CM2-AVP700-2003

Smart Valve Positioner
700 Series
Control Valve Diagnostic

Function Manual

Azbil Corporation

azbil

Important

- Make sure that this manual is delivered to the user of this product.
- It is prohibited to copy or reprint this manual in whole or in part without permission.
- The contents of this manual are subject to change without notice.
- We have taken all possible measures to ensure the accuracy of this manual, but please contact us if you find any errors or missing information.
- Note that we cannot in some cases accept responsibility for the results of the customer's operation of this product.

Introduction

Thank you very much for purchasing the Smart Valve Positioner 700 Series. This is the manual for the control valve diagnosis feature of the 700 series.

Inquiries

Please direct inquiries about this feature to our company's branch office or sales office that's closest to you.

Safety Precautions

■ Regarding Symbols

Safety precautions are intended to help you to use the product safely and correctly, and to prevent injury to yourself or others as well as damage to property. Be sure to follow all safety precautions.

This manual makes use of the following symbols. Please gain a good understanding of this information before reading the main text of this manual.

Caution	To anticipate dangerous situations, in which the product user may experience minor injuries, or physical damage as a result of mishandling.

■ Examples of visual indicators

	This indicator indicates a caution that the user should be aware of for handling.

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Chapter 1 Stick-Slip Diagnosis

[Overview]

■ Objective

■ Stick-Slip Phenomenon

■ Detection of Stick-Slip

Stick-Slip diagnosis detects any sticking or galling of the gland, guiding surfaces, and plug/seat.

The stick-slip phenomenon is when the valve shaft stops (sticks) and slips repeatedly (Figure 1-1).

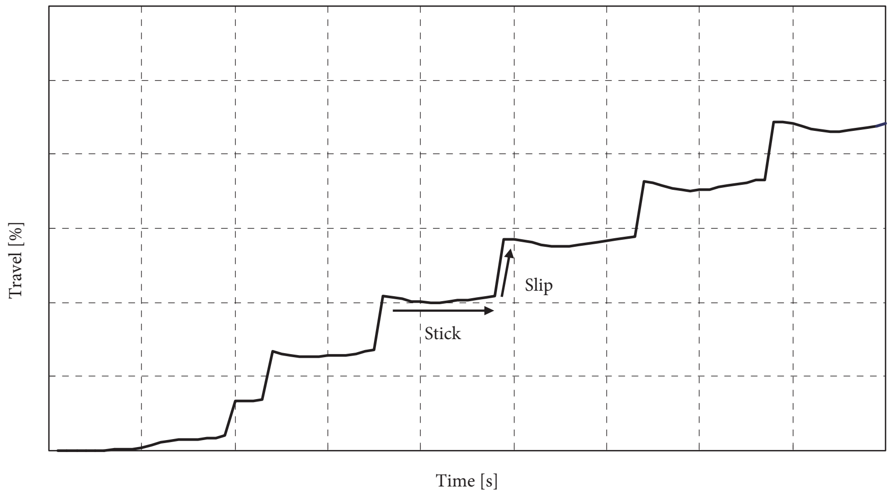


Figure 1-1 Stick-Slip Phenomenon

Stick-Slip diagnosis focuses on the ratio of the average valve shaft speed and its mean square, and how that ratio differs during normal state, and when stick-slip is happening.

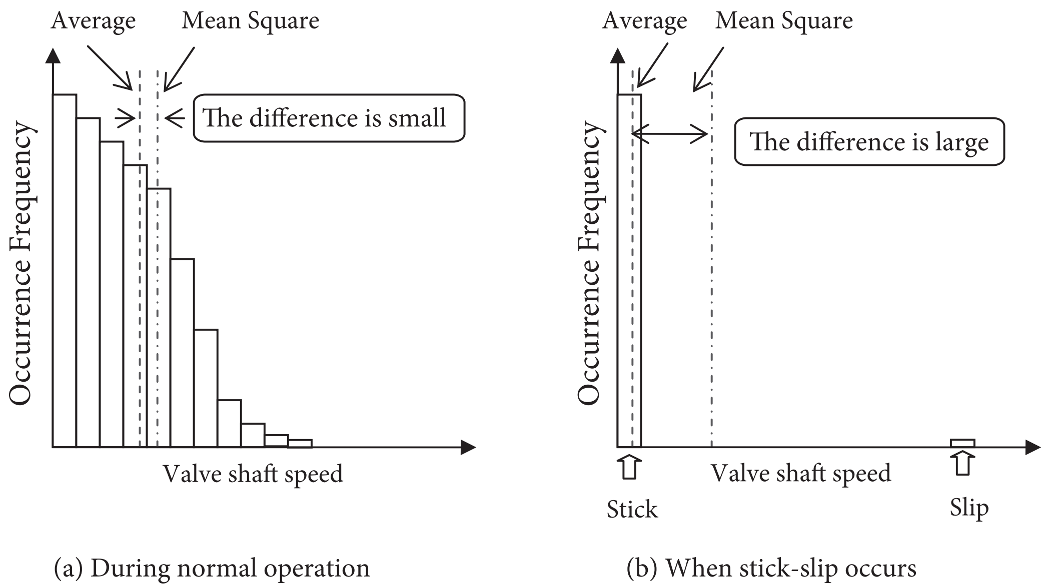


Figure 1-2 Occurrence of Stick-Slip and Distribution of the Valve Shaft's Speed

Fig. 1-2 (a) illustrates if the valve shaft's speed distribution is wide, its average and mean square values will be very close to each other. On the other hand in (b), the distribution is divided into two parts, one when opening is stopped (sticks) and the other during slipping. In this case, the difference between the average and mean square is large. Stick-slip diagnosis makes use of this property.

[Algorithm]

- Calculation of Stick-Slip X and Stick-Slip Y
- Properties of Stick-Slip X and Stick-Slip Y

The valve shaft's speed is calculated from the difference in the travel data measured every 50 ms, and then the 400-second data (8000 samples) is used to calculate the square of the average value of valve shaft' speed (Stick-Slip X) and the mean square of the valve shaft's speed (Stick-Slip Y).

The value that results from dividing Stick-Slip Y with Stick-Slip X (hereinafter referred to as "Y/X") is close to 1 during a normal state, but will get larger as stick-slip increases.

[Threshold and Alarm]

- Understanding stick-slip using three thresholds
- Alarm suppression using SS Validity
- Calculation of SS Validity
- Utilization of alarm count

To detect a gradual rise in Y/X, threshold values are established: Stick-Slip Threshold High, Stick-Slip Threshold Medium and Stick-Slip Threshold Low. Their initial values are 10, 5.5 and 3, respectively. Alarms are activated in the order of Stick-Slip Alarm Low → Medium → High, and will not be activated simultaneously.

If the set point is increased significantly, SS_Validity (the parameter that enables or disables stick-slip diagnosis) is invalidated (set to 0). When SS_Validity is 0, alarms will not be activated, even if Y/X exceeds the threshold, since no abnormality is present.

SS Validity conducts the same calculation with Stick-Slip X and Stick-Slip Y for the set points, and calculates the Stick-Slip X / Stick-Slip Y (hereinafter referred to as "SP_Y/X") for the set points. When the SP_Y/X is equal to or less than Stick-Slip Threshold High, SS_Validity is set to 1 (enabled), and it is set to 0 (disabled) when SP_Y/X goes above the threshold.

In Figure 1-3, Y/X and SP_Y/X are plotted on the vertical and horizontal axis, respectively, illustrating the relationship between each alarm. When SP_Y/X is greater than 10, alarms will not be activated, even if Y/X is large enough for the alarm to be activated.

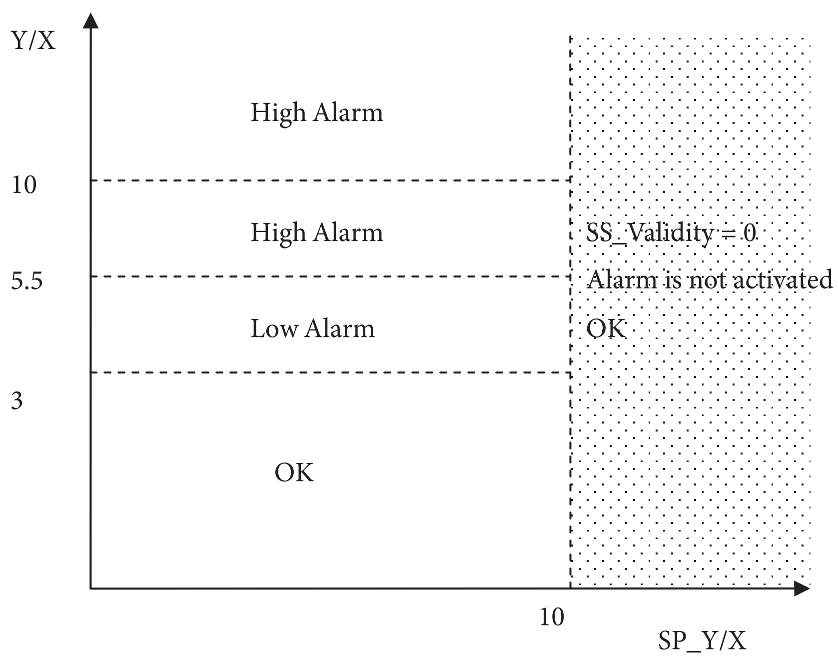


Figure 1-3 Relationship between alarm and SS_Validity

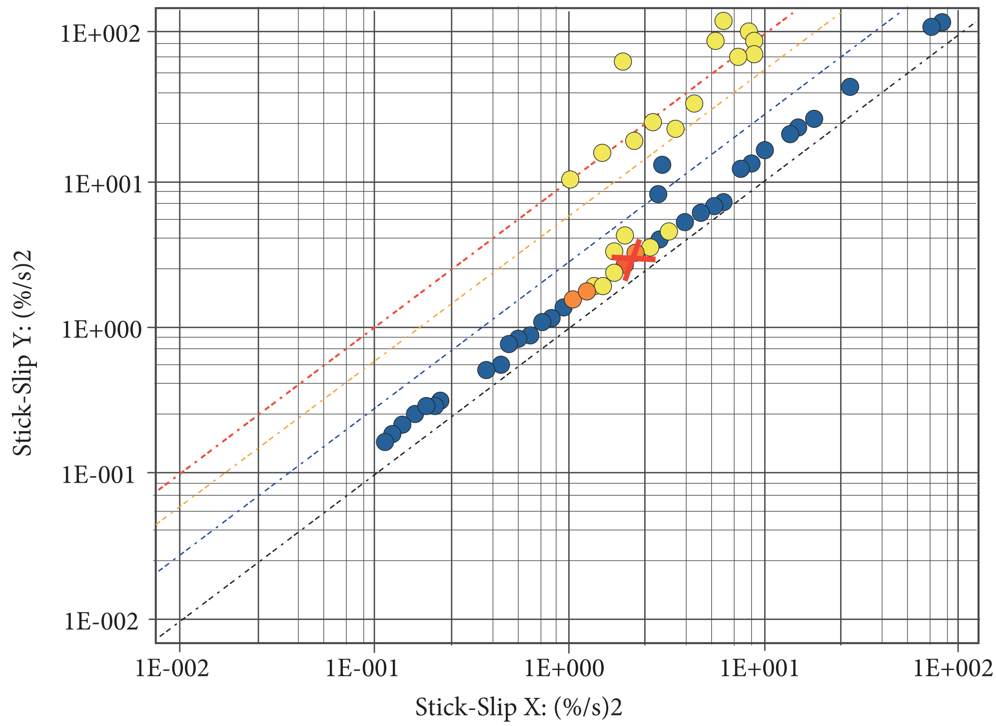


Figure 1-4 Stick-Slip diagnosis data

Table 1-1 Stick-Slip diagnosis and abnormality

Parameter	Threshold	Abnormality detected	Abnormality index (estimated)
(Stick-Slip Y / Stick-Slip X)	10.0 5.5 3	Sticking or galling of the gland, guiding surfaces, and plug/seat	Deterioration of gland packing is estimated.

Table 1-2 Stick-Slip Diagnostic Parameters (HART)

Parameter	Description	Initial Value
Stick-Slip X	Square of the averages of shaft valve speed	0
Stick-Slip Y	Mean square of shaft valve speed	0
Stick-Slip Validity	Whether to enable stick-slip diagnosis or not	-
Stick-Slip Updated Date (MM/DD/YYYY)	Date when diagnostic parameter was updated	04/01/2012
Stick-Slip Updated Time	Time when diagnostic parameter was updated	00:00:00
Stick-Slip High Alarm Count	Alarm count for High Alarm	0
Stick-Slip Medium Alarm Count	Alarm count for Medium Alarm	0
Stick-Slip Low Alarm Count	Alarm count for Low Alarm	0
Stick-Slip Threshold High	High Alarm Threshold	10
Stick-Slip Threshold Medium	Medium Alarm Threshold	5.5
Stick-Slip Threshold Low	Low Alarm Threshold	3

Table 1-3 Stick-Slip Diagnostic Parameters (FF)

Parameter	Description	Initial Value
Stick-Slip X[1]	Square of the averages of shaft valve speed	0
Stick-Slip Y[1]	Mean square of shaft valve speed	0
Stick-Slip Validity[1]	Whether to enable stick-slip diagnosis or not	255 (before the update)
Stick-Slip Updated Time[1]	Date and time when diagnostic parameter was updated	0
Stick-Slip High Alarm Count	Alarm count for High Alarm	0
Stick-Slip Medium Alarm Count	Alarm count for Medium Alarm	0
Stick-Slip Low Alarm Count	Alarm count for Low Alarm	0
Stick-Slip Threshold High	High Alarm Threshold	10
Stick-Slip Threshold Medium	Medium Alarm Threshold	5.5
Stick-Slip Threshold Low	Low Alarm Threshold	3

Chapter 2 Input Signal / Travel Deviation Diagnosis

[Overview]

■ Objective

Input signal / travel deviation diagnosis detects abnormality in the actuator (spring deterioration) or in the positioner (clogging of nozzle or restriction). Measures the deviation between the input signal and the valve's travel, and measures the time during which the deviation continues due to abnormality.

[Algorithm]

■ Deviation error range

■ Calculation of deviation duration

When the deviation (travel - set point) exceeds the positive deviation threshold "Deviation Threshold +" (5%), its duration is measured, and the maximum value is updated as the Deviation Time Max+. On the other hand, when the deviation exceeds the negative deviation threshold "Deviation Threshold -" (-5%), the maximum duration is updated as Deviation Time Max-. When it is forcefully closed or opened, or during a simulation, the degree of opening is not in a control situation, so deviation diagnosis is suspended, and the duration time is reset to 0.

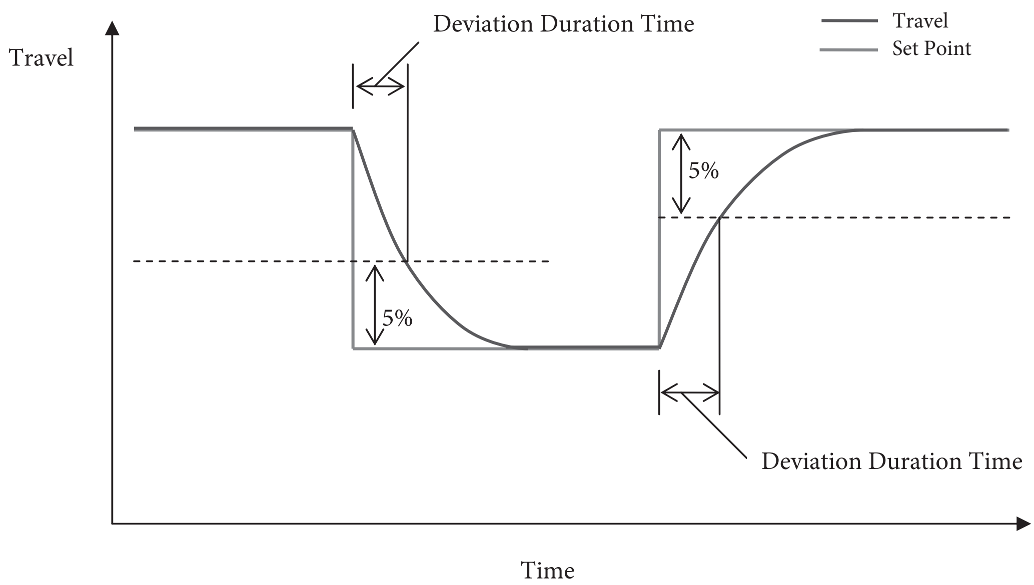


Figure 2-1 Measurement of deviation duration time

[Threshold and Alarm]

■ Explanation of threshold

■ How to set the threshold for actuators with long stroke time

When Deviation Time Max+ exceeds Deviation Waiting Time (10 seconds), A device status alarm is activated. The same is true when Deviation Time Max- exceeds Deviation Waiting Time. Figure 2-2 shows when an alarm is activated with Deviation Time Max+.

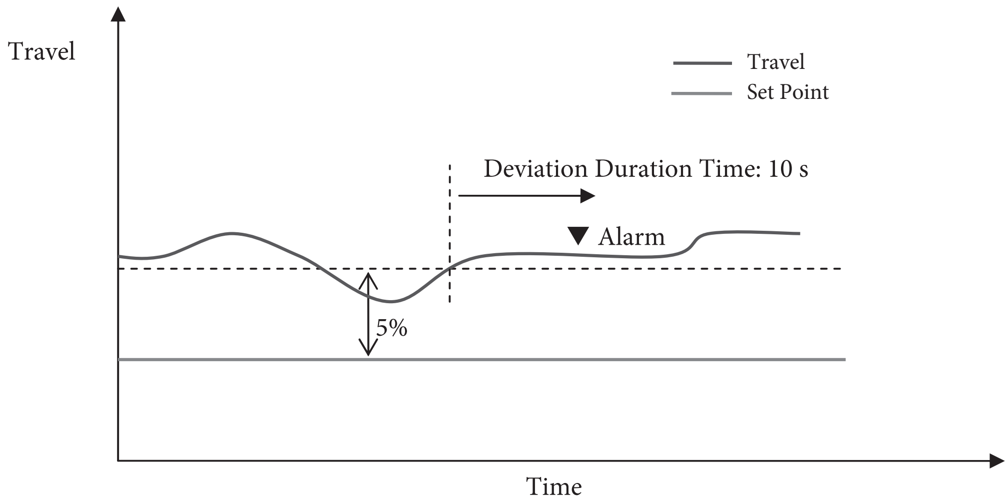


Figure 2-2 Activation of Deviation+ Alarm

Table 2-1 shows the relationship diagram between the deviation diagnosis and abnormality.

Table 2-1 Deviation diagnosis and abnormality

Diagnostic parameter	Threshold	Abnormality detected
Deviation Time Max +	When 5% continues for 10 s	Sticking or galling of the gland, guiding surfaces, and plug/seat Abnormality in the actuator Air leak Spring deterioration Spring falling off Breakage of the stem Positioner abnormality Clogging of nozzle/restriction Air leak from air circuit Falling off of feedback lever Failure of electric / angle sensor Pilot failure
Deviation Time Max -	When -5% continues for 10 s	

Handling Precautions:

For control valves with a long operation time, the Deviation Waiting Time cannot be 10 seconds, but must be significantly larger. If the set point is changed dramatically, the alarm will be activated if the deviation does not normalize to less than 5% within 10 seconds, even if the control valve is in a normal state. Depending on the operation time of the control valve, the threshold for the Deviation Waiting Time must be reset.

Table 2-2 Input Signal / Travel Deviation Diagnosis Parameters (identical for HART & FF)

Parameter	Description	Initial Value
Deviation Time Max +	Maximum duration (s) of the deviation in the positive direction	0
Deviation Time Max -	Maximum duration (s) of the deviation in the negative direction	0
Deviation Threshold +	Threshold of Deviation+ Alarm (%)	5
Deviation Threshold -	Threshold of Deviation- Alarm (%)	-5
Deviation Waiting Time	Deviation Alarm Waiting Time (s)	10
Deviation+ Alarm Count	Frequency of Deviation+ Alarm	0
Deviation- Alarm Count	Frequency of Deviation- Alarm	0

Chapter 3 Zero Point Travel Comparison Diagnosis

[Overview]

■ Objective of Zero Point Travel Comparison Diagnosis

Zero point travel diagnosis detects abnormalities such as foreign objects getting caught in the plug/seat, seat abrasion, misalignment of the fully-closed position and actuator spring deterioration.

The degree of opening of the control valve when it is completely closed (zero point travel) is monitored, and the amount of shift from 0% is compared with the threshold; if it exceeds the threshold, an alarm is activated.

Also, when zero point travel is shifted to the positive side, since the valve is operating with a small opening when it should be closed, there may be some abnormality, such as damage to the plug/seat, adhesion of fluids on the plug/seat, erosion/abrasion, corrosion, etc.

[Algorithm]

■ Explanation of Zero Point Travel Comparison Diagnosis

■ Explanation of Zero Point Travel Monitoring

■ Measurement when the Control Valve is not Fully Closed

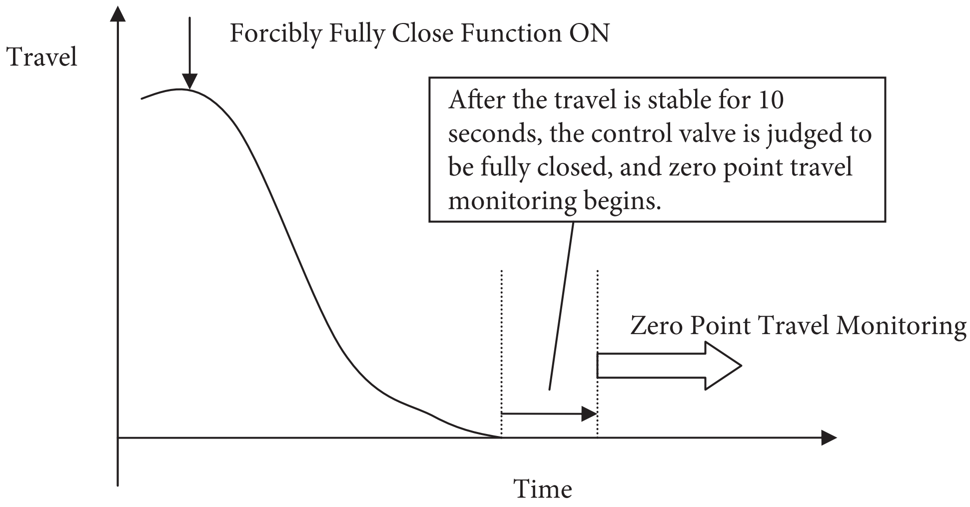


Figure 3-1 Timing of start of monitoring of the zero point travel

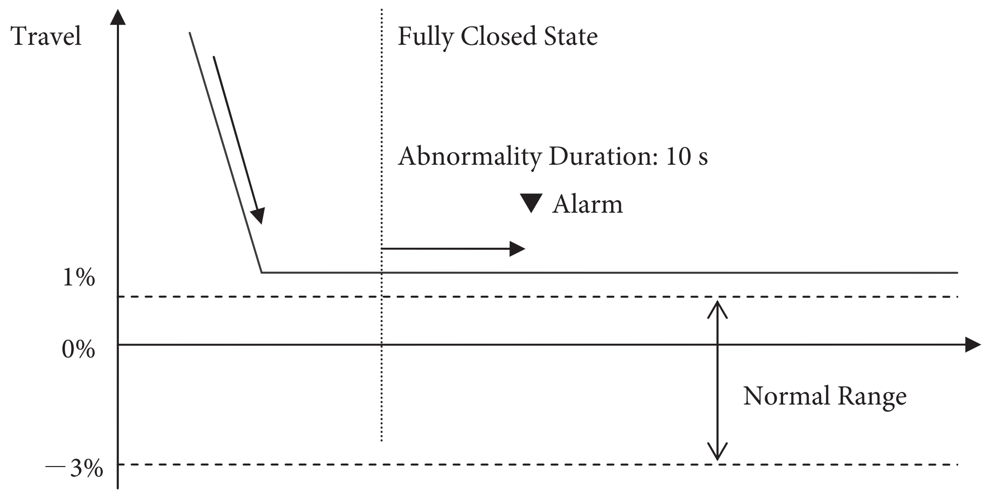


Figure 3-2 Zero Point Travel Comparison Diagnosis: abnormality duration and alarm

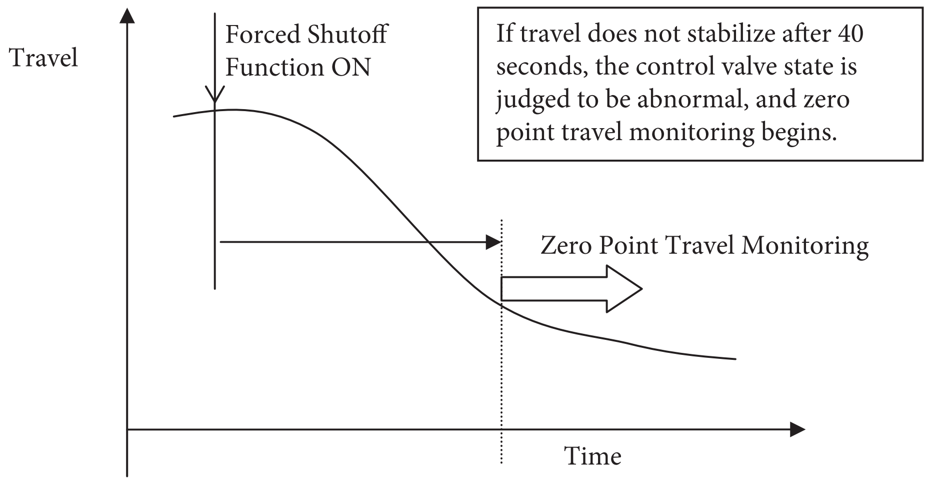


Figure 3-3 Timing of the start of zero point travel monitoring when travel does not stabilize

[Threshold and Alarm]

■ Explanation of threshold

■ How to set the threshold for actuators with a long stroke time

It is normal if travel in the fully closed state is between -3% and 1%. If departure from that normal range is not temporary and continues for at least 10 seconds, the zero point travel alarm on either the positive or negative side will be activated for the device status. Table 3-1 shows the diagnostic parameter, threshold, and applicable abnormality.

Table 3-1 Zero point travel diagnosis and abnormality

Diagnostic parameter	Threshold	Abnormality detected	Abnormality index (estimated)
Zero Travel Max	1% (Travel Waiting Time 10 s)	Intrusion of foreign object Misadjustment of fully closed position	The following abnormalities are expected. Damage of plug/seat Adhesion of fluid on the plug/seat Erosion Ablation Corrosion
Zero Travel Min	-3% (Travel Waiting Time 10 s)	Seat abrasion Misadjustment of fully closed position	

Table 3-2 Zero Point Travel Comparison Diagnostic Parameters (identical for HART & FF)

Parameter	Description	Initial Value
Zero Travel Max	Maximum value in positive direction of zero point travel	0
Zero Travel Min	Min value in negative direction of zero point travel	0
Zero Travel Stable Threshold	Zero point travel stability threshold	0.25
Zero Travel Static Time	Zero point travel static time	10
Zero Travel Error Waiting Time	Zero point travel error waiting time (Waiting time if it's not fully closed)	40
Zero Travel Threshold +	"Zero point travel +" alarm threshold	1
Zero Travel Threshold -	"Zero point travel -" alarm threshold	-3
Zero Travel Waiting Time	Zero point travel waiting time (Waiting time until alarm activation)	10
"Zero Travel +" Alarm Count	"Zero point travel +" alarm frequency	0
"Zero Travel -" Alarm Count	"Zero point travel -" alarm frequency	0

Chapter 4 Po Validity Monitoring

[Overview]

■ Objective and Method of Po Validity Monitoring (Po Validity)

Output air pressure validity is an index related to sticking or galling inside the valve's main body, unbalance between actuator output and flow force, as well as actuator defects.

Output air pressure validity is a calculation of how much the actuator's output air pressure has shifted from the standard determined by auto setup. The cause of the output air pressure validity straying from the standard is related to abnormalities, including actuator defects.

[Algorithm]

■ Properties of the control valve

■ Travel segments

■ Measurement of Po Max and Po Min

■ Calculation of output pressure validity

■ Acquisition of standard from auto setup

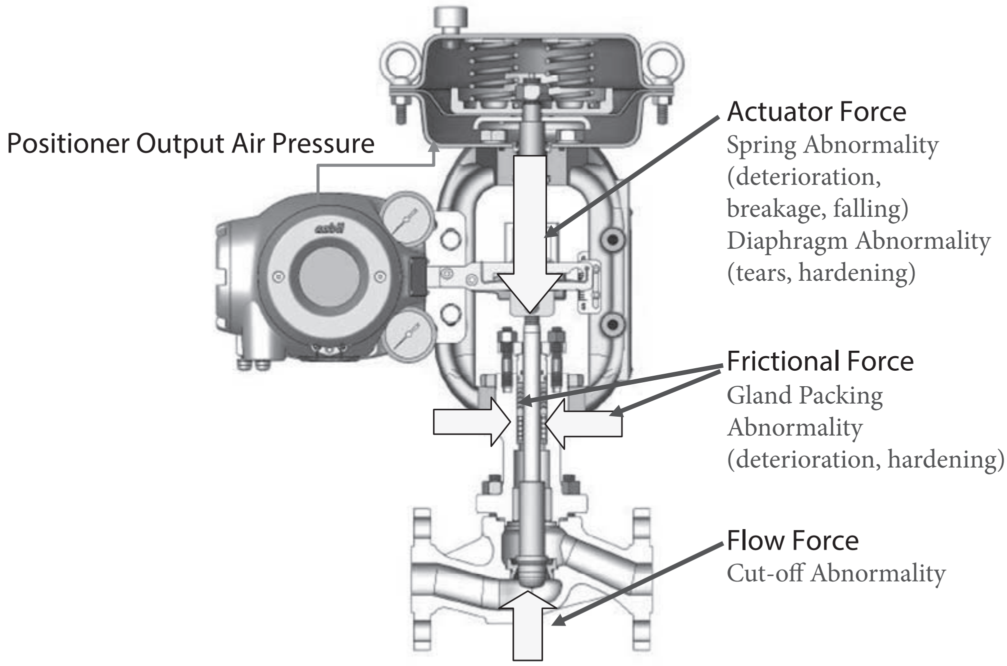


Figure 4-1 Relationship between the forces of the actuator, frictional force, and flow force in relation to the control valve

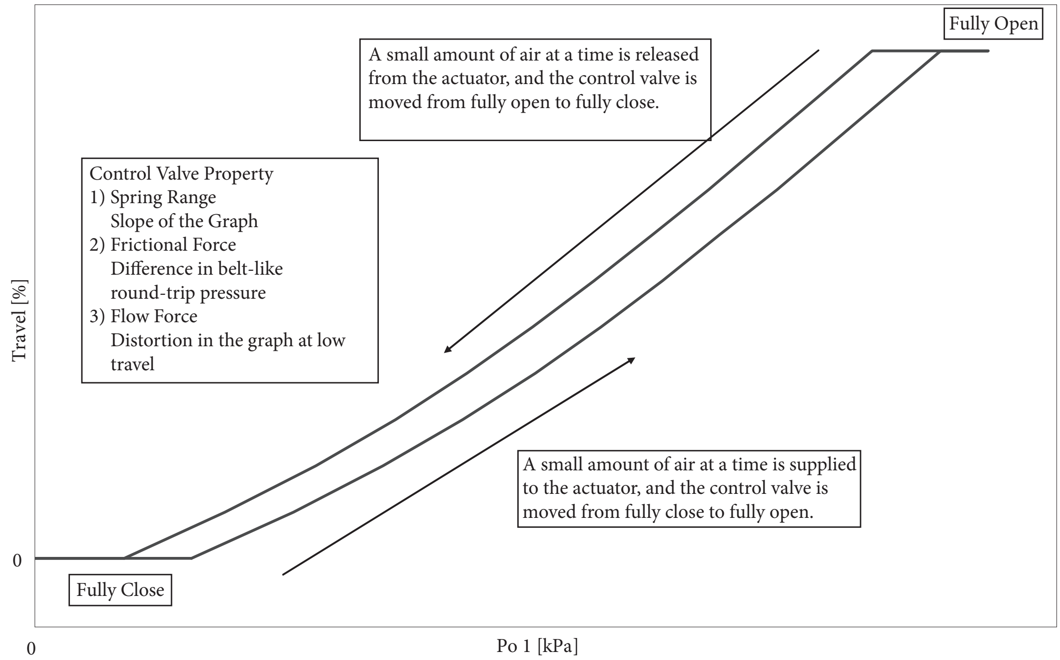


Figure 4-2 Properties of the control valve (single-acting/reverse-acting actuator)

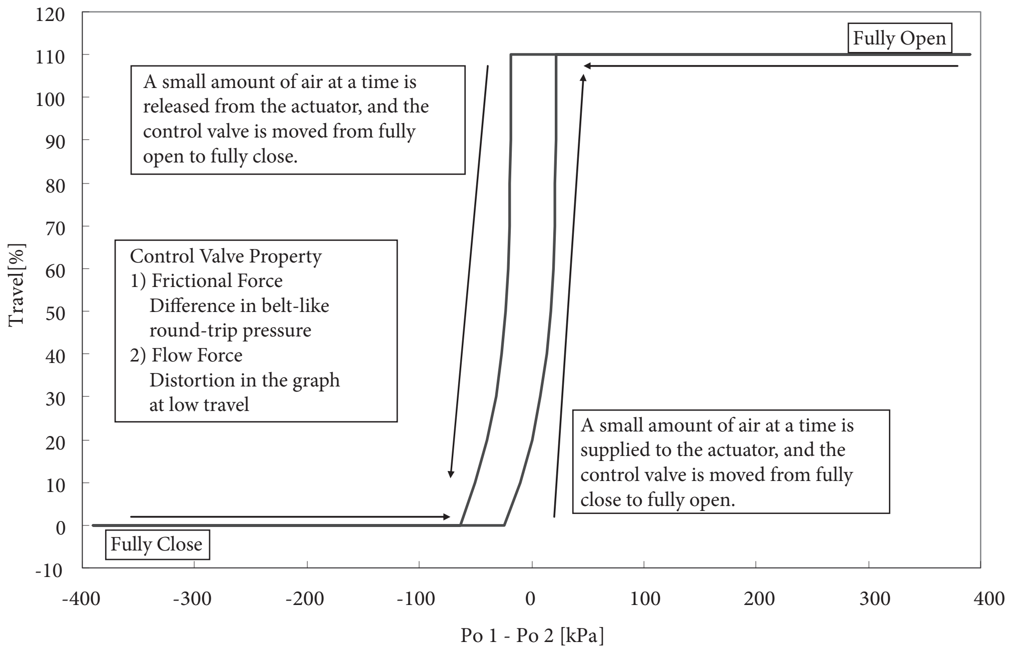


Figure 4-3 Properties of the control valve (double-acting/reverse-acting)

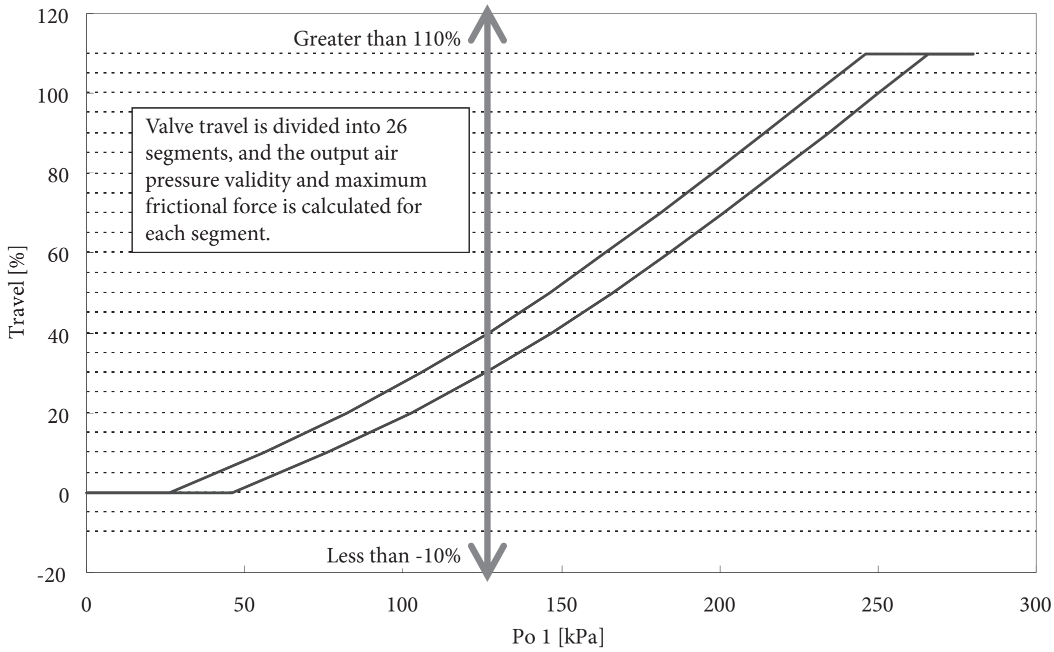


Figure 4-4 Travel segments

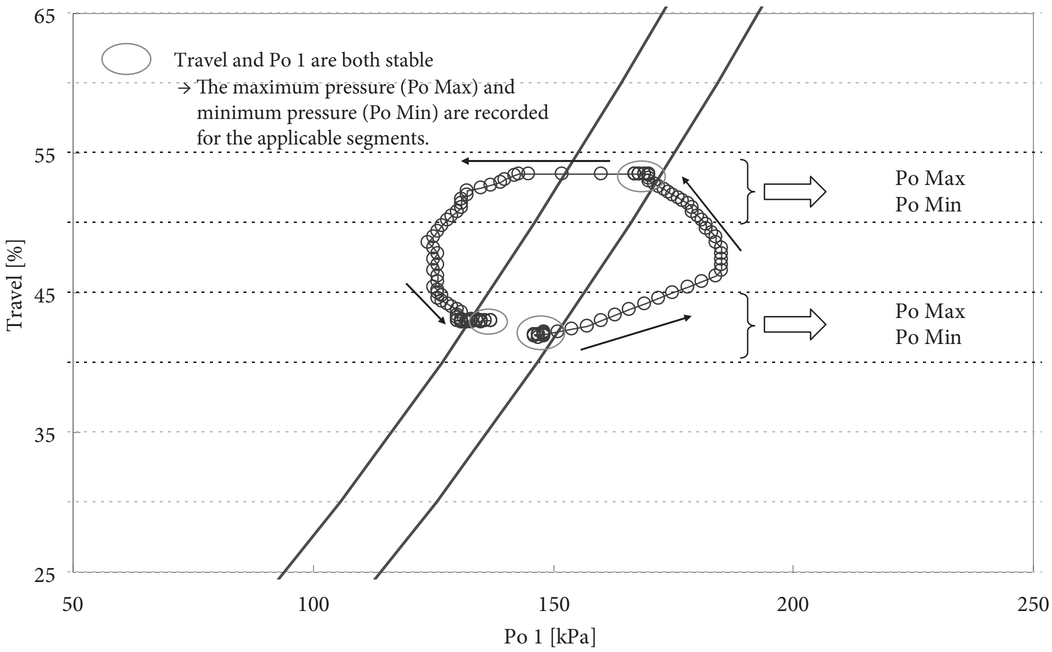


Figure 4-5 Measurement method of Po Max and Po Min

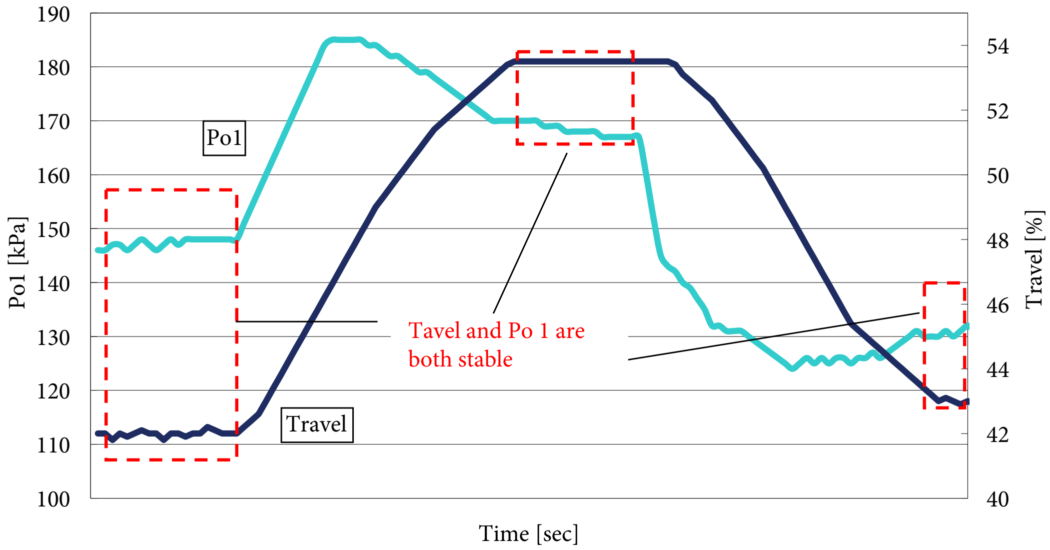


Figure 4-6 Method of determining stability

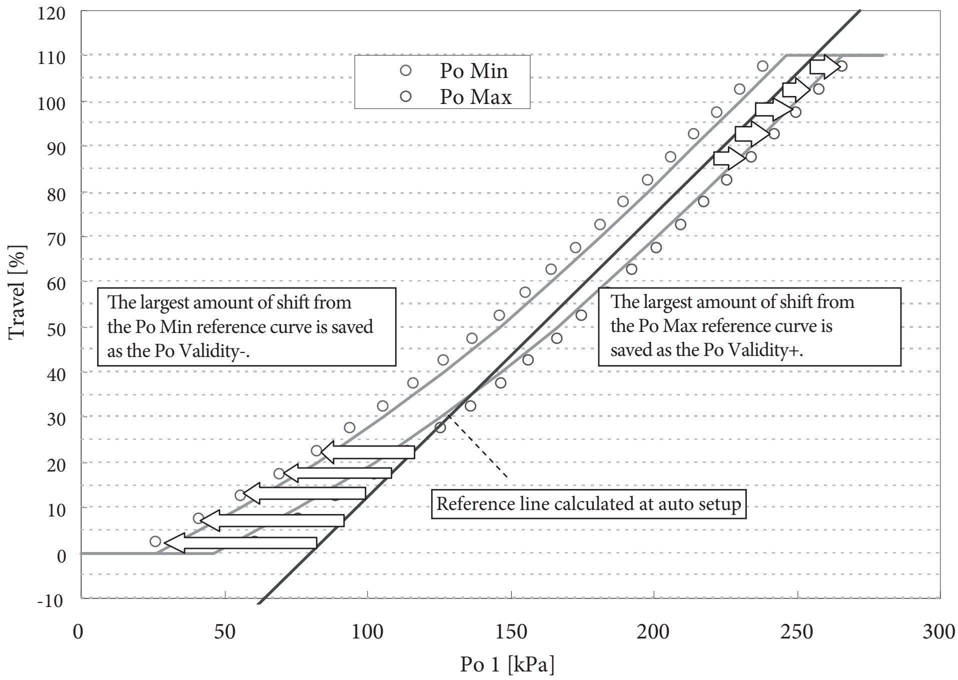


Figure 4-7 Calculation of Po Validity+ and Po Validity-

[Threshold and Alarm]

■ Explanation of threshold value and alarm (for each combination)

Single-acting and reverse-acting

Single-acting and direct-acting

Double-acting and reverse-acting

Double-acting and direct-acting

The output air pressure validity thresholds are set at the outer limits of the area where the control valve can be controlled to 0% and 100%. If a threshold is exceeded, there's a high probability that the valve can't be adjusted to 0% or 100%. This is probably because actuator force, frictional force, and flow force are out of balance. Specifically, calculation is done using the upper and lower limits of the spring range and the standard supply air pressure that were calculated during auto setup.

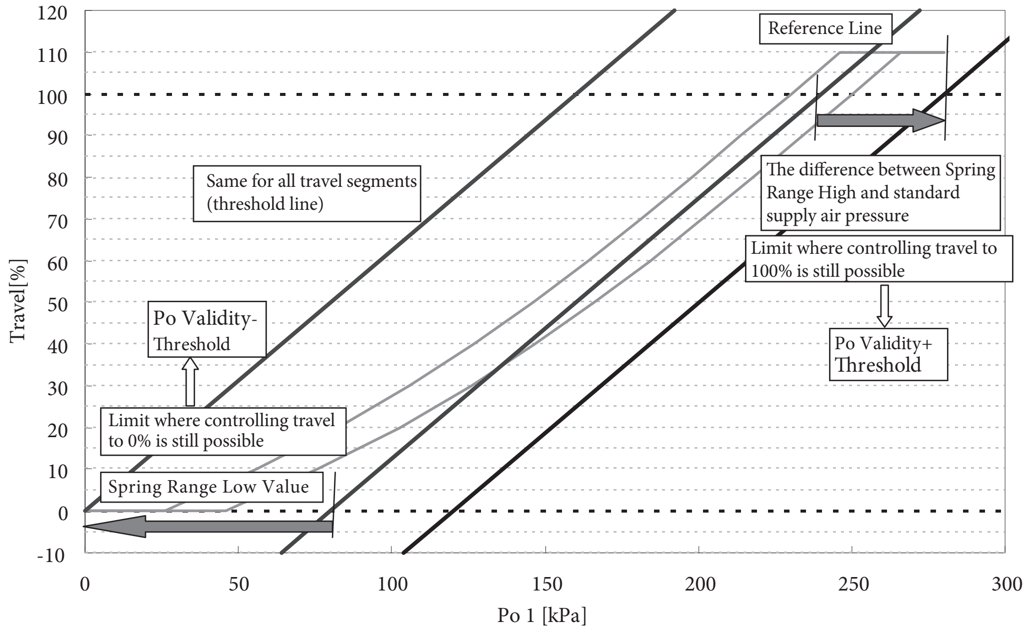
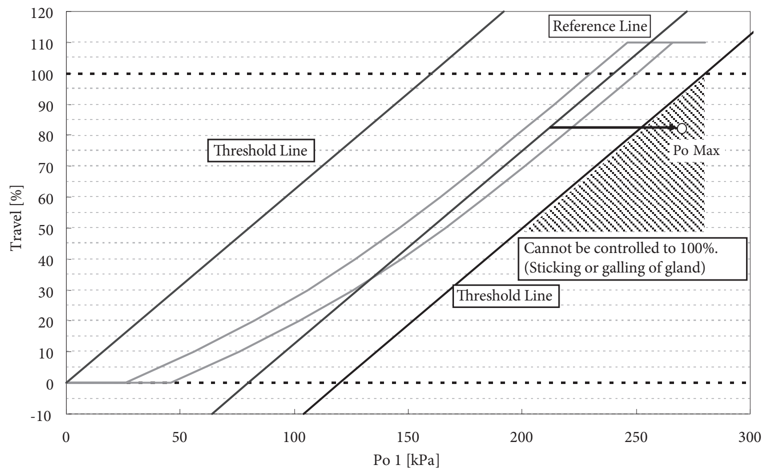
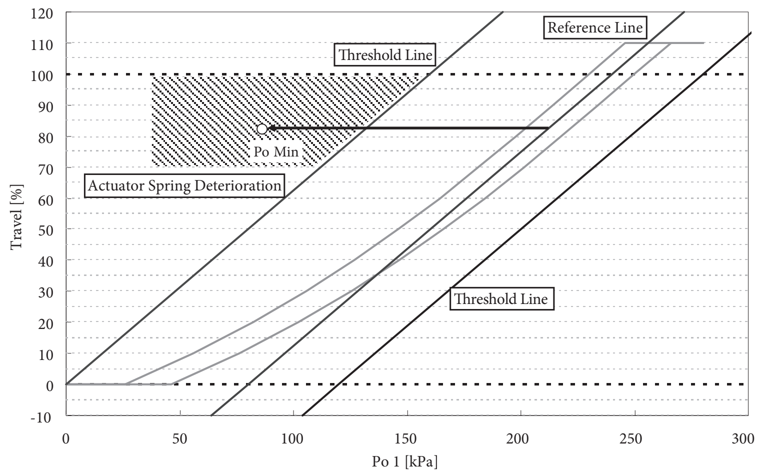


Figure 4-8 Po Validity Monitoring thresholds
(single-acting and reverse-acting actuator)





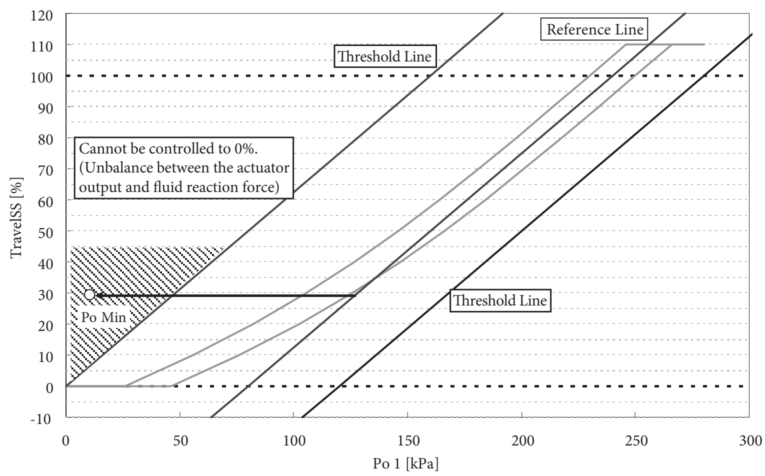


Figure 4-9 Po Validity Monitoring thresholds and abnormal phenomenon
(single-acting and reverse-acting actuator)

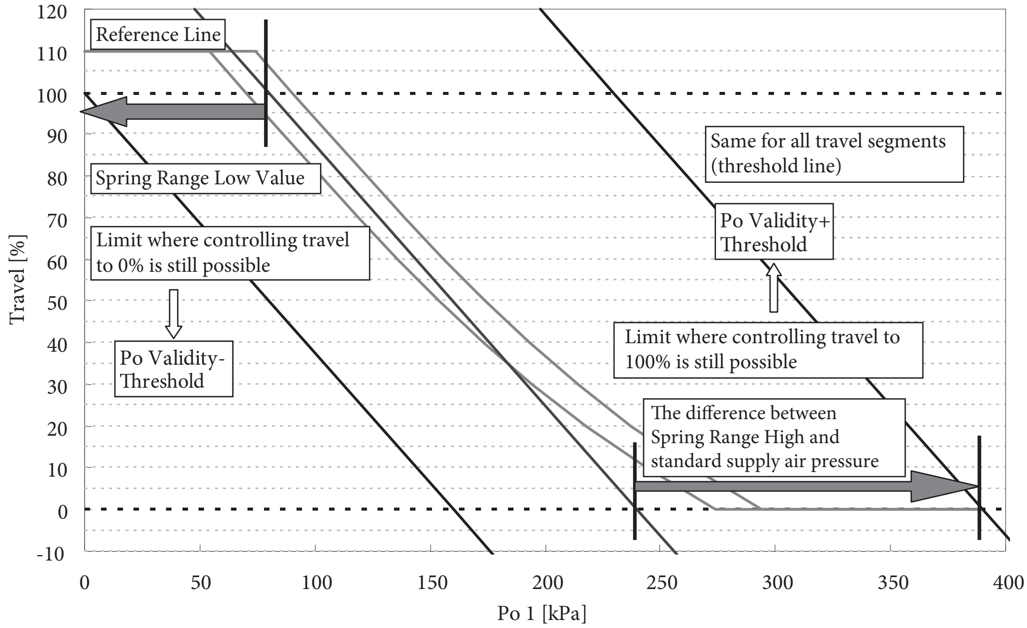


Figure 4-10 Po validity threshold (single-acting and direct acting actuator)

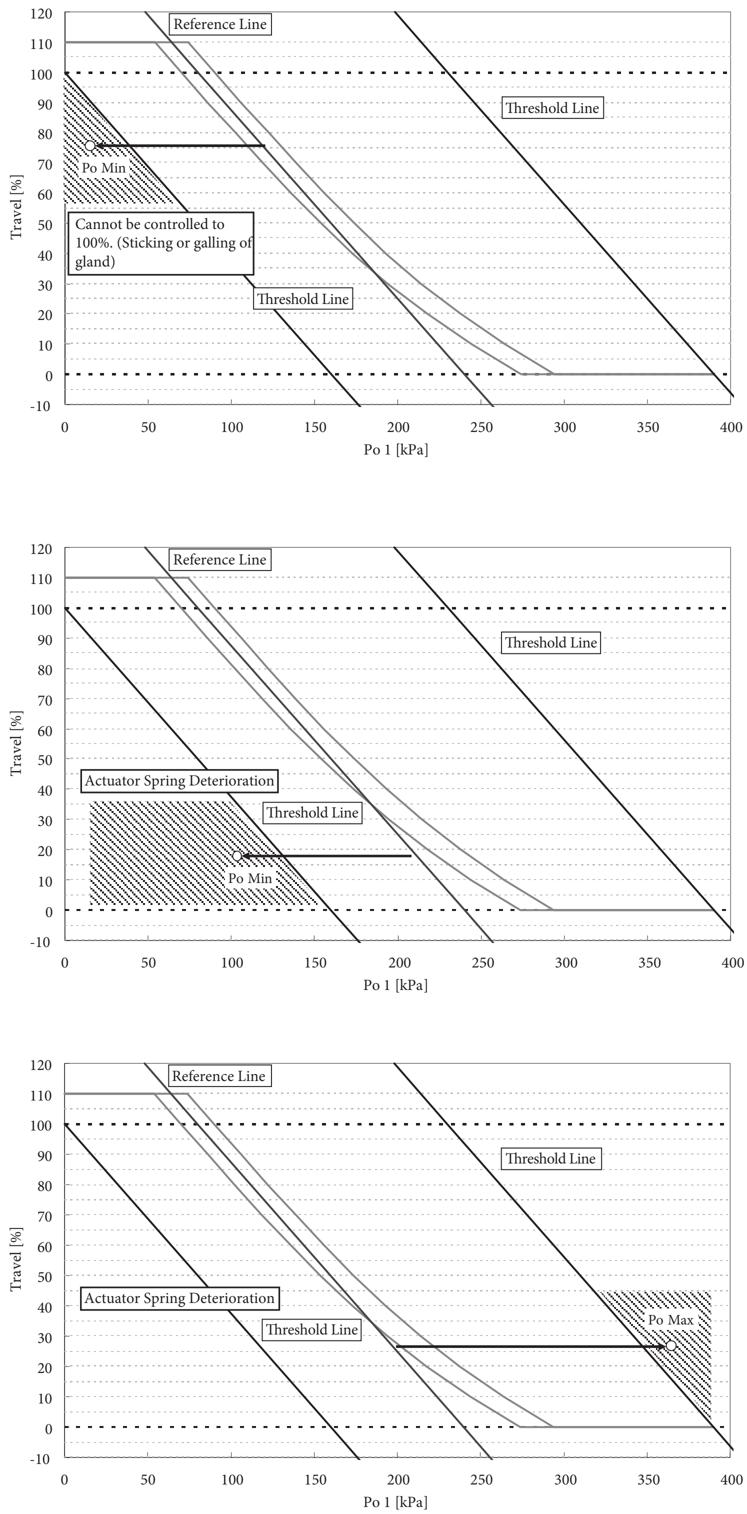


Figure 4-11 Output air pressure validity thresholds and abnormality (double-acting and direct acting actuator)

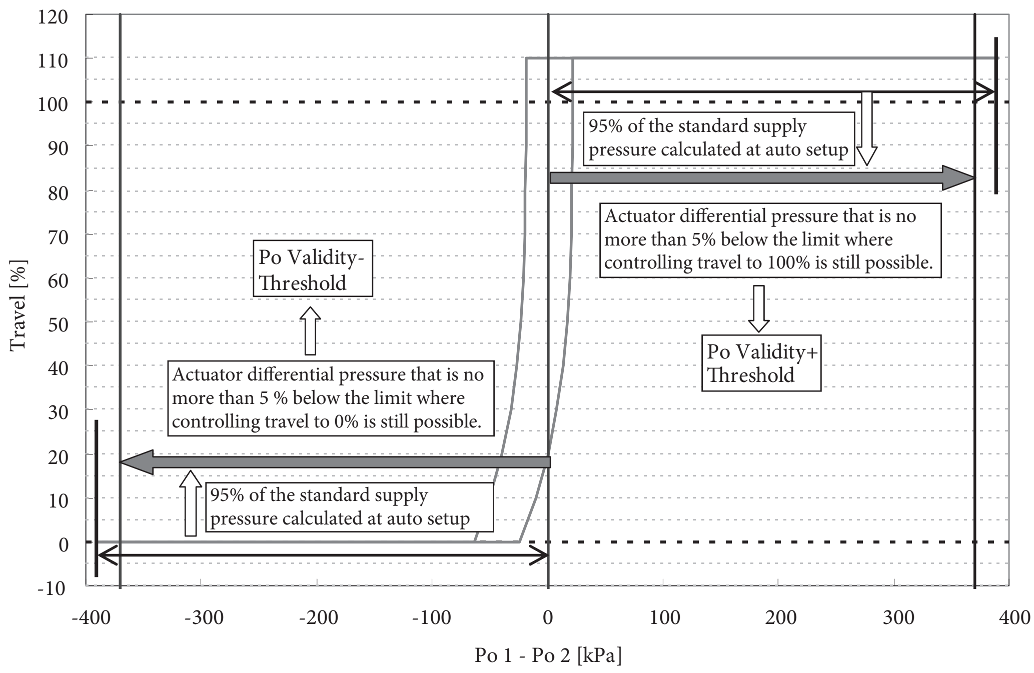


Figure 4-12 Po validity thresholds (double-acting and reverse-acting actuator)

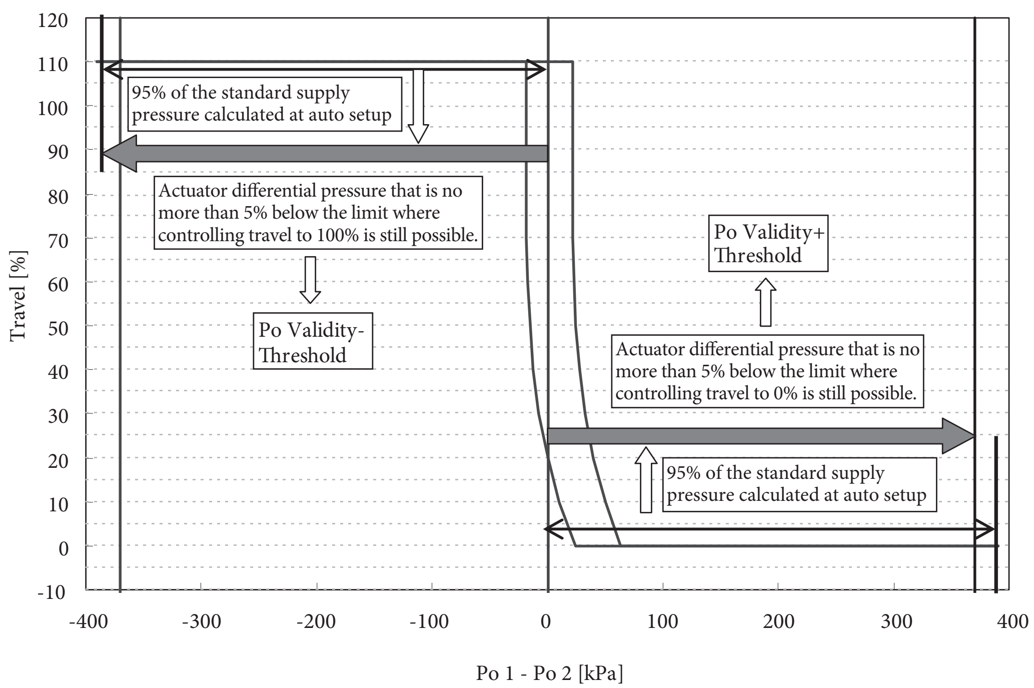


Figure 4-13 Po validity thresholds (double-acting and direct-acting actuator)

Table 4-1 Po Validity Monitoring and abnormality
(single-acting and reverse-acting actuator)

Parameter	Threshold	Abnormality
Po Validity +	(Initial Supply Pressure) - (Spring Range High)	Sticking or galling of the gland, guiding surfaces, and plug/seat
Po Validity -	- (Spring Range Low)	Unbalance between the actuator output and flow force Actuator air leak Spring deterioration Spring falling off Poor adjustment: spring tightening

Table 4-2 Po Validity Monitoring and abnormality
(single-acting and direct-acting actuator)

Parameter	Threshold	Abnormality
Po Validity +	(Initial Supply Pressure) - (Spring Range High)	Unbalance between the actuator output and flow force
Po Validity -	- (Spring Range Low)	Actuator air leak Spring deterioration Spring falling off Sticking or galling of the gland, guiding surfaces, and plug/seat

Table 4-3 Po Validity Monitoring and abnormality
(double-acting and reverse-acting actuator)

Parameter	Threshold	Abnormality
Po Validity +	(Initial Supply Pressure) × (0.95)	Sticking or galling of the gland, guiding surfaces, and plug/seat
Po Validity -	(Initial Supply Pressure) × (-0.95)	Sticking or galling of the gland, guiding surfaces, and plug/seat Unbalance between the actuator output and flow force

Table 4-4 Po Validity Monitoring and abnormality
(double-acting and direct-acting actuator)

Parameter	Threshold	Abnormality
Po Validity +	(Initial Supply Pressure) × (0.95)	Unbalance between the actuator output and flow force Sticking or galling of the gland, guiding surfaces, and plug/seat
Po Validity -	(Initial Supply Pressure) × (-0.95)	Sticking or galling of the gland, guiding surfaces, and plug/seat

Table 4-5 Po Validity Monitoring Parameters (HART)

Parameter	Description	Initial Value
Po Validity +	Output Air Pressure Validity +	-
Po Validity -	Output Air Pressure Validity -	-
Unbalance Force Seg 1	Flow Force by Travel Segment 1	-
…		-
Unbalance Force Seg 26	Flow Force by Travel Segment 26	-
Po Validity Threshold +	“Output Air Pressure Validity +” Alarm Threshold	40
Po Validity Threshold -	“Output Air Pressure Validity -” Alarm Threshold	-80

Table 4-6 Po Validity Monitoring Parameters (FF)

Parameter	Description	Initial Value
Po Validity +	Output Air Pressure Validity +	-
Po Validity -	Output Air Pressure Validity -	-
Po Validity Threshold +	Output Air Pressure Validity + Alarm Threshold	40
Po Validity Threshold -	Output Air Pressure Validity - Alarm Threshold	-80

Chapter 5 Max Friction Monitoring

[Overview]

■ Objective of maximum frictional force monitoring

Maximum frictional force is an index related to the sticking or galling of the gland, guiding surfaces, and plug/seat. Maximum frictional force is calculated from the difference in the round-trip output pressures of the actuator, which is a characteristic of the control valve.

[Algorithm]

■ Calculation of maximum friction

Friction is calculated as half of the difference between Po1's maximum and minimum values. The largest friction from all the travel segments is saved as Max Friction (Figure 5-1).

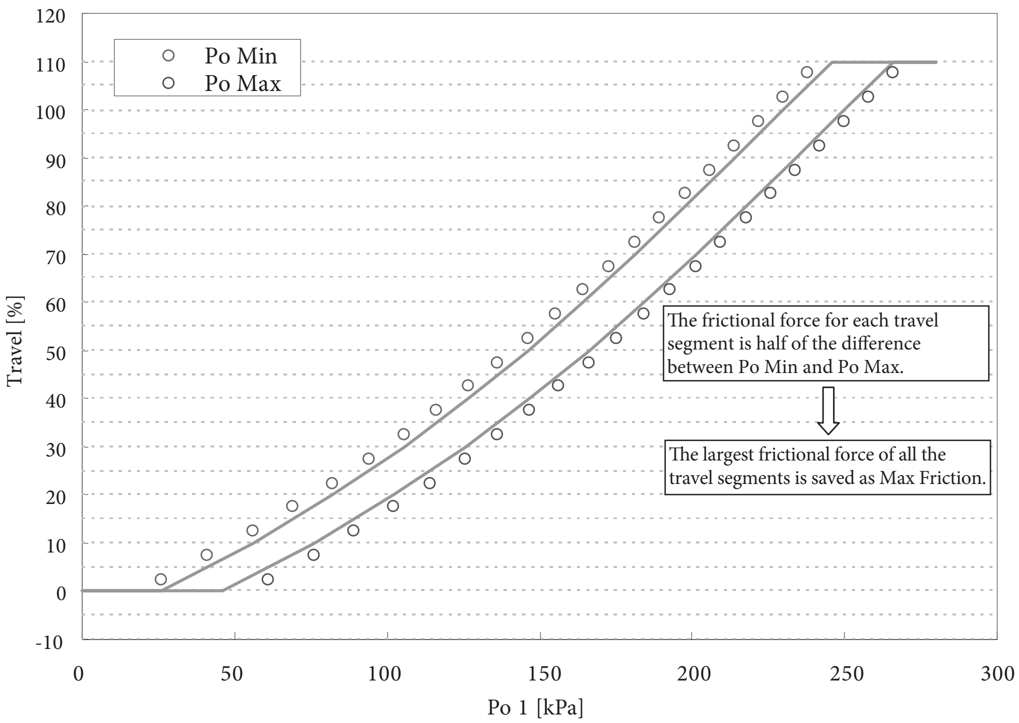


Figure 5-1 Calculation of Max Friction

[Threshold and Alarm]

■ Explanation of auto setup and threshold

The threshold for maximum friction is 25% of the spring range calculated by auto setup. This means that the hysteresis will reach 50% of the spring range, which is the limit at which the positioner can still control the control valve.

Table 5-1 Maximum friction monitoring and abnormality (single-acting actuator)

Parameter	Threshold	Abnormality
Max Friction	{(Spring Range High) - (Spring Range Low) } × 0.25	Sticking or galling of the gland, guiding surfaces, and plug/seat Deterioration of gland packing Decrease of gland packing compression

Table 5-2 Maximum friction monitoring and abnormality (double-acting actuator)

Parameter	Threshold	Abnormality
Max Friction	(Initial Supply Pressure) × 0.5	Sticking or galling of the gland, guiding surfaces, and plug/seat Deterioration of gland packing Decrease of gland packing compression

Table 5-3 Max Friction Monitoring Parameters (HART)

Parameter	Description	Initial Value
Max Friction	Max Frictional Force	-
Friction Seg 1	Friction Force by Travel Segment 1	-
…		-
Friction Seg 26	Friction Force by Travel Segment 26	-
Max Friction Threshold	Max Friction Force Alarm Threshold	40

Table 5-4 Max Friction Monitoring Parameters (FF)

Parameter	Description	Initial Value
Max Friction	Max Frictional Force	-
Max Friction Threshold	Max Friction Force Alarm Threshold	40

Table 5-5 Output Air Pressure Validity /
Max Friction Monitoring Common Parameters (HART)

Parameter	Description	Initial Value
Po Max Seg1	Maximum Output Air Pressure by Travel Segment 1	-
…		-
Po Max Seg 26	Maximum Output Air Pressure by Travel Segment 26	-
Po Min Seg 1	Minimum Output Air Pressure by Travel Segment 1	-
…		-
Po Min Seg 26	Minimum Output Air Pressure by Travel Segment 26	-
Travel Seg Divider 1	Travel Segment Delimiter 1	-5 (not writable)
…		(Not writable)
Travel Seg Divider 26	Travel Segment Delimiter 25	110 (not writable)
Po Stable Threshold	Output Air Pressure Stability Threshold	0.5
Travel Stable Threshold	Travel Stability Threshold	0.25
Travel Upper Limit	Upper Limit of Applicable Travel	109
Travel Lower Limit	Lower Limit of Applicable Travel	1

Table 5-6 Output Air Pressure Validity /
Max Friction Monitoring Common Parameters (FF)

Parameter	Description	Initial Value
Po Max Seg1	Maximum Output Air Pressure by Travel Segment 1	-
…		-
Po Max Seg 26	Maximum Output Air Pressure by Travel Segment 26	-
Po Min Seg 1	Minimum Output Air Pressure by Travel Segment 1	-
…		-
Po Min Seg 26	Minimum Output Air Pressure by Travel Segment 26	-
Travel Seg Divider 1	Travel Segment Delimiter 1	-10
…		
Travel Seg Divider 26	Travel Segment Delimiter 25	110
Po Stable Threshold	Output Air Pressure Stability Threshold	0.5
Travel Stable Threshold	Travel Stability Threshold	0.25
Travel Upper Limit	Upper Limit of Applicable Travel	109
Travel Lower Limit	Lower Limit of Applicable Travel	1

⚠ Caution

For the Travel Upper Limit, which is a shared parameter, the following precautions must be taken into account for its relationship with the forced full open value (Travel Cutoff High).

Set the Travel Upper Limit so that it is less than (Travel Cutoff High - 5) %.

In addition, if you conduct any of the following operations, please confirm that you still satisfy this requirement.

- Changed the Travel Cutoff High
- Span adjustment after auto setup

  After this adjustment, the shutoff value will automatically change to a value equivalent to overstroke % - 1%.

  Overstroke refers to the degree of valve opening (%) at which contact is made with a physical barrier to further opening.

Chapter 6 Total Stroke Monitoring

[Overview]

■ Objective of total stroke monitoring

Total Stroke is an index related to the deterioration of the gland and actuator.

[Algorithm]

■ Calculation of deadband and total stroke

If all the slight oscillations from the travel sensor are added up as the total travel, it will not be the same as the actual total travel. To prevent this, travel is measured every 50 ms, and movement of 0.5% or less is not added to Total Stroke.

[Threshold and Alarm]

■ Explanation of threshold

The durability of a control valve is specified as 100,000 cycles. The total stroke that corresponds to that number is 20 million %, which serves as the threshold value. When the total stroke exceeds 20 million %, the total stroke alarm is displayed as the device status.

Table 6-1 Total Stroke Monitoring and Abnormality

Parameter	Threshold	Abnormality
Total Stroke	20 million %	Deterioration of gland packing (tattered, hardened) Decrease of gland packing compression Insufficiency packing lubricant Air leak (O-ring deterioration, diaphragm damage) Spring deterioration

Table 6-2 Total Stroke Monitoring Parameters (HART)

Parameter	Description	Initial Value
Total Stroke	Total Stroke Value	0
Total Stroke Deadband	Total Stroke Deadband	0.5
Total Stroke Threshold	Total Stroke Alarm Threshold	20,000,000

Table 6-3 Total Stroke Parameters (FF)

Parameter	Description	Initial Value
Total Stroke	Total Stroke Value	0
Total Stroke Threshold	Total Stroke Alarm Threshold	20,000,000
Travel Accumulator Deadband	Total Stroke Deadband	0.5
Travel Accumulation Unit	Display Unit for Accumulated Value	%

Chapter 7 Max Travel Speed Monitoring

[Overview]

■ Objective of Max Travel Speed Monitoring

Maximum operation speed monitoring is an index related to gland packing deterioration (tattered, hardened), falling off of spring, and breakage of stem.

[Algorithm]

■ Calculation of Max Tvl Speed+ and Max Tvl Speed-

Speed is calculated from the difference in travel measurements, which are taken every 50 ms. The maximum value (Max Tvl Speed+) on the positive side and the maximum value (Max Tvl Speed-) on the negative side are saved and successively updated.

[Threshold and Alarm]

■ Explanation of threshold

There are extremely fast small control valves that allow movement from 0% to 100% within a second. Movement at 10 times that speed is unrealistic, so 10 times 100%/s (1000%/s) is used as the threshold. When either the maximum travel speed + or - exceeds the threshold of 1000%/s or -1000%/s, the positive maximum travel speed alarm or the negative maximum travel speed alarm will be activated as the device status.

Table 7-1 Max Travel Speed and Abnormality

Parameter	Threshold	Abnormality
Max Tvl Speed+	1000% /s	Deterioration of gland packing (tattered, hardened) Spring falling off Breakage of the stem
Max Tvl Speed-	-1000% /s	

Table 7-2 Max Travel Speed Parameters (HART)

Parameter	Description	Initial Value
Max Tvl Speed+	Max Travel Speed+	0
Max Tvl Speed-	Max Travel Speed-	0
Max Tvl Speed Threshold+	Maximum Operation Speed + Alarm Threshold	1,000
Max Tvl Speed Threshold-	Maximum Operation Speed - Alarm Threshold	-1,000

Table 7-3 Max Travel Speed Parameters (FF)

Parameter	Description	Initial Value
Max Travel Speed+	Max Travel Speed+	0
Max Travel Speed-	Max Travel Speed-	0
Max Travel Speed Threshold+	Maximum Operation Speed + Alarm Threshold	1,000
Max Travel Speed Threshold-	Maximum Operation Speed - Alarm Threshold	-1,000

Chapter 8 Travel Histogram

[Overview]

■ Objective of Travel Histogram

Travel Histogram is an index related to damage or fluid adhesion on the plug/seat, erosion, corrosion, or unsuitable control valve capacity.

[Algorithm]

■ Calculation of Travel Histogram

Travel is measured every 200 ms, and the frequency with which it falls in each of the 26 travel segments is counted. There are 26 segments as follows: less than -10%, (-10 -5], (-5 0], (0 5] ... (105 110], and greater than 110%. Counts are converted to percentages and saved as the diagnostic parameter. Figure 8-1 illustrates a histogram using the diagnostic parameter of frequency distribution by travel segment.

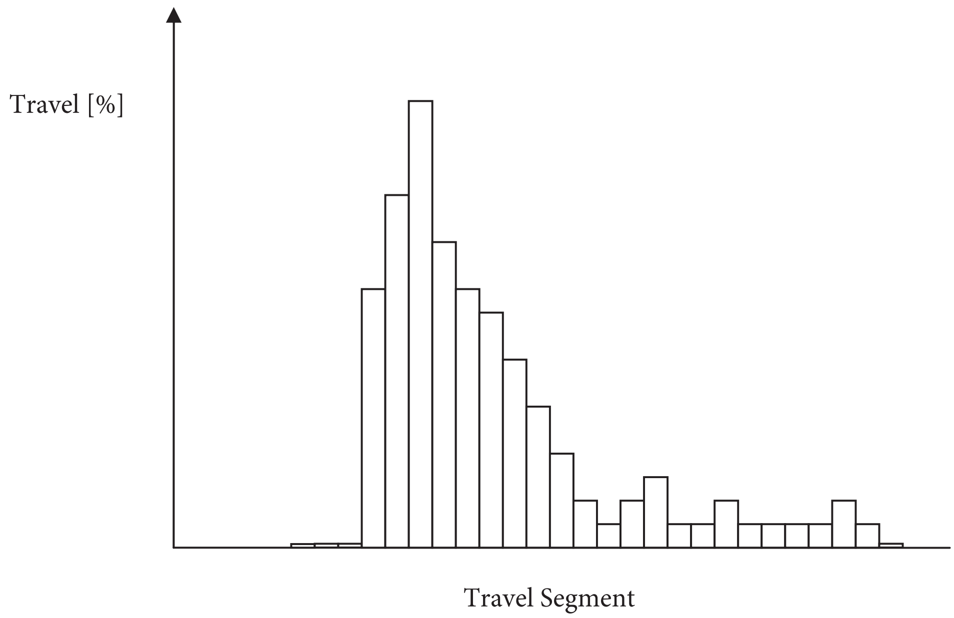


Figure 8-1 Illustration of Frequency Distribution (Histogram) by Travel Segment

Table 8-1 Travel Histogram and Abnormality

Parameter Characteristics	Abnormality
When the most frequent travel segment in the Travel Histogram is a small travel.	Damage of plug/seat Adhesion of fluid on the plug/seat Overall Erosion of the Seat Overall Corrosion of the Seat The control valve capacity is too large

Table 8-2 Travel Histogram Parameters (HART)

Parameter	Description	Initial Value
Travel Histogram 1	Frequency by Travel Segment 1	0
…		0
Travel Histogram 26	Frequency by Travel Segment 26	0
Travel Seg Divider 1	Travel Segment Delimiter 1	-5 (not writable)
…		(not writable)
Travel Seg Divider 26	Travel Segment Delimiter 26	110 (not writable)

Table 8-3 Frequency Distribution by Travel Segment Parameters (FF)

Parameter	Description	Initial Value
Travel Histogram 1	Frequency by Travel Segment 1	0
…		0
Travel Histogram 26	Frequency by Travel Segment 26	0

Chapter 9 Shut Count Monitoring

[Overview]

■ Objective of Shut Count Monitoring

The shut count is an index related to seat abrasion and damage of the plug/seat. Forced full-close commands are counted as the diagnostic parameter. This value is believed to be almost equivalent to the actual number of times the valve is fully closed, and the larger this number is the higher the possibility of seat abrasion and damage.

[Algorithm]

■ Calculation of Shut Count

The number of times the full-close command changes from OFF to ON is counted.

[Threshold and Alarm]

■ Explanation of threshold

The durability of control valve is determined to be 100,000 cycles. The shut count that corresponds to that number is 100,000 times, which is the threshold value. When the shut count exceeds 100,000 times, the shut count alarm is displayed as the device status.

Table 9-1 Shut Count Monitoring and Abnormality

Parameter	Threshold	Abnormality
Shut Count	100,000 times	Seat abrasion Damage of plug/seat

Table 9-2 Shut Count Monitoring Parameters (common to HART/FF)

Parameter	Description	Initial Value
Shut Count	Shut Count	0
Shut Count Threshold	Threshold of the shut count alarm	100,000

Chapter 10   Cycle Count Monitoring

[Overview]

■ Objective of Cycle Count Monitoring

The cycle count is an index related to the deterioration of the gland and actuator.

The number of times the control valve changes direction is counted as the diagnostic parameter. A large cycle count signifies that the control valve has traveled a long distance between fully opened to fully closed quite a bit.

[Algorithm]

■ Method of adding up the upper and lower travel limits and inverse operation frequency

Because the frequency of the control valve's reversal over small distances does not directly impact the deterioration of parts affected by friction, only reversals involving large movements close to fully opened or fully closed positions are counted. The upper and lower travel limits are set (95% and 5%) and the times the travel strays from that range are counted (Figure 10-1).

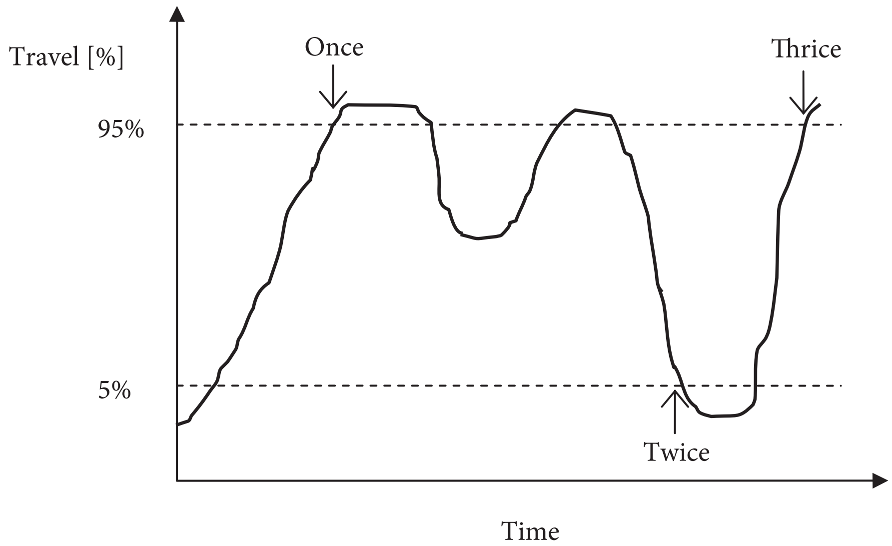


Figure 10-1 Counting of cycle count

This method adds up the number of reversals of the control valve stroke.

[Threshold and Alarm]

■ Threshold and Alarm

Control valve durability is set at 100,000 cycles. The cycle count equivalent to 100,000 round trips is 200,000 times, and this is the threshold value. When the cycle count exceeds 200,000 times, the cycle count alarm is displayed as the device status.

Table 10-1 Cycle Count Monitoring and Abnormality

Parameter	Threshold	Abnormality
Cycle Count	200,000 times	Deterioration of gland packing (tattered, hardened) Decrease of gland packing compression Insufficient packing lubricant Air leak (O-ring deterioration, diaphragm damage) Spring deterioration

Table 10-2 Cycle Count Monitoring Parameters (HART)

Parameter	Description	Initial Value
Cycle Count	Cycle Count	0
Cycle Count Deadband High	Upper Side of Cycle Count Deadband	95
Cycle Count Deadband Low	Lower Side of Cycle Count Deadband	5
Cycle Count Threshold	Threshold of the Alarm for Cycle Count	200,000

Table 10-3 Cycle Count Monitoring Parameters (FF)

Parameter	Description	Initial Value
Cycle Count	Cycle Count	0
Cycle Count Deadband High	Upper Side of Cycle Count Deadband	95
Cycle Count Deadband Low	Lower Side of Cycle Count Deadband	5
Cycle Count Threshold	Threshold of the Alarm for Cycle Count	200,000

Chapter 11 Positioner Air Circuit Diagnosis

[Overview]

■ Objective of Positioner Air Circuit Diagnosis

■ Abnormality Detection Method (Comparison with Standard)

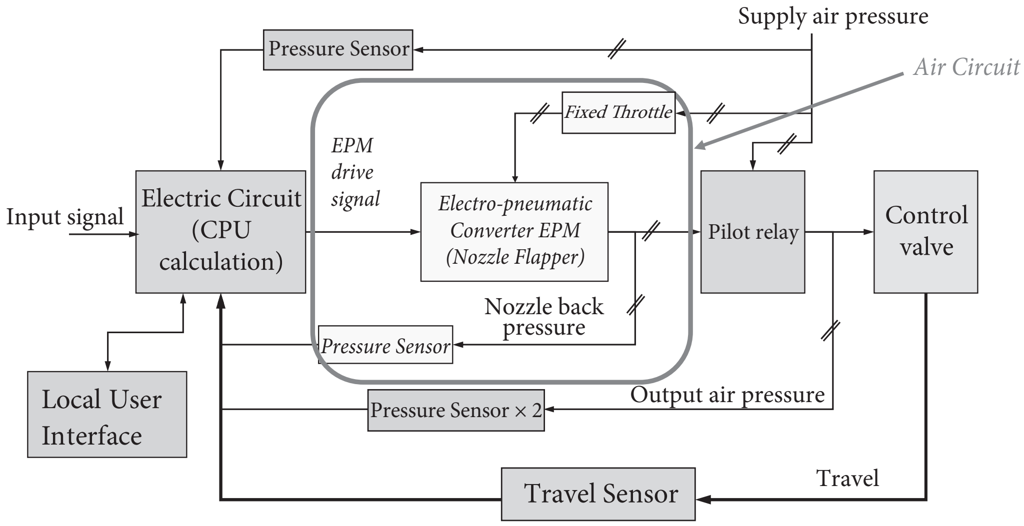


Figure 11-1 Air Circuit

The positioner air circuit diagnosis detects hardened restrictions inside the positioner, and abnormalities of air circuit which mostly occur due to nozzle flapper clogs. Therefore, the nozzle back pressure (Pn) is measured by pressure sensor to detect any abnormality from its relationship with the EPM drive signal, which is the value of the current that is sent to the coils to move the nozzle flapper.

For example, because Pn gets smaller as the fixed restriction becomes more clogged, the EPM drive signal increases to normalize Pn back to its original value. In addition, because Pn decreases as the nozzle flapper gets more clogged, the EPM drive signal decreases to normalize Pn back to its original value. From observing such a relationship, abnormality is detected by monitoring the change in the relationship between the EPM drive signal and Pn from a normal state.

[Algorithm]

■ Determine the stability of Pn and EPM drive signal

■ Acquisition of standard from auto setup

The algorithm's objective is to be able to diagnose even when the plant is in operation.

Therefore, it measures the relationship between Pn and EPM drive signal during a stable state, and not when the control valve is functioning. This is because as the EPM drive signal fluctuates greatly when the control valve is functioning, air circuit abnormality becomes indeterminable.

Furthermore, the Pn and EPM drive signal measured during auto setup as representative of a normal state is taken into account to figure out the standard, which is when its slope and EPM drive signal reach the 50% mark. Therefore, auto setup has to be conducted during a normal state for the correct operation of this diagnosis.

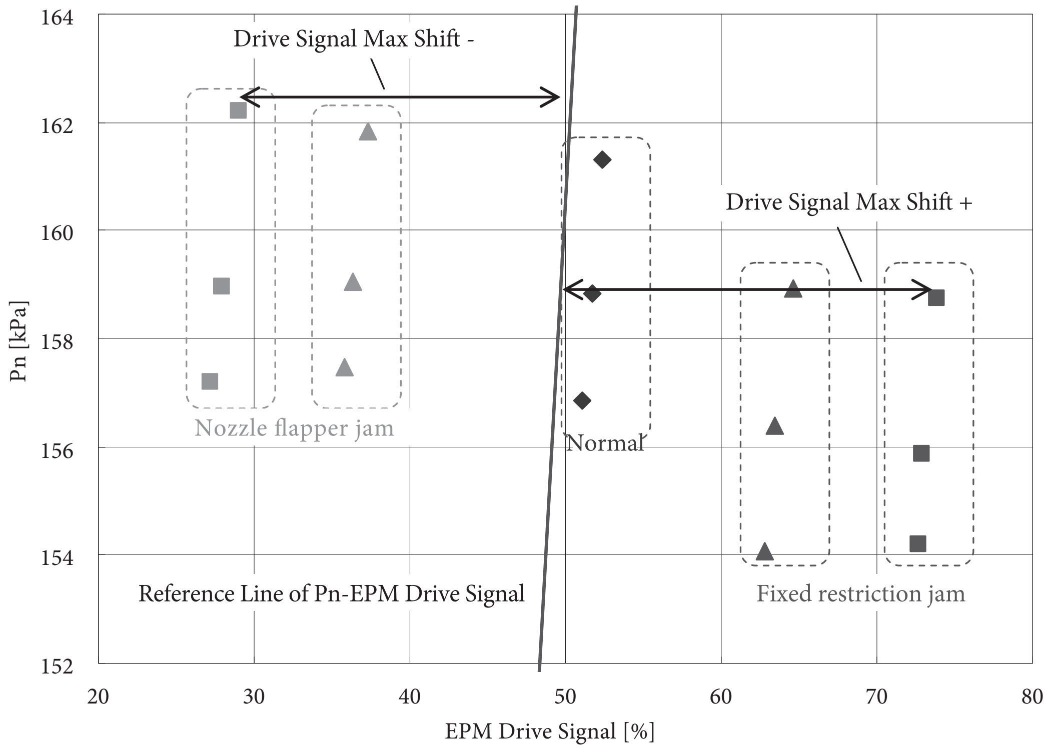


Figure 11-2 Measurement of Shift Amount via Positioner Air Circuit Diagnosis (for direct acting positioner)

The maximum value of the shift of positive-side drive signal, and minimum value of the shift of negative-side drive signal from the reference line, are saved as the Drive Sig Max Shift + parameter and Drive Sig Max Shift - parameter, respectively, and when those parameters exceed the threshold, the alarm is activated. When the positive-side Drive Sig Max Shift + exceeds the threshold, it is understood as a symptom of a restriction clog, which will activate the restriction clog alarm. In addition, when the Drive Sig Max Shift - exceeds the threshold, it is deemed as a nozzle flapper clog, which will activate the nozzle flapper clog alarm.

[Threshold and Alarm]

■ Explanation of threshold

The diagnosis parameter threshold of Drive Sig Max Shift + is 25%, and -25% for Drive Sig Max Shift -. When these thresholds are crossed, a restriction clog or nozzle flapper clog have occurred, respectively, which points to a failure of the positioner control function.

The relationship between the control valve diagnostic parameter and abnormal phenomenon is illustrated as follows.

Table 11-1 Positioner Air Circuit Diagnosis and Abnormality (direct acting positioner)

Parameter	Threshold	Abnormality
Drive Sig Max Shift +	25%	Restriction clog
Drive Sig Max Shift -	-25%	Nozzle clog

If the positioner is reverse-acting, the diagnosis algorithm stays the same, but the corresponding relationship between the diagnosis parameter and alarm will become the opposite of that with direct action. With direct action, the gap of nozzle flapper gets narrow as the Drive Signal increases, but with the reverse action, the gap becomes wider. The corresponding relationship is illustrated below.

Table 11-2 Positioner Air Circuit Diagnosis and Abnormality (reverse-acting positioner)

Parameter	Threshold	Abnormality
Drive Sig Max Shift +	25%	Nozzle clog
Drive Sig Max Shift -	-25%	Restriction clog

Table 11-3 Positioner Air Circuit Diagnosis Parameters (HART)

Parameter	Description	Initial Value
Drive Sig Max Shift +	EPM Drive Signal Max Shift+	0
Drive Sig Max Shift -	EPM Drive Signal Max Shift-	0
Drive Sig Shift Threshold +	“EPM Drive Signal Shift +” Threshold	25
Drive Sig Shift Threshold -	“EPM Drive Signal Shift -” Threshold	-25
Drive Sig Stable Threshold	EPM Drive Signal Stable Threshold	1
Pn Stable Threshold	Nozzle Back Pressure (Pn) Stable Threshold	0.5
“Drive Sig +” Alarm Count	“EPM Drive Signal +” Alarm Occurrence Frequency	0
“Drive Sig -” Alarm Count	“EPM Drive Signal -” Alarm Occurrence Frequency	0

Table 11-4 Positioner Air Circuit Diagnosis Parameters (FF)

Parameter	Description	Initial Value
Drive Signal Max Shift +	EPM Drive Signal Max Shift+	0
Drive Signal Max Shift -	EPM Drive Signal Max Shift-	0
Drive Signal Shift Threshold +	“EPM Drive Signal Shift +” Threshold	25
Drive Signal Shift Threshold -	“EPM Drive Signal Shift -” Threshold	-25
Drive Signal Stable Threshold	EPM Drive Signal Stable Threshold	1
Pn Stable Threshold	Nozzle Back Pressure (Pn) Stable Threshold	0.5
“Drive Signal +” Alarm Count	“EPM Drive Signal +” Alarm Occurrence Frequency	0
“Drive Signal -” Alarm Count	“EPM Drive Signal -” Alarm Occurrence Frequency	0

Chapter 12 Supply Air Pressure Diagnosis

[Overview]

■ Objective of Supply Air Pressure Diagnosis

The supply air pressure diagnosis detects insufficient or excess supply pressure. The supply air pressure is measured with a pressure sensor embedded in the positioner, and monitors supply air pressure by observing whether the pressure is decreasing or increasing compared with the standard, etc.

[Algorithm]

■ Supply Air Pressure Standard

Supply air pressure diagnosis sequentially updates the maximum and minimum measurements of the supply air pressure. The supply air pressure standard used for comparison is measured during auto setup during a normal state. The supply air pressure is measured during auto setup as well, and the maximum, minimum and standard values are calculated. The supply air pressure diagnosis threshold is calculated using this data.

[Threshold and Alarm]

■ Calculation of threshold by auto setup

The supply air pressure diagnosis threshold is calculated by adding the minimum and maximum values of supply air pressure measured during auto setup, with the allowable supply pressure change specification (±7% during normal operating conditions).

※ When the maximum supply pressure (auto setup) is > 1.05 × standard supply pressure (auto setup)
High pressure alarm threshold =
Maximum supply pressure (auto setup) + 0.05 × standard supply pressure (auto setup)
※ All other scenarios
High pressure alarm threshold = 1.1 × standard supply pressure (auto setup)

※ When the minimum supply pressure (auto setup) is < 0.95 × standard supply pressure (auto setup)
Low pressure alarm threshold =
Minimum supply pressure (auto setup) - 0.05 × standard supply pressure (auto setup)
※ All other scenarios
Low pressure alarm threshold = 0.9 × standard supply pressure (auto setup)

During auto setup, the drive signal is shifted from 0 to 100, and during this time, maximum air supply to the positioner and maximum exhaust from the positioner occur. At the same time, there is a decrease and increase of supply air pressure. The upper and lower limits of the supply air pressure's variation will be revealed at the time the auto setup is conducted. Based on these values, the threshold values are automatically set as above.

Table 12-1 Supply Air Pressure Diagnosis and Abnormality

Parameter	Threshold (as above)	Abnormality
Sup Press Max	High Pressure Alarm Threshold	Excessive Supply Pressure
Sup Press Min	Low Pressure Alarm Threshold Difference	Insufficient Supply Pressure

Table 12-2 Supply Air Pressure Parameters (HART)

Parameter	Description	Initial Value
Sup Press Max	Max Supply Air Pressure	-
Sup Press Min	Min Supply Air Pressure	-
Sup Press Threshold High	Supply Air Pressure Validity High Alarm Threshold	308
Sup Press Threshold Low	Supply Air Pressure Validity Low Alarm Threshold	252
Sup Press High Alarm Count	Supply Air Pressure Validity High Alarm Frequency	0
Sup Press Low Alarm Count	Supply Air Pressure Validity Low Alarm Frequency	0

Table 12-3 Supply Air Pressure Diagnosis Parameters (FF)

Parameter	Description	Initial Value
Pressure Supply Max	Max Supply Air Pressure	-
Pressure Supply Min	Min Supply Air Pressure	-
Pressure Supply Threshold High	Supply Air Pressure Validity High Alarm Threshold	308
Pressure Supply Threshold Low	Supply Air Pressure Validity Low Alarm Threshold	252
Pressure Supply High Alarm Count	Supply Air Pressure Validity High Alarm Frequency	0
Pressure Supply Low Alarm Count	Supply Air Pressure Validity Low Alarm Frequency	0

Chapter 13 Internal Positioner Temperature Monitoring

[Overview]

■ Objective of Internal Positioner Temperature Monitoring

Internal positioner temperature monitoring is an index related to the deterioration of the gland packing. The temperature is measured using a temperature sensor that is installed inside the positioner.

[Algorithm]

■ Temperature Calculation Method

It sequentially updates and saves the maximum and minimum values of the values measured by the temperature sensor on the electric board.

[Threshold and Alarm]

■ Explanation of threshold

The threshold follows the usage condition of AVP700 (-40 to 80 °C).

Table 13-1 Electric Board Temperature Diagnosis and Abnormal Phenomena

Diagnostic parameter	Threshold	Abnormal Phenomenon
Temp Max	80 °C	Deterioration of gland packing (tattered, hardened)
Temp Min	-40 °C	

Table 13-2 Internal Positioner Temperature Diagnosis Parameters (HART)

Parameter	Description	Initial Value
Temp Max	Max Temp	-
Temp Min	Min Temp	-
Temp Threshold High	Temp Alarm High Alarm Threshold	80
Temp Threshold Low	Temp Alarm Low Alarm Threshold	-40
Temp High Alarm Count	Temp Alarm High Alarm Frequency	0
Temp Low Alarm Count	Temp Alarm Low Alarm Frequency	0

Table 13-3 Internal Positioner Temperature Diagnosis Parameters (FF)

Parameter	Description	Initial Value
Temperature Max	Max Temp	-
Temperature Min	Min Temp	-
Temperature Threshold High	Temp Alarm High Alarm Threshold	80
Temperature Threshold Low	Temp Alarm Low Alarm Threshold	-40
Temperature High Alarm Count	Temp Alarm High Alarm Frequency	0
Temperature Low Alarm Count	Temp Alarm Low Alarm Frequency	0

Chapter 14 Valve Signature

[Overview]

■ Objective of Valve Signature

■ Graph Shape

■ Parameter Calculation

The valve signature is a test conducted during periodic maintenance, which slowly actuates the control valve from being fully closed → fully open → fully closed again. The test results illustrate in a graph the relationship of the air pressure being supplied to the actuator, and the travel. The graph shape points to the control valve's frictional abnormality or shutoff abnormality.

※ The test is not supported by just AVP700 alone. It requires PLUG-IN Valstaff, a control valve maintenance support tool.

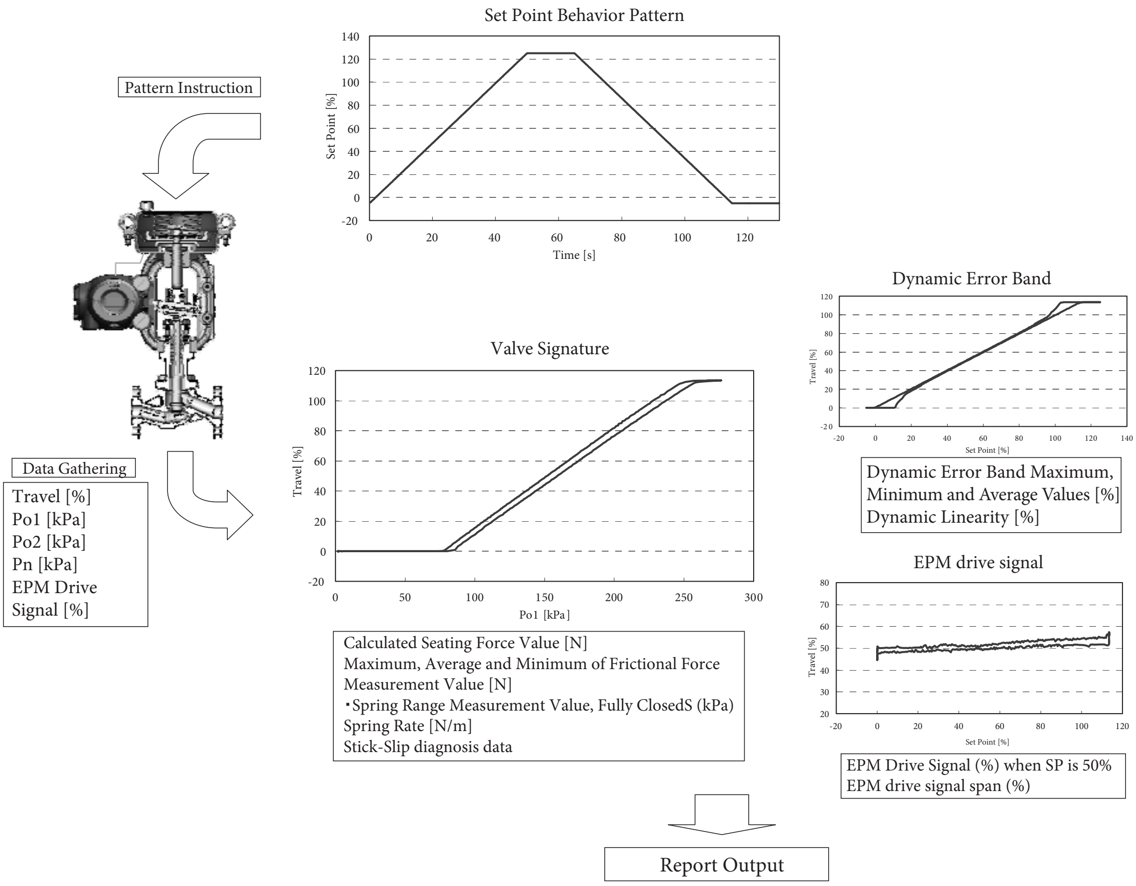


Figure 14-1 Valve Signature Overview

[Algorithm]

■ Behavior of Control Valve Based on its Pattern

■ PLUG-IN Valstaff (Reporting Function)

- Graph illustration
- Parameter calculation

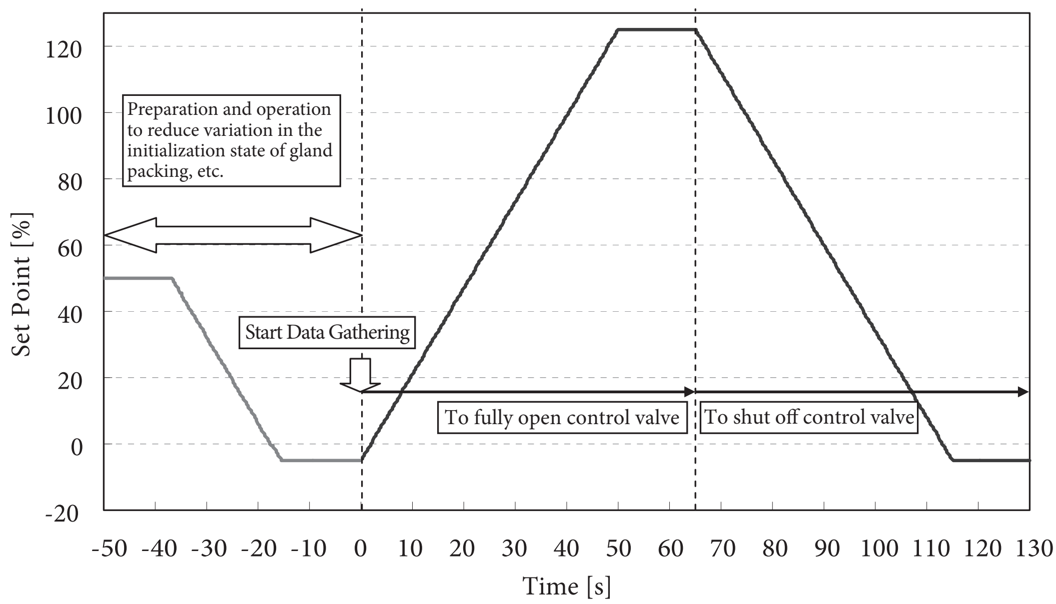


Figure 14-2 How to provision a pattern (set point)

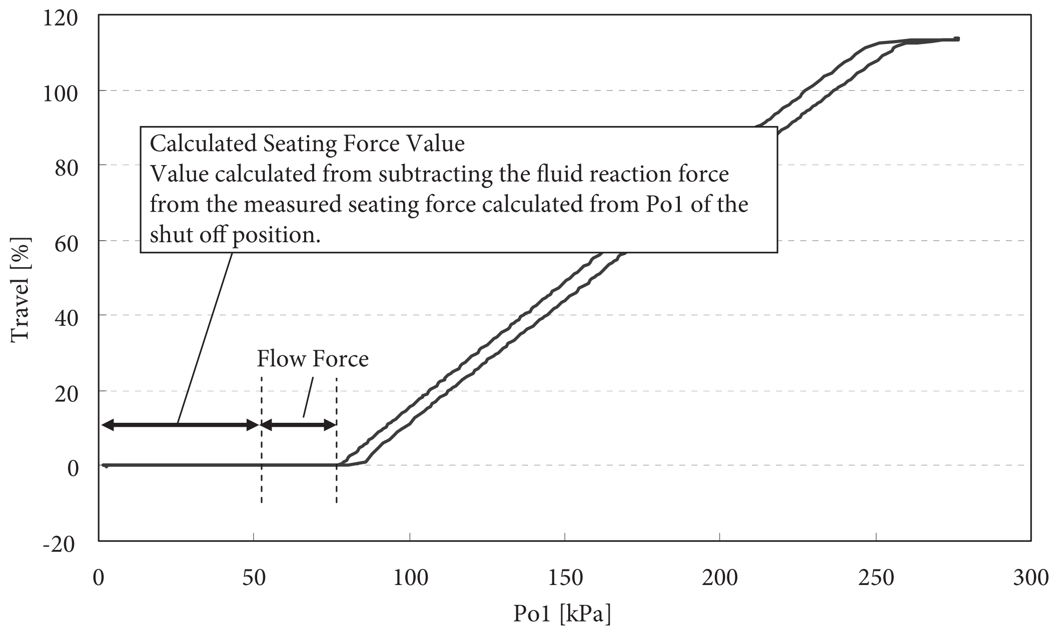


Figure 14-3 Index: calculated seating force value

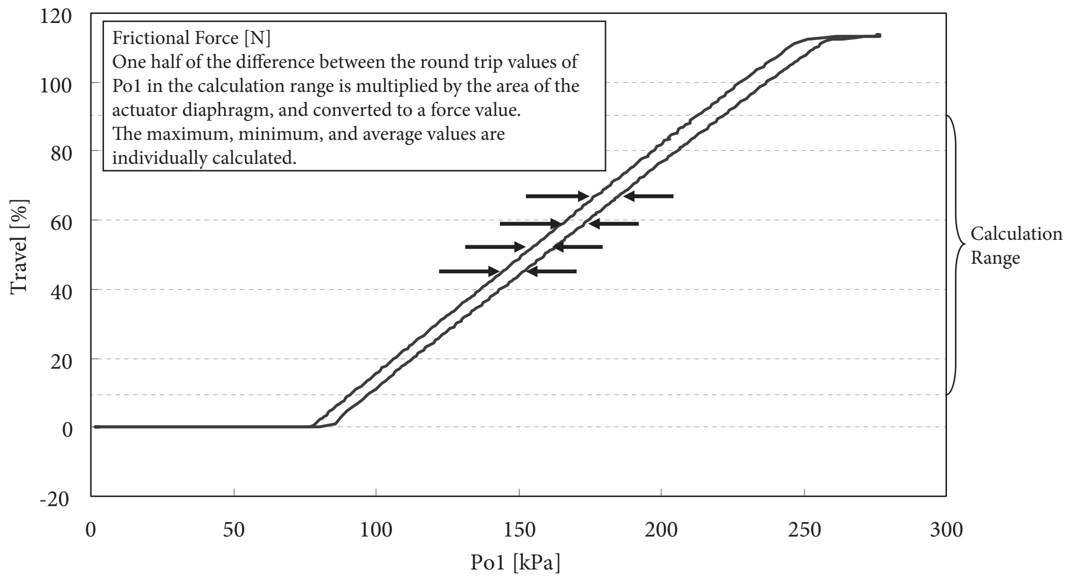


Figure 14-4 Index: frictional force calculation method

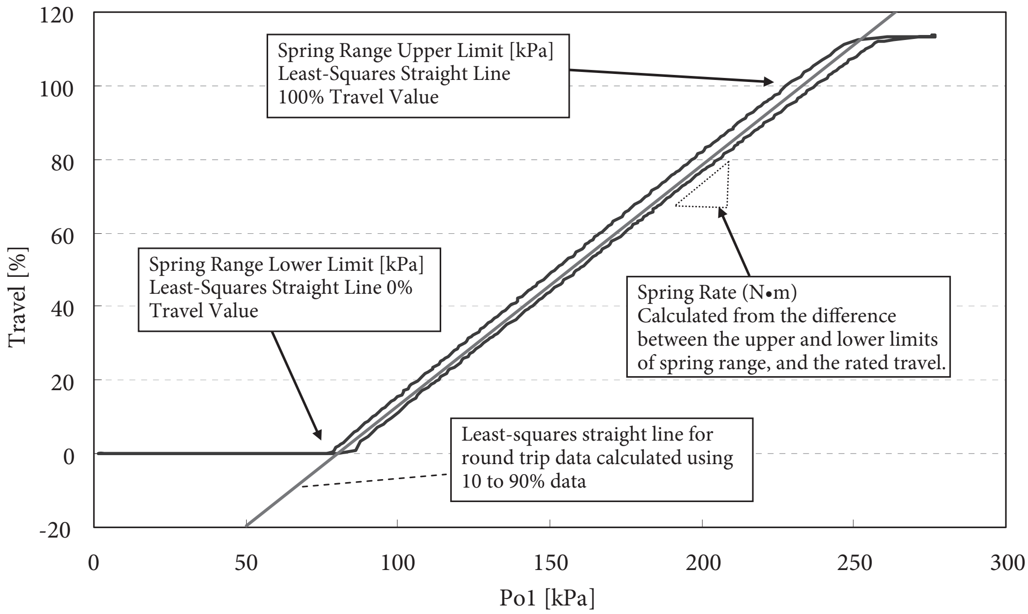


Figure 14-5 Index: spring range and stiffness calculation

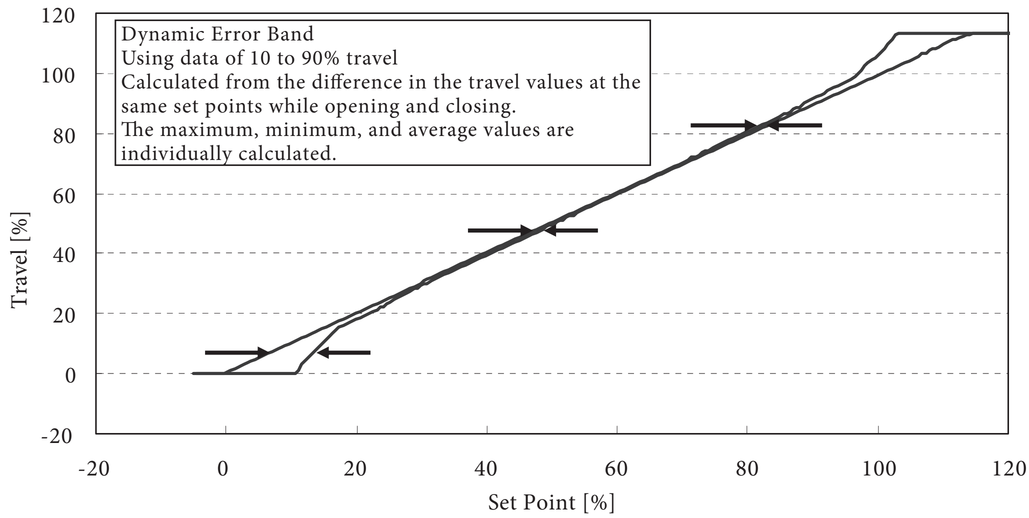


Figure 14-6 Index: dynamic error band calculation method

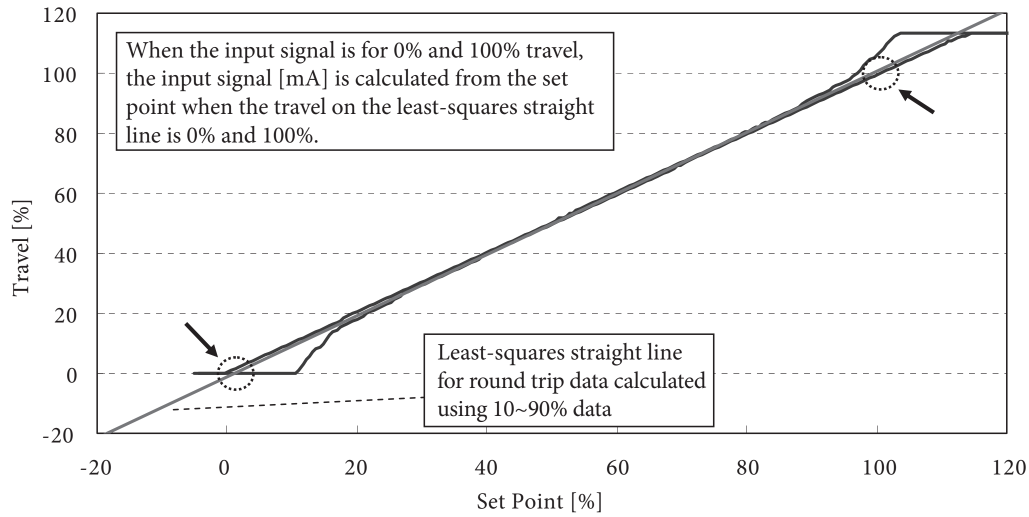


Figure 14-7 Index: calculation method when the input signal travel is 0% and 100%

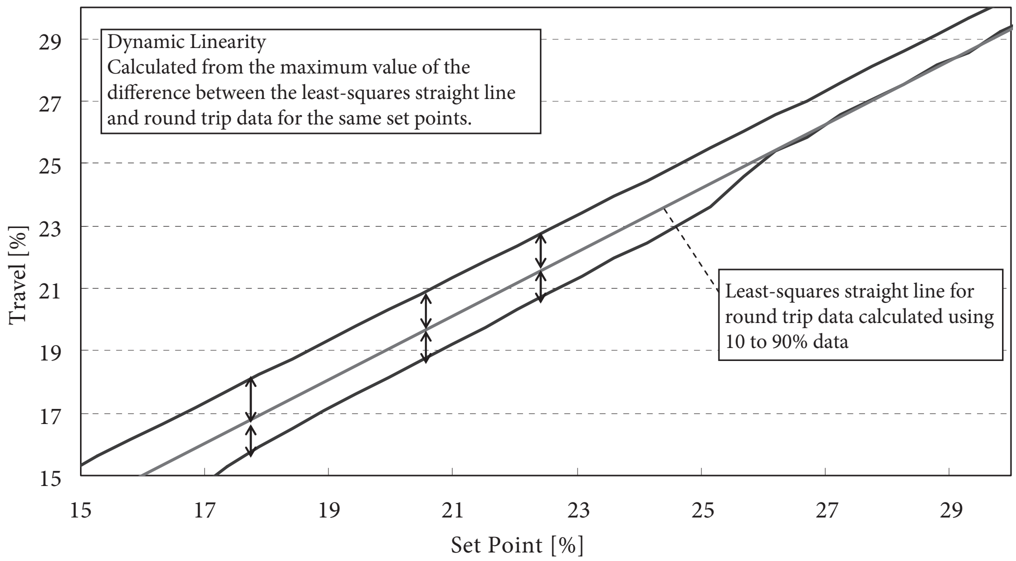


Figure 14-8 Index: dynamic linearity calculation method

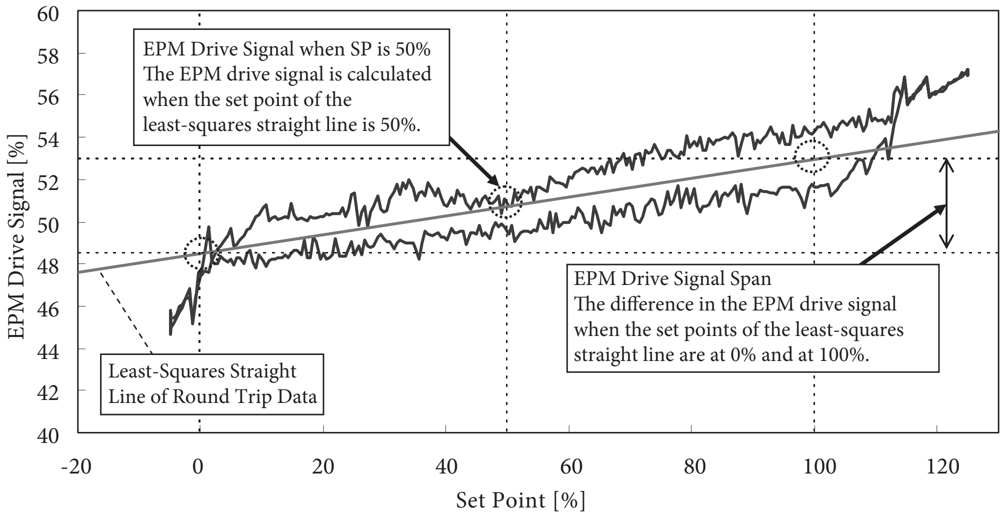


Figure 14-9 Index: Method of calculating the span of EPM drive signal, and EPM drive signal when SP is 50%

[Threshold and Alarm]

■ Explanation of threshold

- Seating force threshold
- Maximum and minimum frictional threshold
- Spring range for fully closed side
- Stick-Slip
- EPM drive signal

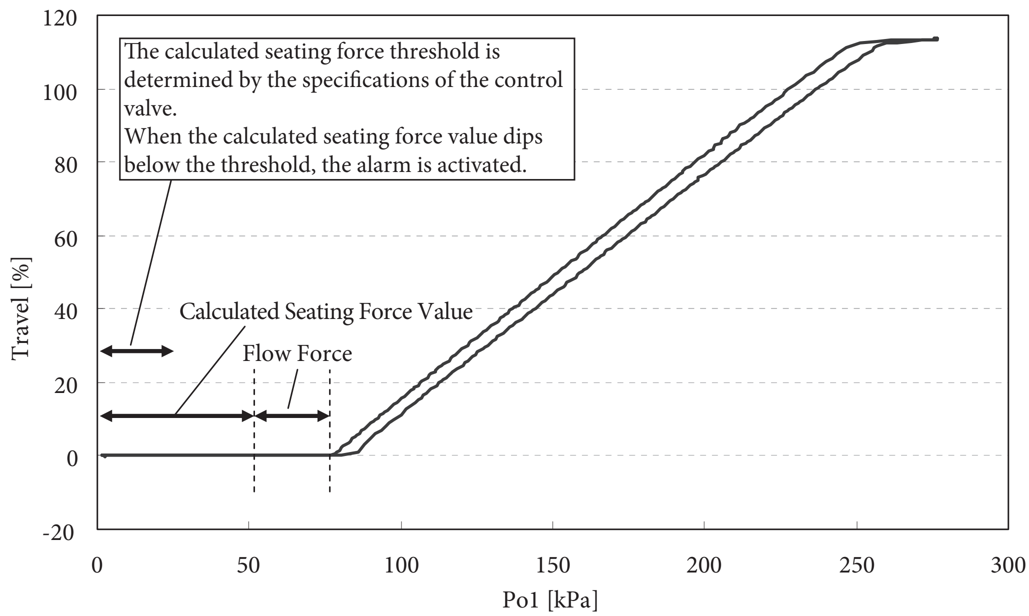


Figure 14-10 Calculated Seating Force Threshold

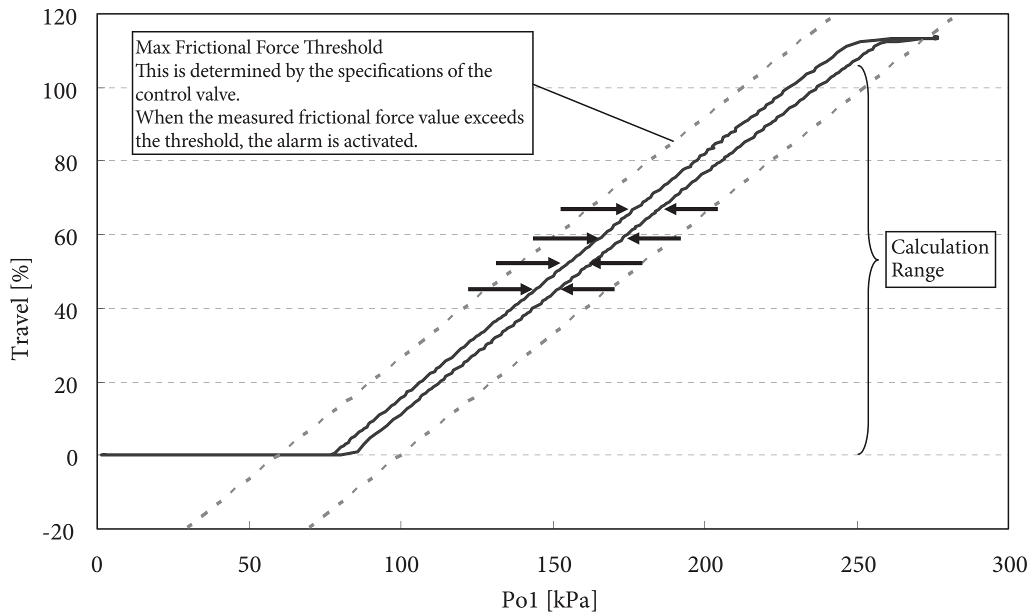


Figure 14-11 Max Frictional Force Threshold

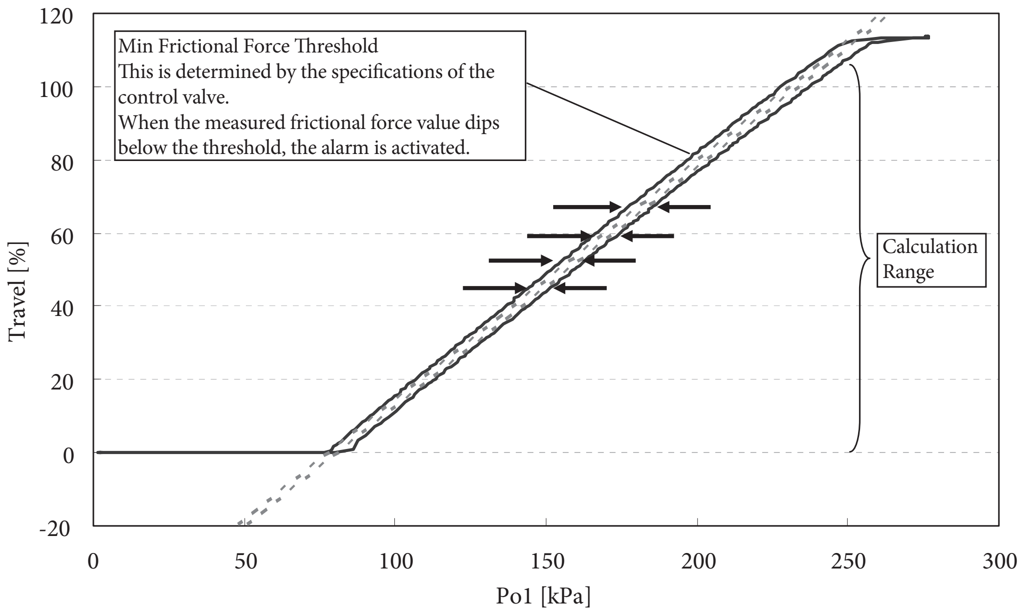


Figure 14-12 Min Frictional Force Threshold

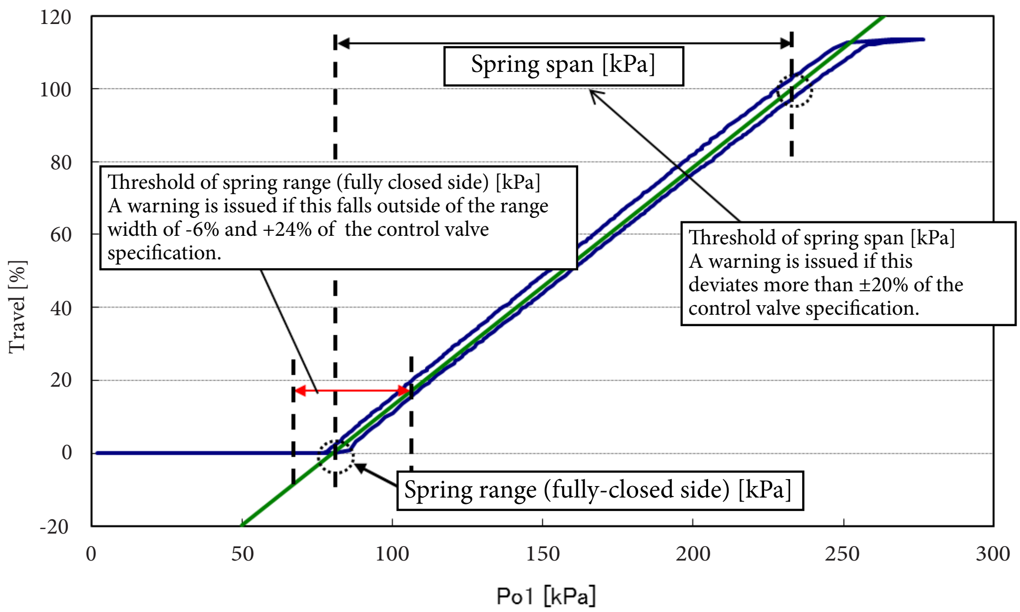


Figure 14-13 Spring range threshold

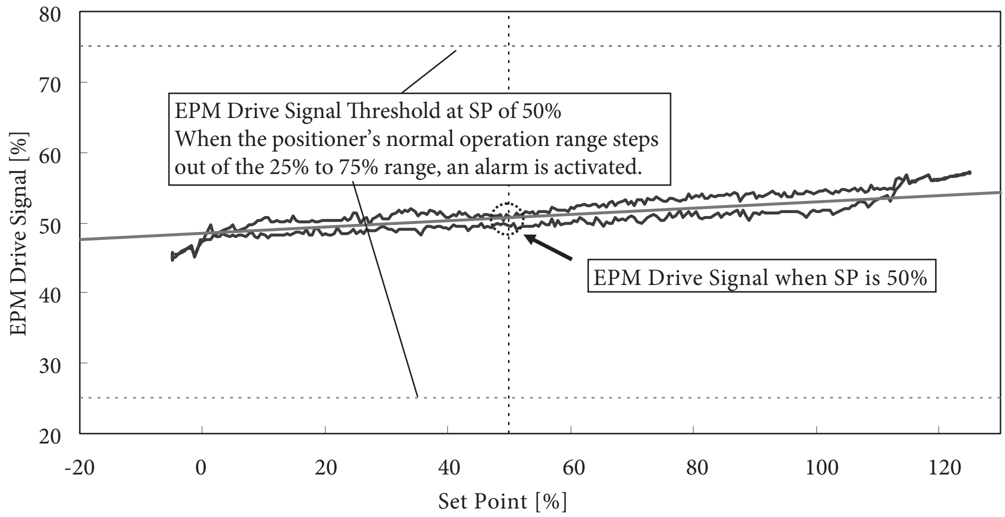


Figure 14-14 EPM Drive Signal Threshold at 50% SP

Table 14-1 Valve Signature Parameters (identical for HART & FF)

Parameter	Description
Calculated seating force value (N)	Force that pushes the plug into the seat in a seated state
Max Frictional Force Measurement Value (N)	Maximum frictional force calculated from the valve signature data
Average Frictional Force Measurement Value (N)	Average frictional force calculated from the valve signature data
Min Frictional Force Measurement Value (N)	Minimum frictional force calculated from the valve signature data
Shut off-side spring range measurement value (kPa)	Spring range calculated from the valve signature data
Spring rate (N/m)	Actuator spring rate calculated from the valve signature data
Stick-Slip diagnosis data	Result of Stick-Slip diagnosis during a valve signature
When input signal travel is 0% (mA)	This is the input signal (mA) when travel is 0%. This is not displayed when the positioner is using FF communication.
When input signal travel is 100% (mA)	This is the input signal (mA) when travel is 100%. This is not displayed when the positioner is using FF communication.
Max dynamic error band value (%)	Maximum round trip travel difference
Min dynamic error band value (%)	Minimum round trip travel difference
Average dynamic error band value (%)	Average round trip travel difference
Dynamic linearity (%)	Maximum value of difference between the travel value calculated from valve signature data, and the actual travel value
EPM Drive Signal (%) when SP is 50%	EPM drive signal when set point is at 50%
EPM drive signal span (%)	Width of EPM drive signal when set point is 0% and 100%

Table 14-2 Valve Signature Parameters and Abnormalities (identical for HART and FF)

<table>
<tr><th>Parameter</th><th>Threshold</th><th>Abnormality</th></tr>
<tr><td>Calculated seating force value (N)</td><td>Specification</td><td>Sticking or galling of the gland, guiding surfaces, and plug/seat
Unbalance between the actuator output and flow force
Air leak (O-ring deterioration, diaphragm damage)
Spring deterioration
Spring falling off
Poor adjustment of spring (insufficient compressed load)</td></tr>
<tr><td>Max Frictional Force Measurement Value (N)</td><td>Specification</td><td>Sticking or galling of the gland, guiding surfaces, and plug/seat</td></tr>
<tr><td>Min Frictional Force Measurement Value (N)</td><td>Specification</td><td>Feedback lever out of place</td></tr>
<tr><td>Shut off-side spring range measurement value (kPa)</td><td>Specification</td><td>Spring deterioration
Spring falling off
Poor adjustment of spring (insufficient compressed load)</td></tr>
<tr><td>Spring rate (N•m)</td><td>None</td><td>Spring deterioration
Spring falling off</td></tr>
<tr><td>Stick-Slip diagnosis data</td><td>Threshold shall be 10</td><td>Sticking or galling of the gland, guiding surfaces, and plug/seat</td></tr>
<tr><td>Max dynamic error band value (%)</td><td>None</td><td rowspan="4">Control parameter is unsuitable</td></tr>
<tr><td>Min dynamic error band value (%)</td><td>None</td></tr>
<tr><td>Average dynamic error band value (%)</td><td>None</td></tr>
<tr><td>Dynamic linearity (%)</td><td>None</td></tr>
<tr><td>EPM Drive Signal (%) when SP is 50%</td><td>Normal range shall be between 25% and 75%</td><td>Clogging of positioner nozzle/restriction</td></tr>
<tr><td>EPM drive signal span (%)</td><td>None</td><td>Pilot failure</td></tr>
</table>

Chapter 15 Step Response Test

[Overview]

■ Objective of the Step Response Test

■ Typical Pattern

・Fully open / closed
・5-point check
・1% step

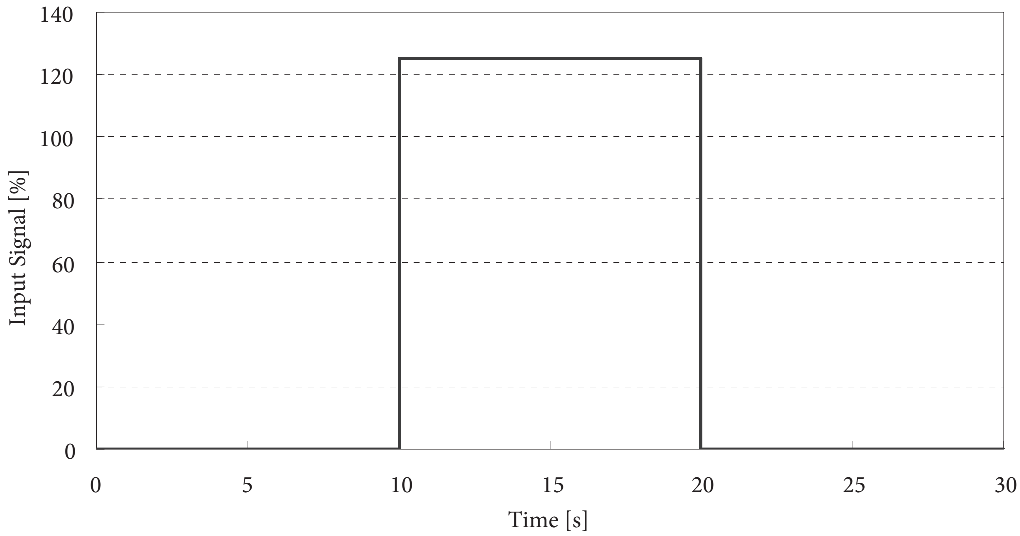


Figure 15-1 Fully open/closed pattern

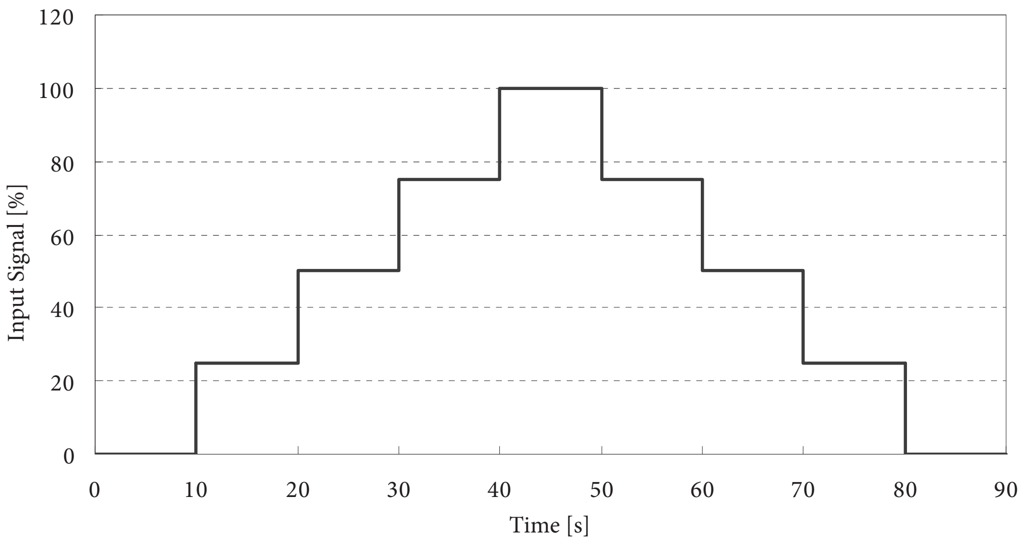


Figure 15-2 5-point check

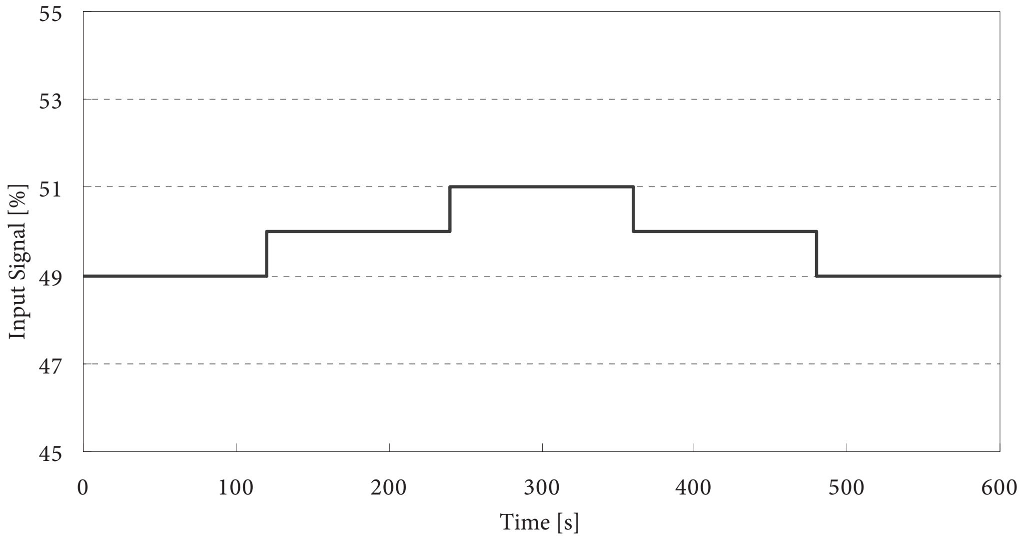


Figure 15-3 1% step

The step response test is conducted during periodic maintenance. A step signal is input to the control valve, and the travel response is recorded. Using the results on the trend display, the control valve's condition can be judged as good or bad, and the index data for dynamic characteristics from the test results can be used to quantify the control valve's performance.

※ The test is not supported by AVP700 alone. It requires PLUG-IN Valstaff, a control valve maintenance support tool.

[Algorithm]

■ Calculation of parameter that is output to the test report

Table 15-1 Full-open/closed test report's output Parameters (common to HART/FF)

Judgment method and parameters	Description
Zero Point Judgment Final PV Value	Final PV value when set point is 0%
Operating speed judgment T99FS	Time until it reaches 99% FS

Table 15-2 5-point check: test report's output Parameters (common to HART/FF)

Judgment method and parameters	Description
Zero Point Judgment Final PV Value	Final PV value when set point is 0%
Deviation Judgment Final PV Value	Final PV value of the step when the set point is greater than 0%
Settling Time Judgment Tss/T86	Value that is normalized by dividing the settling time Tss with T86. Tss: Time it takes for the ultimate travel value to be within ±0.5% of FS after step input. T86: Time it takes to reach 86.5% of the step width after step input.
Overshoot / Undershoot Judgment Overshoot Undershoot	Overshoot: absolute value (%FS) of maximum excess amount from the input signal, when excess travel has occurred for the input signal. Undershoot: absolute value (%FS) of maximum excess amount from the input signal, when it returned back too much in respect to the input signal, after an overshoot had occurred.

Table 15-3 1% check: test report's output parameters (common to HART/FF)

Judgment method and parameters	Description
Deviation Judgment Final PV Value	Final PV value of the step when the set point is greater than 0%
Settling Time Judgment Tss	Time it takes for the final travel value to be within ±0.5% of FS after step input.

[Threshold and Alarm]

■ Explanation of threshold

Table 15-4 Report output parameters (common to HART/FF)

Parameter	Threshold	Abnormality
Zero Point Judgment Final PV Value	Satisfactory range: -3% to 1%	Intrusion of foreign object Seat abrasion Misadjustment of fully closed position
Deviation Judgment Final PV Value	±1%	Control parameters are unsuitable
Settling Time Judgment Tss/T86	Satisfactory range: below 14.0	Control parameters are unsuitable
Settling Time Judgment Tss	Half of the record time	Control parameters are unsuitable
Overshoot / Undershoot Judgment	5%	Control parameters are unsuitable
Operating speed judgment T99FS	Half of the record time	Air leak (O-ring deterioration, diaphragm damage) Control parameters are unsuitable

Chapter 16 Partial Stroke Test (PST)

[Overview]

■ Objectives of Partial Stroke Test

The partial stroke test (PST) is conducted for an emergency shutoff valve. The test partially actuates the shutoff valve by a slow ramping motion without interrupting the production process. If the PST does not detect any failures, the probability of shutoff valve failure decreases, and the periodic maintenance interval may be lengthened. By moving the shutoff valve slowly and partially, a test can be conducted without impacting the process.

[Algorithm]

■ PST Behavior Pattern

■ How to determine failures

The PST controls the opening of the emergency shutoff valve via the patterns illustrated in Figure 16-1. It closes the set point from 100% to 90% within 5 seconds, and after maintaining that for 5 s, it returns it to 100% once again, and maintains that state for another 5 seconds. With these three timeouts, it detects failure of the emergency shutoff valve. It detects the following three states and activates the alarm for the device status (Table 16-1): when the emergency shutoff valve doesn't start moving within 5 seconds, or when it doesn't close to the 90% mark within 10 seconds, or if it doesn't return to 100% within 20 seconds. Even when the above three alarms are activated, PST does not stop, but continues to control the travel according to the pattern.

Continuing to enable the PST when there's an abnormality with the emergency shutoff valve may have a negative impact on the plant. When the values dip below the thresholds during the monitoring of Po 1 or Po 1 - Po2, the associated danger is avoided by making sure the shutoff valve does not close more than necessary. The recommended value for this threshold is calculated by auto setup.

The stick-slip phenomenon can also be detected during the PST, which includes stick-slip diagnosis.

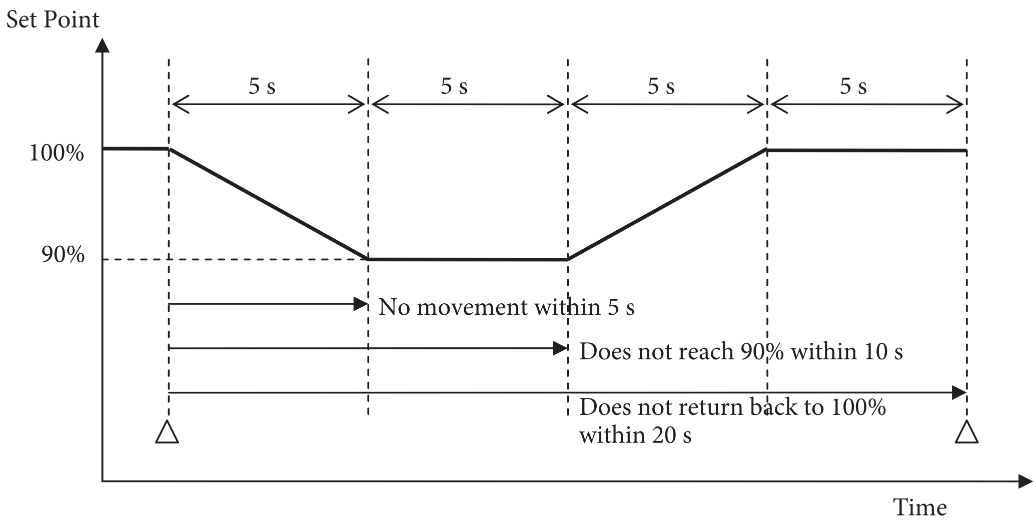


Figure 16-1 Partial ramping and time out during partial stroke test

[Threshold and Alarm]

■ Explanation of threshold

PST does not calculate a diagnostic parameter. It activates alarms for the device status if there is an abnormality of the emergency shutoff valve. The stick-slip diagnosis threshold during the PST is the same as threshold 10 of the stick-slip diagnosis during normal state.

Table 16-1 Partial stroke test and abnormality (common with 700SIS/FF)

Device status	Threshold	Abnormality
PST Start Position Failure	Initial travel is ±5% from the prescribed travel	Air leak (O-ring deterioration, diaphragm damage) Clogging of nozzle/restriction Air leak from air circuit Feedback lever out of place Failure of electric / angle sensor Pilot failure
No change in valve travel in PST	The control valve does not move within 5 s from start of PST.	Sticking or galling of the gland, guiding surfaces, and plug/seat Breakage of the stem
Did not Reach Target in PST	Does not reach within ±5% of target travel within 10 s from starting PST.	Spring deterioration Spring falling off
PST Pressure Failure	Po 1 (or Po 1 - Po 2) drops below 90% of the spring range.	Sticking or galling of the gland, guiding surfaces, and plug/seat
PST Incomplete	Does not return to within ±5% of the original travel within 20 s.	Sticking or galling of the gland, guiding surfaces, and plug/seat Air leak from air circuit
Stick-Slip During in PST	10 (Stick-Slip Y/X)	Sticking or galling of the gland, guiding surfaces, and plug/seat

Table 16-2 Partial Stroke Test Parameters (700SIS)

Parameter	Description	Initial Value
PST Enabled	PST starting command - enable/disable	Disable
PST Initial Travel	Initial travel	100
PST Target Travel	Target travel	90
PST Pause Time	Wait time after reaching the preset travel	5
PST Ramp Rate	Ramp rate	2
PST Next Execute Time	Time until the next PST execution	0
PST Interval	Execution Cycle	0
PST Breakout Timeout	Breakout Timeout	5
PST Stroke Travel Timeout	Stroke Travel Timeout	10
PST Completion Timeout	Completion Timeout	22
PST Pressure Threshold	Pressure Threshold	208
PST Stick-Slip Threshold	Stick-Slip Y/X Threshold during Execution	10
Result	(Explained in the following tables.)	

Table 16-3 Partial Stroke Test Result Parameter (700SIS)

Parameter	Description	Initial Value
PST Result	PST Result	No Result
Detailed Result		
PST Start Position Failure	Start Position Failure	Off
No Change in Valve Travel in PST	Travel doesn't change after starting	Off
Did not Reach to Target in PST	Doesn't reach target value	Off
PST Pressure Failure	Abnormal pressure	Off
PST Incomplete	The travel at the end is abnormal	Off
Stick-Slip Occurrence in PST	Stick-slip occurs	Off
Rejection of Request for PST	Rejected due to conditions before executing PST	Off
PST Overridden (aborted)	Suspended during PST execution	Off
PST Breakout Time	Time until the detection of travel alteration	0
PST Start Travel	Travel Value at the start of the test	0
PST Start Pressure	Pressure at the start of the test	0
PST Pause Travel	Travel value at the end of the PAUSE period	0
PST Pause Pressure	Pressure at the end of the PAUSE period	0
PST End Travel	Travel value at the end of the test	0
PST End Pressure	Pressure at the end of the test	0

Table 16-4 Partial Stroke Test Parameters (FF)

Parameter	Description	Initial Value
VST_MODE	VST Mode	Disable
Partial Stroke Test		
PST Enabled	PST starting command - enable/ disable	FF Only
PST Initial Travel	Initial travel	100
Partial Stroke Travel	Target travel	90
VST Pause	Wait time after reaching the preset travel	5
Partial Stroke Ramp Rate	Ramp rate	2
Partial Stroke Init Start Time	Time until the next PST execution	0 Invalid Value
Partial Stroke Interval	Execution cycle	0
Partial Stroke Breakout Timeout	Breakout timeout	5
Partial Stroke Travel Timeout	Stroke travel timeout	10
PST Completion Timeout	Completion timeout	22
PST Pressure Threshold	Pressure threshold	208
PST Stick-Slip Threshold	Stick-slip Y/X threshold during execution	10
PST Stick-Slip Alarm Enabled	Permission for stick-slip alarm during PST	0:Disable
Partial Stroke Options	Options which the user may select to influence block behavior during valve stroke test 1.	0 Freeze analog Feedback

Table 16-5 Partial Stroke Test Result Parameter (FF)

Parameter	Description	Initial Value
VST Mode	VST (PST/FST) Mode	
VST Result	PST and FST Result	
VST Detailed Result	Detailed PST and FST Result	
PST Result		
Partial Stroke Breakout Time	Time until the detection of travel alteration	0
PST Start Travel	Travel Value at the start of the test	0
PST Start Pressure	Pressure at the start of the test	0
PST Pause Travel	Travel value at the end of the PAUSE period	0
PST Pause Pressure	Pressure at the end of the PAUSE period	0
PST End Travel	Travel value at the end of the test	0
PST End Pressure	Pressure at the end of the test	0

Chapter 17 Full stroke test

[Overview]

■ Objective of Full Stroke Test

The full stroke test (FST) is applied to the emergency shutoff valve. The test executes shutoff and full open operation when the production process is offline during periodic maintenance. If the FST does not detect any failures, the emergency shutoff valve's error-free status can be confirmed.

[Algorithm]

■ FST Behavior Pattern

■ How faults are identified

The FST controls the travel of the emergency shutoff valve according to the patterns illustrated in Figure 17-1. It sets the set point to 0% when the test starts, and after maintaining that state for 5 seconds, it sets the set point to 100%, and maintains that for another 5 seconds. With these three timeouts, it detects problems with the emergency shutoff valve. It detects the following three states and activates the alarm for the device status (Table 17-1): when the emergency shutoff valve doesn't start moving within 1 second, or when it doesn't close to the 0% mark within 5 seconds, or doesn't return to 100% within 10 seconds.

By way of a diagnostic parameter, the FST measures and saves the time it takes from full open to shut off.

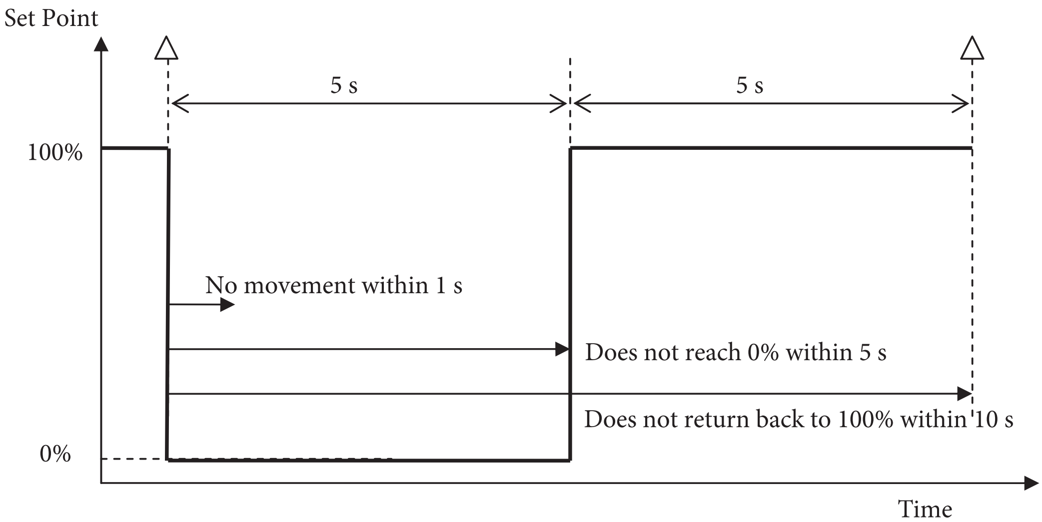


Figure 17-1 Full open/closed procedure and time out during full stroke test

[Threshold and Alarm]

■ Explanation of threshold

Device status alarms are issued if there is an abnormality of the emergency shutoff valve.

Table 17-1 Full stroke test and abnormality (common with 700SIS/FF)

Device status	Threshold	Abnormal Phenomenon
FST Start Position Failure	±5% from the initial travel	Air leak (O-ring deterioration, diaphragm damage) Clogging of nozzle/restriction Air leak from air circuit Feedback lever out of place Failure of electric / angle sensor Pilot failure
No Change in Valve Travel in FST	The control valve does not move within 1 s from start of FST.	Sticking or galling of the gland, guiding surfaces, and plug/seat Breakage of the stem
Did not Reach to Target in FST	Does not reach within ±5% of target travel within 5 s from starting FST.	Spring deterioration Spring falling off
FST Pressure Failure	A threshold is not normally used.	Sticking or galling of the gland, guiding surfaces, and plug/seat
FST Incomplete	Does not return to within ±5% of the original travel within 10 s.	Sticking or galling of the gland, guiding surfaces, and plug/seat Air leak from air circuit

Table 17-2 Full Stroke Test Parameters (700SIS)

Parameter	Description	Initial Value
FST Enabled	Enable or disable FST starting command	Disable
FST Pause Time	Wait time after reaching the preset travel	5
FST Ramp Rate	Ramp rate	2000
FST Breakout Timeout	Breakout timeout	1
FST Stroke Travel Timeout	Stroke travel timeout	5
FST Completion Timeout	Completion timeout	11
FST Result	(Explained in the following tables.)	

Table 17-3 Full Stroke Test Less than FST Result Parameters (700SIS)

Parameter	Description	Initial Value
FST Result	FST Result	No Result
FST Detailed Result		
FST Start Position Failure	Start position failure	
No Change in Valve Travel in FST	Travel doesn't change after starting	OFF
Did not Reach to Target in FST	Didn't reach target value	OFF
FST Pressure Failure	Abnormal pressure	OFF
FST Incomplete	The travel at the end is abnormal	OFF
Rejection of Request for FST	Rejected due to FST execution prerequisites	OFF
FST Overridden (aborted)	Suspended during FST execution	OFF
FST Breakout Time	Time until the detection of travel alteration	0
FST Stroke Travel Time	Time until reaching the preset travel value	0
FST Start Travel	Travel Value at the start of the test	0
FST Start Pressure	Pressure at the start of the test	0
FST Pause Travel	Travel value at the end of the PAUSE period	0
FST Pause Pressure	Pressure at the end of the PAUSE period	0
FST End Travel	Travel value at the end of the test	0
FST End Pressure	Pressure at the end of the test	0

Table 17-4 Full Stroke Test Parameters (FF)

Parameter	Description	Initial Value
VST_MODE	VST (PST/FST) mode	Disable
Full Stroke Test		
VST Pause	Wait time after reaching the preset travel	5
Full Stroke Ramp Rate	Ramp rate	2000
Full Stroke Breakout Timeout	Breakout Timeout	1
Full Stroke Travel Timeout	Stroke Travel Timeout	5
Full Stroke Completion Timeout	Completion Timeout	11

Table 17-5 Full Stroke Test Parameters (FF)

Parameter	Description	Initial Value
VST_RESULT	FST Result	No initial Result
VST_DETAILED_RESULT	Detailed FST Result	No detail of result
FST Result		
Full Stroke Breakout Time	Time until the detection of travel alteration	0
FST Stroke Travel Time	Time until reaching the preset travel value	0
FST Start Travel	Travel Value at the start of the test	0
FST Start Pressure	Pressure at the start of the test	0
FST Pause Travel	Travel value at the end of the PAUSE period	0
FST Pause Pressure	Pressure at the end of the PAUSE period	0
FST End Travel	Travel value at the end of the test	0
FST End Pressure	Pressure at the end of the test	0

Appendix A Connection between AVP700's Diagnostic Functions and Abnormalities

Table A-1 Control Valve Diagnosis and Tests

◎ : Abnormality Detected ○ : Abnormality Index

Location	Abnormality	Stick-Slip Diagnosis	Input Signal / Travel Deviation Diagnosis	Zero Point Travel Comparison Diagnosis	Po Validity Monitoring (Po Validity)	Max Friction Monitoring (Max Friction)	Total Stroke Monitoring	Max Travel Speed Monitoring	Travel Histogram	Shut Off Frequency Monitoring	Cycle Count Monitoring	Valve Signature	STEP Response Test	Partial Stroke Test (PST)	Full Stroke Test (FST)
Valve	Sticking or galling of the gland, guiding surfaces, and plug/seat	◎	◎		○	○		◎				◎	◎	◎	◎
	Deterioration of gland packing (tattered, hardened)	○				○	○	○			○				
	Unbalance between the actuator output and fluid reaction force				○							◎			
	Decrease of gland packing compression					○	○				○				
	Damage of plug/seat member			○					○	○					
	Adhesion of fluid on the plug/seat			○					○						
	Overall erosion of Seat			○					○						
	Overall abrasion of seat			○											
	Overall corrosion of the Seat			○					○						
	The control valve capacity is too large								○						
	Insufficient packing lubricant						○				○				
	Intrusion of foreign object			◎									◎		
	Seat abrasion			◎						○			◎		
	Misadjustment of fully closed position			◎											
Actuator	Air leak (O-ring deterioration, diaphragm damage)		◎		○		○				○	◎	◎	◎	◎
	Spring deterioration		◎	◎	○		○				○	◎		◎	◎
	Spring falling off		◎		○			○				◎		◎	◎
	Breakage of the stem		◎					○				◎		◎	◎
	Poor adjustment of spring (insufficient compressed load)				○										
	Poor Adjustment Valve Shaft Connection														
Positioner	Clogging of nozzle/restriction		◎									◎		◎	◎
	Air leak from air circuit		◎											◎	◎
	Feedback lever out of place		◎									◎		◎	◎
	Failure of electric / angle sensor		◎											◎	◎
	Pilot failure		◎									◎		◎	◎
	Control parameters are unsuitable		○									◎	◎		

Table A-2 Positioner Diagnosis

Location	Applicable for Abnormality Detection	Positioner Air Circuit Diagnosis	Supply Air Pressure Diagnosis	Internal Positioner Temperature Monitoring
Valve	Deterioration of gland packing (tattered, hardened)			○
Positioner	Clogging of nozzle/restriction	◎		
	Insufficient Supply Pressure		◎	
	Excessive Supply Pressure		◎	

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1.2 Warranty scope

In the event that Azbil Corporation's product has any failure attributable to azbil during the aforementioned warranty period, Azbil Corporation shall, without charge, deliver a replacement for the said product to the place where you purchased, or repair the said product and deliver it to the aforementioned place. Notwithstanding the foregoing, any failure falling under one of the following shall not be covered under this warranty:

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(2) Failure caused for other reasons than Azbil Corporation's product;
(3) Failure caused by any modification or repair made by any person other than Azbil Corporation or Azbil Corporation's subcontractors;
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(5) Failure that the state-of-the-art at the time of Azbil Corporation's shipment did not allow Azbil Corporation to predict; or
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(3) Measures to be taken to secure the required level of the reliability and safety of your Equipment in your use
Although azbil is constantly making efforts to improve the quality and reliability of Azbil Corporation's products, there exists a possibility that parts and machinery may break down. You are required to provide your Equipment with safety design such as fool-proof design, *1 and fail-safe design*2 (anti-flame propagation design, etc.), whereby preventing any occurrence of physical injuries, fires, significant damage, and so forth. Furthermore, fault avoidance, *3 fault tolerance,*4 or the like should be incorporated so that the said Equipment can satisfy the level of reliability and safety required for your use.

*1. A design that is safe even if the user makes an error.
*2. A design that is safe even if the device fails.
*3. Avoidance of device failure by using highly reliable components, etc.
*4. The use of redundancy.

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In addition,
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Moreover, you are required to provide your Equipment with fool-proof design, fail-safe design, anti-flame propagation design, fault avoidance, fault tolerance, and other kinds of protection/safety circuit design on your own responsibility to ensure reliability and safety, whereby preventing problems caused by failure or nonconformity.

(1) For use under such conditions or in such environments as not stated in technical documents, including catalogs, specification, and instruction manuals
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* Nuclear energy/radiation related facilities
  [For use outside nuclear energy controlled areas] [For use of Azbil Corporation's Limit Switch For Nuclear Energy]
* Machinery or equipment for space/sea bottom
* Transportation equipment
  [Railway, aircraft, vessels, vehicle equipment, etc.]
* Antidisaster/crime-prevention equipment
* Burning appliances
* Electrothermal equipment
* Amusement facilities
* Facilities/applications associated directly with billing

(3) Supply systems such as electricity/gas/water supply systems, large-scale communication systems, and traffic/air traffic control systems requiring high reliability
(4) Facilities that are to comply with regulations of governmental/public agencies or specific industries
(5) Machinery or equipment that may affect human lives, human bodies or properties
(6) Other machinery or equipment equivalent to those set forth in items (1) to (5) above which require high reliability and safety

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In addition, electronic components such as electrolytic capacitors will reach the end of their life due to aged deterioration based on the conditions or environment in which such electronic components are used. Although acceleration of the above situation varies depending on the conditions or environment of use, the number of open/close operations of relays, etc. as prescribed in specifications or instruction manuals, or depending on the design margin of your machine or equipment, you are required to renew any Azbil Corporation's products every 5 to 10 years unless otherwise specified in specifications or instruction manuals.
System products, field instru ments (sensors such as pressure/flow/level sensors, regulating valves, etc.) will reach the end of their life due to aged deterioration of parts. For those parts that will reach the end of their life due to aged deterioration, recommended replacement cycles are prescribed. You are required to replace parts based on such recommended replacement cycles.

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(2) Maintenance, inspection, adjustment, and repair
(3) Technical guidance and technical education
(4) Special test or special inspection of a product under the conditions specified by you
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