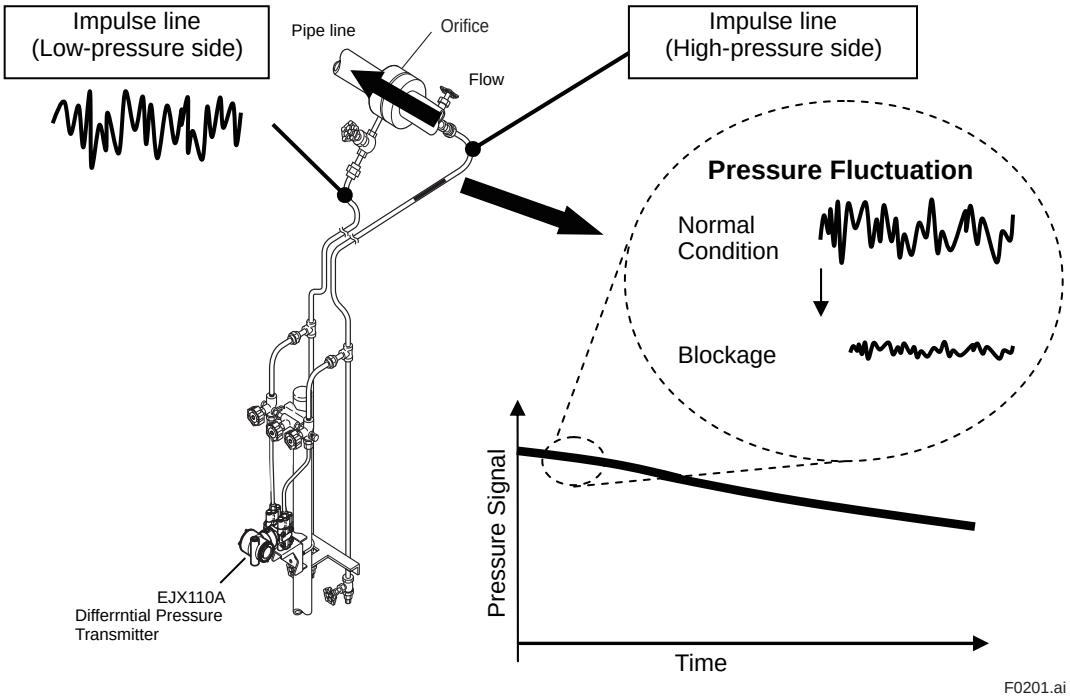
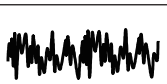


Figure 1 Impulse Line Blockage Detection (ILBD)

Classification of Impulse Line Blockages

There are three types of impulse line blockages: both sides, high-pressure side, and low-pressure-side. Table 1 shows examples of idealized pressure fluctuation waveforms for each of the impulse line blockage conditions. The main feature of an EJX differential pressure transmitter with the blockage detection function is the ability to independently detect all of the potential blockage types using a silicon resonant sensor which is capable of simultaneously measuring the differential pressure as well as high- and low-pressure-side static pressure [1].

Table 1 Impulse Line Blockage Types and Examples of Pressure Fluctuation Waveforms

Signal \ Impulse Line Condition	No blockage (Normal)	Blockage		
		High-Pressure Side	Low-Pressure Side	Both Side
Differential Pressure (DP)				
High-pressure-side Static Pressure (SP_H)				
Low-pressure-side Static Pressure (SP_L)				
Fluctuation Level	DP: High SP_H: High SP_L: High	DP: High SP_H: Low SP_L: High	DP: High SP_H: High SP_L: Low	DP: Low SP_H: Low SP_L: Low

Conditions Required for ILBD

The pressure fluctuations of differential pressure and the high- and low-pressure-side static pressures are calculated at an interval of 100 msec [2]. If there is little fluctuation, i.e. if the pressure waveforms have a lower amplitude, there is the likelihood that a blockage cannot be detected. To increase the certainty of the blockage detection, the pressure fluctuation of the process needs to be higher. To check whether the blockage can be detected, the appropriate manifold can be used to simulate an impulse line blockage and verify whether the blockage alarm is generated correctly.

Parameters for ILBD

The EJX differential pressure/pressure transmitter calculates the following values to perform detection [3].

Average Value of the Sum of Squares of Differential Pressure/Pressure Fluctuations (fDP)

The average value of the sum of squares of differential pressure/pressure fluctuations, fDP, is obtained based on several hundred calculated pressure fluctuation values. When the differential pressure/pressure fluctuation value decreases as the blockage progresses, fDP decreases.

Reference Value of the Sum of Squares of Differential Pressure/Pressure Fluctuations (Ref_fDP)

Since the amplitude of pressure fluctuations varies naturally within the process, the initial amplitude of pressure fluctuations inherent in the process needs to be obtained as a reference value before blockage detection can be performed. This is the average value of the sum of squares of differential pressure fluctuations under the normal conditions.

1 With level or pressure measurement, ILBD is performed on the process pressure measurement side. Since this TI document is intended to be a guideline for selecting the most suitable blockage detection function option, unless otherwise mentioned, only blockage detection with a differential pressure transmitter is described in order to make the description clear.

2 FOUNDATION Fieldbus type. 135 msec for HART protocol type.

3 The fact is that the average value of the sum of squares of low-pressure side static pressure fluctuations, fSPl, the average value of the sum of squares of high-pressure side static pressure fluctuations, fSPh, and the corresponding respective reference values, Ref_fSPl and Ref_fSPh, are also obtained simultaneously. The use of these values in conjunction with BlkF increases the accuracy of high- and low-pressure-side blockage detection. For the convenience of explanation of the principles, however, it is supposed in this document that the high- and low-pressure-side blockage detection is performed using BlkF alone. fSPl and fSPh will be mentioned only when necessary.

● Both-side Blockage Detection Using Average Value of Fluctuations

When a blockage simultaneously occurs on both the high- and low-pressure sides, fDP will decrease and SQRT (fDP / Ref_fDP) will be used to determine whether one or both sides are plugged.

● High- or Low-Pressure-Side Blockage Detection Using BlkF

The blockage degree is characterized by a comparison of the high- and low-pressure side fluctuation values, BlkF, is calculated based on the fluctuation values of the differential pressure, and the high- and low-pressure-side static values. As BlkF approaches +1, the high-pressure-side blockage progresses. On the other hand, if it approaches -1, the low-pressure-side blockage progresses. Figure 2 shows the correlation between the blockage progress and BlkF. BlkF allows for the detection of both high- and low-pressure-side blockages.

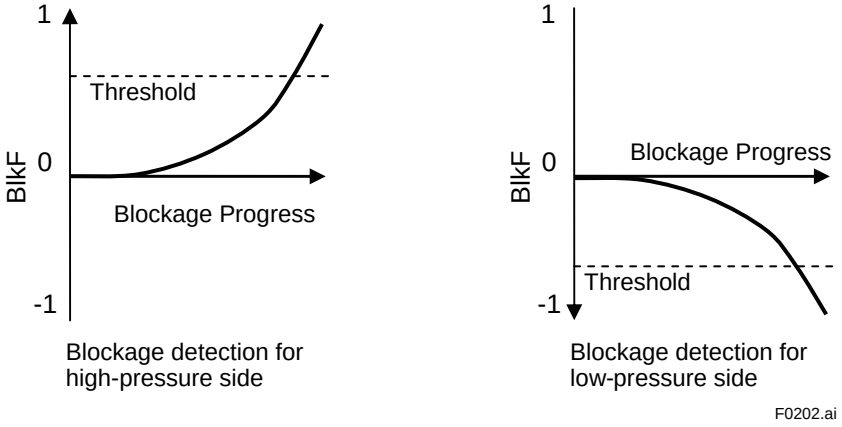


Figure 2 Correlation between Blockage Progress and BlkF

3. Blockage Detection Procedure with EJX

■ Characteristics of Blockage Detection with EJX

An EJX differential pressure transmitter is capable of rapidly measuring the differential pressure and the high- and low-pressure-side static pressures using a silicon resonant sensor. These newly developed parameters combining the differential pressure and the high- and low-pressure-side static pressures enable the differential pressure transmitter to independently detect a high- or low-pressure-side blockage. Furthermore, ILBD advanced diagnostic is immune to the influence of flow variations. The following shows the characteristics of blockage detection with an EJX.

- A standalone EJX differential pressure/pressure transmitter is capable of monitoring, detecting, and displaying the blockage condition.
- A high- or low-pressure-side blockage can be detected independently using the blockage degree, BlkF, which indicates a complete high- or low-pressure-side blockage with +1 and -1, respectively.
- The BlkF parameter is influenced less by fluid density, viscosity, and flow rate.
- fDP, which is based on the fluctuation value of differential pressure/pressure, allows for detecting both-side blockages that form simultaneously on the high- and low-pressure-sides.

■ Procedure for ILBD

An EJX differential pressure/pressure transmitter performs detection by combining two parameters, SQRT(fDP / Ref_fDP) and BlkF. Figure 3 shows the main blockage detection procedure. Blockage detection consists of the following three steps: obtaining a reference value, checking the operation, and the performing blockage detection operation. EJX blockage detection configuration can be performed with FOUNDATION fieldbus™ compatible software such as PRM™ and FieldMate™. Since the EJX differential pressure transmitter is capable of obtaining a reference value, no other special measuring device is required. If the fluctuations of differential pressure and static pressure are small when a reference value is obtained, the reference value may be invalid and a blockage will not be detected. Therefore, this operation needs to be checked first with the appropriate manifold to ensure that blockage detection can be successfully implemented.

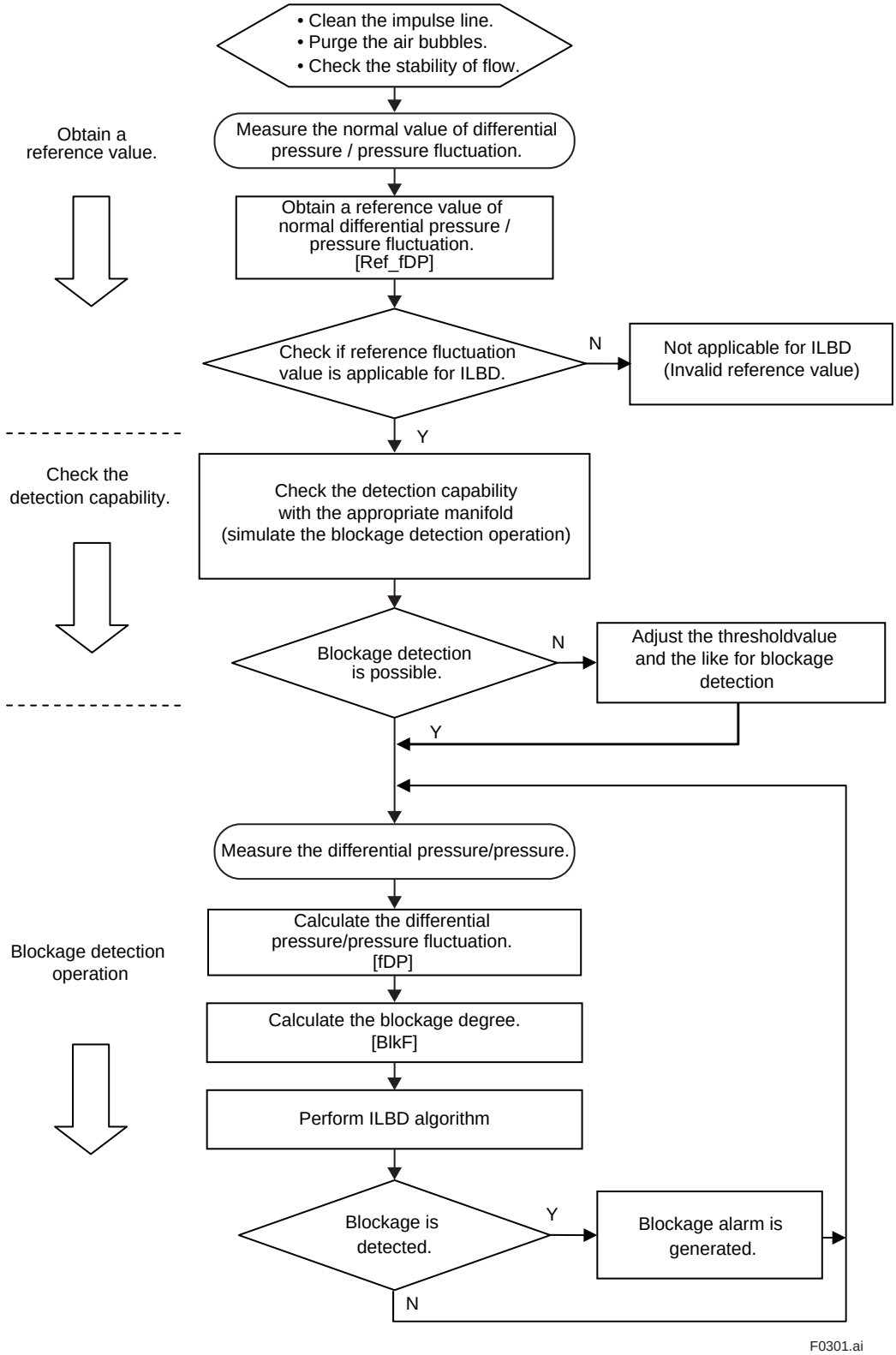


Figure 3 Flow Chart of Detection Algorithm [4]

4 Figure 3 is simplified to make it easy to understand the basic sequence of the detection algorithm, i.e. this differs from the actual process performed by an EJX differential pressure/pressure transmitter.

Obtain a Reference Value

Before performing blockage detection, the pressure fluctuation value of the process needs to be measured and Ref_fDP and Ref_BlkF need to be checked. Ref_fDP and Ref_BlkF need to be within a specified range for all possible blockages to be detected. If Ref_fDP alone meets the required condition, both-side blockages and single-side blockages can be detected by measuring only the differential pressure. If both Ref_fDP and Ref_BlkF meet the required conditions, both-side blockages and high- and low-pressure-side blockages can be detected [5].

Check the Detection Ability

With a differential pressure transmitter, the detection capability needs to be checked after a reference value has been obtained. Specifically, the appropriate manifold mounted on the impulse line is operated to simulate an impulse line blockage and to ensure that a blockage alarm is generated correctly. With level or pressure measurement, a stop valve is closed to check the operation. If the blockage alarm is not generated, the threshold values need to be changed. Figure 4 shows an example where the operation is checked with a differential pressure transmitter. When the high-pressure-side three-valve manifold is closed gradually to simulate a high-pressure-side blockage, BlkF approaches +1, and the high-pressure-side blockage alarm is generated when it exceeds the threshold preset (A in the figure). When the high-pressure-side three-valve manifold is then reopened and the low-pressure-side three-valve manifold is then closed gradually, BlkF approaches –1, and the low-pressure-side blockage alarm is generated when this exceeds the threshold preset (B in the figure). Finally, when both valves are gradually closed, the SQRT (fDP / Ref_fDP) value decreases and a both-side blockages can be detected (C in the figure). In this example, the three types of impulse line blockages are detected correctly.

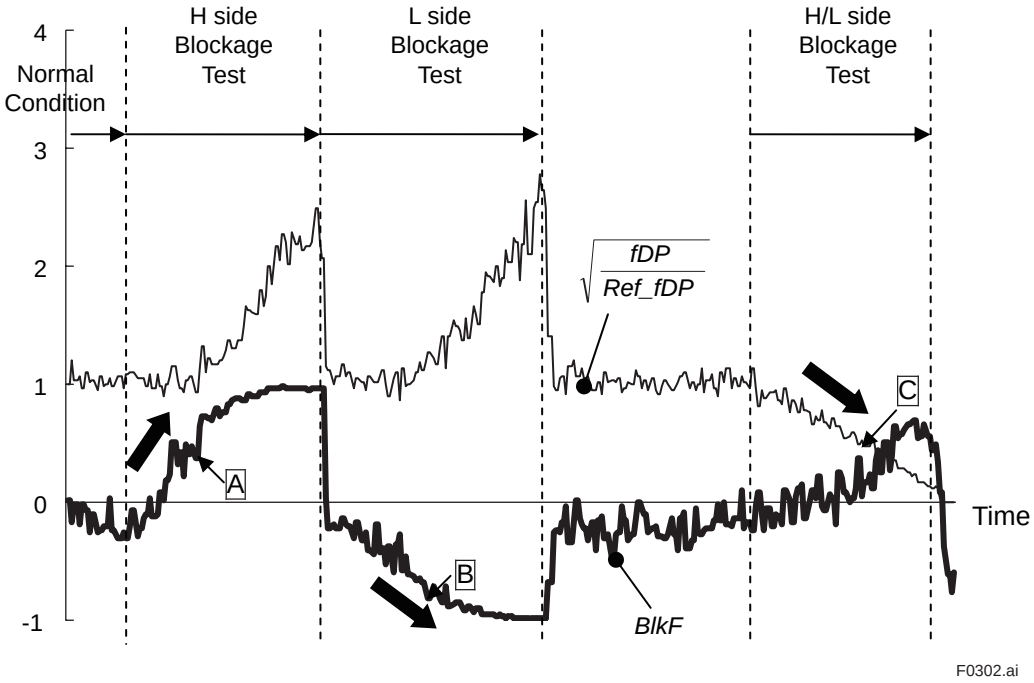


Figure 4 Example of Checking Blockage Detection Operation with Three-valve Manifold

Blockage Detection Operation

While the differential pressure and the high- and low-pressure-side static pressures are being measured, the respective pressure fluctuations and the blockage degree are calculated. A blockage detection algorithm based on these parameters can be used to determine whether there is a blockage. When a blockage is detected, the corresponding blockage alarm is generated. After that, the detection operation procedure is repeated.

5 The fSPl and fSPh also need to be within a specified range. Also, when Ref_fDP, Ref_fSPl, and Ref_fSPh meet the required conditions, both-side blockage and high- and low-pressure-side blockage can be detected.

4. Applicable Scope of ILBD

Applicable Models

With a differential pressure transmitter, the blockage detection function detects high-pressure, low-pressure, and both-side blockages. As for level or pressure measurements, an impulse line blockage on the process pressure measurement side can be detected. Table 2 shows the blockage detection items for EJX models.

Table 2 Blockage Detection Items and Applicable EJX Models

Model		Communication protocol**	Blockage detection item
EJX110A	Differential Pressure Transmitter	FF/HART	High-pressure side blockage Low-pressure side blockage Both-side blockages
EJX118A	Diaphragm Sealed Differential Pressure Transmitter	FF/HART	
EJX130A	Differential Pressure Transmitter	FF/HART	
EJX210A	Flange Mounted Differential Pressure Transmitter	FF/HART	
EJX120A	Draft Range Differential Pressure Transmitter *	FF/HART	
EJX115A	Low Flow Transmitter	FF/HART	
EJX910A	Multivariable Transmitter	FF	
EJX930A	Multivariable Transmitter	FF	
EJX310A	Absolute Pressure Transmitter	FF/HART	Impulse line blockage on the process pressure measurement side
EJX430A	Gauge Pressure Transmitter	FF/HART	
EJX438A	Diaphragm Sealed Gauge Pressure Transmitter	FF/HART	
EJX440A	Gauge Pressure Transmitter	FF/HART	
EJX510A	Absolute Pressure Transmitter	FF/HART	
EJX530A	Gauge Pressure Transmitter	FF/HART	

* Applicable for both-side blockage only.
** FF: FOUNDATION Fieldbus.

Measurable Differential Pressure and Static Pressure Range

Generally speaking, when the differential pressure and static pressure are high, pressure fluctuations are relatively large, so stable blockage detection is possible. Figure 5 shows an example of the applicable range of blockage detection with an EJX110A M-range measurement capsule. The amplitude of the pressure fluctuations varies with the process, so there is the likelihood that a range in which blockages can be detected in the process shown in this example is not necessarily a detectable range of blockages in another process.

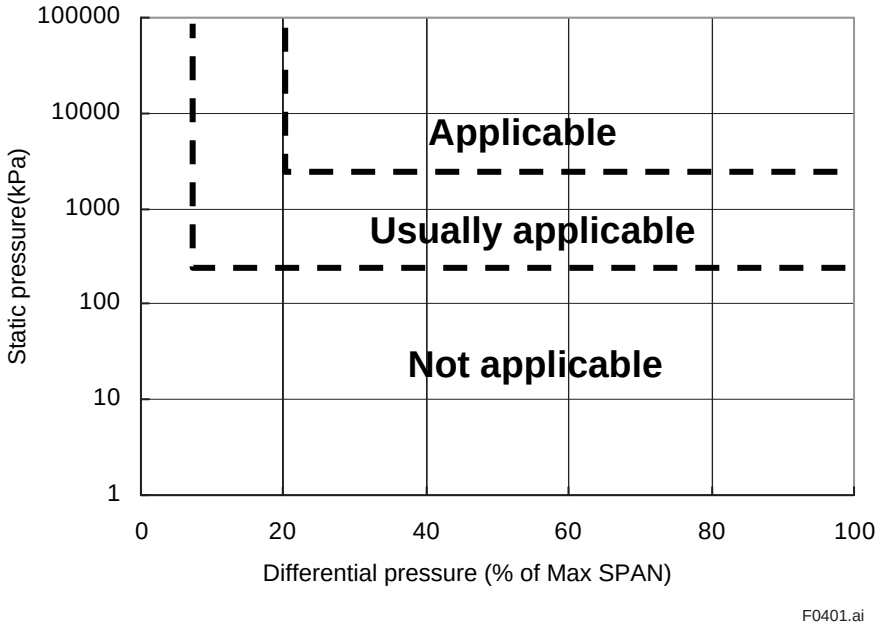


Figure 5 Example of EJX110A M-Range Blockage Detection for Oil Application

Applicable Fluids

The ILBD function is applicable for many fluid types. Although fluids with a viscosity of 10 cSt or more have less than half the pressure fluctuation amplitude of water, blockages can be detected sooner than with water. Gas pressure fluctuation amplitude is low, so blockage detection cannot be applied. Table 3 lists some of the fluids for which differential pressure transmitter blockage detection can be applied.

Table 3 Examples of Fluids Applicable for ILBD

Blockage detection	Low viscosity fluid E.g: water (1 cSt)	High viscosity fluid E.g: oil (10 cSt or less)	Gas E.g: natural gas
Both-side blockage	Applicable	Applicable	Occasionally applicable
Single-side blockage	Usually applicable	Usually applicable	Not applicable

5. Notes

- If the impulse line is nearly plugged when the reference value is obtained, blockages cannot be detected accurately. The impulse lines on both the high- and low-pressure-sides need to be cleaned before a reference value is obtained.
- All air bubbles need to be adequately purged before a reference value is obtained.
- The flow needs to be stable when a reference value is obtained.
- FOUNDATION fieldbus compatible configuration software such as PRM and FieldMate can be used to configure blockage detection with an EJX differential pressure / pressure transmitter. Since the EJX is capable of obtaining a reference value, no other special measuring device is required.
- If the pressure fluctuation amplitude is too low for a reference value to be obtained, blockages cannot be detected.
- If the flow increases or decreases by more than 25% after a reference value is obtained, a new reference value needs to be obtained under more stable flow conditions. Otherwise, detection may not function correctly.
- To check the detection ability, when using a differential pressure / pressure transmitter, the appropriate manifold needs be mounted on the impulse lines, and this must then be operated to simulate and detect a blockage. If no valve is mounted to simulate and detect a blockage, it is impossible to determine whether a blockage can be detected.
- Please ensure that the impulse lines are clean and free from obstructions before measuring reference fluctuation.
- The pressure fluctuation amplitude in fluids must be sufficiently large for blockages to be detected. With level or pressure measurement, or when the medium is a gas, the pressure fluctuation amplitude is likely to be too small for blockages to be detected.
- With flow measurement, a false alarm of an impulse line blockage may be generated in the following three cases: 1) A pressure transmitter is used and the pressure drops to nearly the limits of diagnostic capable range. 2) Even though the pressure is constant, the flow decreases after a reference value is obtained. 3) A source of pressure fluctuation (pump, compressor, blower, etc.) is shut down. As a result, the pressure fluctuation amplitude decreases. Before taking action in response to a blockage alarm, you need to consider the plant operating conditions.
- With level measurement, a false alarm of an impulse line blockage may be generated in the following three cases: 1) A transmitter is used to measure tank level and the flow of fluid into or out of the tank comes to a stop. 2) The agitator in the tank is shut down. 3) A source of pressure variation (a compressor, etc.) that controls the internal pressure of a sealed (closed) tank is shut down. As a result, the pressure fluctuation amplitude decreases. Before taking action in response to a blockage alarm, you need to consider the plant operating conditions.
- The ILBD function is performed using the statistical values derived from the measured values of pressure fluctuations in a fluid. Since the characteristic of pressure fluctuations varies with the process conditions, the accuracy of blockage detection depends on the process. When using the ILBD function with an EJX differential pressure/pressure transmitter, 100% accurate detection of all blockages in any conditions is not guaranteed.