Safety manual for Fisher™ FIELDVUE™ DVC6200 Digital Valve Controller

This supplement applies to

Instrument Level	HC, AD, PD, ODV	
Device Type	1309	
Hardware Revision	2	
Firmware Revision	7	
Device Revision	1	3
DD Revision	7	1

1. Purpose

This safety manual provides information necessary to design, install, verify and maintain a Safety Instrumented Function (SIF) utilizing the Fisher DVC6200 digital valve controller. This document must be thoroughly reviewed and implemented as part of the safety lifecycle. This information is necessary for meeting the IEC 61508 or IEC 61511 functional safety standards.

⚠ WARNING

This instruction manual supplement is not intended to be used as a stand-alone document. It must be used in conjunction with the following documents:
Fisher DVC6200 Series Quick Start Guide (D103556X012)
Fisher DVC6200 Instruction Manual (D103605X012)

Failure to use this instruction manual supplement in conjunction with the above referenced documents could result in personal injury or property damage. If you have any questions regarding these instructions or need assistance in obtaining any of these documents, contact your Emerson sales office.

2. Description of the Device

The Fisher DVC6200 digital valve controller is an instrument which delivers controlled pneumatic pressure to modulate a valve actuator in response to an electrical signal.

This safety manual applies to the DVC6200 instrument with electronics hardware revision 2 (HW2) and firmware revision 4, 5, 6, and 7 with the following product options.

MODEL	CONSTRUCTION	OPTION				
		DETT	0-20 mA	24 VDC	Relay A	Relay C
DVC6200	Integral, Aluminum	✓	✓	✓	✓	✓
DVC6200S	Integral, Stainless Steel	✓	✓	✓	✓	✓
DVC6205 DVC6215	Remote Mount, Aluminum	✓	✓	✓	✓	✓
APPLICATION						
DETT		✓	✓	✓	✓	✓
0-20 mA		✓	✓		✓	✓
24 VDC		✓		✓	✓	✓

3. Terms, Abbreviations, and Acronyms

β	Beta factor for common cause effects of failure
DD	Device Description, an electronic data file that describes specific features and functions of a device to be used by host applications.
DETT	De-energize to Trip
DTM	Device driver that provides a unified structure for accessing device parameters, configuring and operating the devices and diagnosing problems.
DVC6200	Digital Valve Controller, product model designation
ESD	Emergency Shut Down
FIT	Failure In Time ($1x10^{-9}$ failures per hour)
FMEDA	Failure Mode Effect and Diagnostic Analysis
HART	Highway Addressable Remote Transducer, open protocol for digital communication superimposed over a direct current.
HFT	Hardware Fault Tolerance
λ	Failure rate. λ_{DD}: dangerous detected; λ_{DU}: dangerous undetected; λ_{SD}: safe detected; λ_{SU}: safe undetected.
Low Demand Mode	Mode of operation of a safety instrumented function where the demand interval is greater than twice the proof test interval.
Multidrop	Operating mode of the DVC6200 where the instrument controls the current drawn to enable it to be powered with 24 VDC.
PFD_{AVG}	Average Probability of Failure on Demand
Point-to-Point	Operating mode of the DVC6200 whereby the instrument is powered with 4-20 mA.
PVST	Partial Valve Stroke Test
Relay A	Pneumatic booster relay for double- or single-acting applications. Typical construction for double-acting DETT applications.
Relay C	Pneumatic booster relay for single-acting direct applications. Typical construction for single-acting DETT applications.
Safety	Freedom from unacceptable risk of harm.
Safety Function	Function of a device or combination of devices intended to be used within a Safety Instrumented System to reduce the probability of a specific hazardous event to an acceptable level.
SFF	Safe Failure Fraction
SIF	Safety Instrumented Function
SIL	Safety Integrity Level
SIS	Safety Instrumented System
SOV	Solenoid Operated Valve
Type A Element	“Non-Complex” element (using discrete components); for details see 7.4.4.1.2 of IEC 61508-2.
Type B Element	“Complex” element (using complex components such as micro controllers or programmable logic); for details see 7.4.4.1.3 of IEC 61508-2.

4. Related Literature

- Fisher DVC6200 Series Quick Start Guide (D103556X012)
- Fisher DVC6200 Instruction Manual (D103605X012)
- 62.1:DVC6200, Fisher DVC6200 Product Bulletin (D103415X012)
- 62.1:DVC6200 HC, Fisher DVC6200 Product Bulletin (D103423X012)
- HART Field Device Specification for Fisher DVC6200 (D103639X012)
- IEC 61508: 2010 Functional safety of electrical/electronic/programmable electronic safety-related systems
- ANSI/ISA 84.00.01-2004 (IEC 61511 Mod.) Functional Safety – Safety Instrumented Systems for the Process Industry Sector
- Exida FMEDA Report for Fisher DVC6200, DETT Applications Report No.: EFC 12-02-027 R004

5. General Requirements

⚠ WARNING

To ensure safe and proper functioning of equipment, users of this document must carefully read all instructions, warnings, and cautions in this safety manual and the Quick Start Guide.

- Refer to the Fisher DVC6200 Quick Start Guide (D103556X012) for mounting and configuration.
- Tools needed:
    - DVC6200
        - Flat Head Screwdriver, 3 mm Thin Blade (wiring terminations)
        - Phillips Screwdriver
        - 3/8” Hex Key (terminal box conduit plug)
        - 6 mm Hex Key (module base screws)
        - 5 mm Hex Key (terminal box screw)
        - 2.5 mm Hex Key (I/P converter screws)
        - 1.5 mm Hex Key (terminal box cover screw)
- Personnel performing maintenance and testing on the DVC6200 shall be competent to do so.

6. Safety Instrumented System Design

When using the DVC6200 digital valve controller in a safety instrumented system, the following items must be reviewed and considered.

6.1 SIL Capability

6.2 Safety Function

6.3 Failure Rates

6.4 Application Limits

6.5 Environmental Limits

6.6 Application of the Switch Output for Diagnostic Annunciation

6.1. SIL Capability

- Systematic Integrity

  SIL 3 Capable— the digital valve controller has met manufacturer design process requirements of IEC 61508 Safety Integrity Level 3.

- Random Integrity

  - The digital valve controller is classified as a Type A device according to IEC 61508. The complete final element subsystem will need to be evaluated to determine the SFF. If the SFF of the subsystem is >90%, and the $PFD_{avg} < 10^{-3}$, the design can meet SIL 3 @ HFT=0.

6.2. Safety Function

- **De-energize to Trip Application:** The application of the digital valve controller is limited to low demand mode. Table 1 describes the normal and safe states of DVC6200 for a DETT configuration. The digital valve controller may be operated with one of the following control signals:

    - **0-24 VDC:** Normal operation is with a 24 VDC signal applied to the digital valve controller. A shut-down command is issued by interrupting the loop or taking the voltage signal to 1 VDC or less.

    - **0-20 mA:** Normal operation is active throttling control with 4-20 mA current loop signal to the digital valve controller. A shut-down command is issued by taking the current signal to 0 mA (nominal).

Table 1. Normal and Safe States for De-Energize to Trip (DETT) Application

Action	Relay	Input Voltage or Current	Normal State	Safe State
Single	C or A	0 VDC or 0 mA		Port A < 1 psi
		24 VDC or 20 mA	Port A ≥ 95% of Supply	
Double	A	0 VDC or 0 mA		Port A pressure ≤ Port B pressure
		24 VDC or 20 mA	Port A ≥ 95% of Supply Port B < 1 psi	

6.3. Failure Rates

The failure rate data listed in table 2 and 3 is only valid for the 15-year useful lifetime of the DVC6200 digital valve controller. The failure rates will increase after this time period. Reliability calculations based on the data listed in the FMEDA report for mission times beyond the useful lifetime may yield results that are too optimistic, i.e. the calculated Safety Integrity Level will not be achieved.

Table 2. Failure Rates for DVC6200 with 0-24 VDC or 0-20 mA Control Signal, DETT

Failure Category	Failure Rate (in FIT)	
	w/Diagnostics	Normal
Fail Safe Detected	182	0
Fail Safe Undetected	264	446
Fail Dangerous Detected	77	0
Fail Dangerous Undetected	48	125
No Effect	942	1,520
Annunciation Failure Detected	398	0
Annunciation Failure Undetected	177	0

Table 3. Failure Rates According to IEC 61508 in FIT

Application	Device	λ_{SD}	λ_{SU}(1)	λ_{DD}	λ_{DU}	SFF(2)	DC(3)
De-Energize to Trip	With Diagnostics	580	264	77	48	-	62%
	Normal	0	446	0	125	-	-

1. The No Effect failures are no longer included in the Safe Undetected failure category according to IEC 61508, ed2, 2010.
2. Safe Failure Fraction needs to be calculated on (sub)system level.
3. Diagnostic coverage (DC) is λ_{DD} / ($\lambda_{DD} + \lambda_{DU}$).

6.4. Application Limits

- Safety Instrumented Function design verification must be done for the entire collection of equipment used in the Safety Instrumented Function including the DVC6200 digital valve controller. The SIS must fulfill the requirements according to the Safety Integrity Level, especially the limitation of average Probability of Failure on Demand (PFDavg)
- The system's response time is dependent on the entire final element subsystem. The user must verify the system response time is less than the process safety time for each final element.
- The DVC6200 needs to be in active throttling control.
- The DVC6200 digital valve controller has a fault reaction time of 30 seconds plus alert annunciation time plus the mean time to repair.
- The DVC6200 position monitor is not safety certified.

Note
The DVC6200 SIS position monitor *is* safety certified. Refer to the Safety Manual for DVC6200 SIS Digital Valve Controller, Position Monitor, and LCP200 Local Control Panel (D103601X012) or contact your Emerson sales office if additional information is needed.

- The valve actuation means must be of a type that automatically moves the valve to the safe state when the digital valve controller achieves the safe state. Valve stroke timing under these conditions may also need to be considered as part of the SIS design.
- When using the DVC6200 in redundant applications, the owner-operator of the facility should institute common cause training and more detailed maintenance procedures specifically oriented toward common cause defense.
- An estimate for the common cause failure rate (β) as determined for the DVC6200 used in a redundant configuration is 2% for DETT applications.
- The digital valve controller safety function is intended for use in an independent SIF loop from the position transmitter or limit switch application. Common cause failures between the digital valve controller and position monitor were not considered as a part of the FMEDA analysis.
- The supply pressure must not exceed 145 psig. The supply medium may be air or natural gas.

  Air: Supply pressure must be clean, dry air that meets the requirements of ISA Standard 7.0.01.

  Natural Gas: Natural Gas must be clean, dry, oil-free and noncorrosive.

  A maximum 40 micrometer particle size in the air system is acceptable. Further filtration down to 5 micrometer particle size is recommended.
- Diagnostic annunciation is dependent on a HART communicating host device being connected to the DVC6200 and being able to annunciate any problems encountered including the absence of a valid response from the DVC6200.

6.5. Environmental Limits

- Operating ambient temperature, refer to:
  - DVC6200 Instruction Manual (D103605X012)
- Humidity: tested per IEC 61514-2
- Electromagnetic Compatibility:
  - EN 61326-1:2013 Electrical equipment for measurement, control and laboratory use - EMC requirements - General requirements
    - Immunity - Industrial locations per Table 2 of EN 61326-1
    - Emission – Class A, Group 1 per Table 4 of CISPR 11
  - To achieve the compatibility, the following installation practices shall be followed
    - Metal conduit shall be used to shield the AUX cable between DVC6200. Ensure that the metal conduit has good contact with the enclosure of each equipment.
    - The DVC6200 enclosure shall be grounded locally.
- Vibration: tested per ANSI/ISA S75.13.01 Section 5.3.5. If excessive vibration can be expected, special precautions shall be taken which may include, but are not limited to:
  - Ensuring the integrity of the instrument mounting to the actuator.
  - Ensuring the integrity of pneumatic connections.
  - Remote mounting the DVC6200 on a pipestand or wall.

6.6. Application of the Switch Output for Diagnostic Annunciation

When using the Failure Rates “with diagnostics”, the system must be capable of monitoring the DVC6200 for alert conditions. To monitor the diagnostic detection, configure the switch output to report an alert condition.

- ☐ Make sure that the electronics hardware is configured for the switch output. See figure 1.
- ☐ Configure the switch to close on detection of an alert.

7. Installation & Commissioning Guidelines

7.1. DVC6200 DETT Safety Function

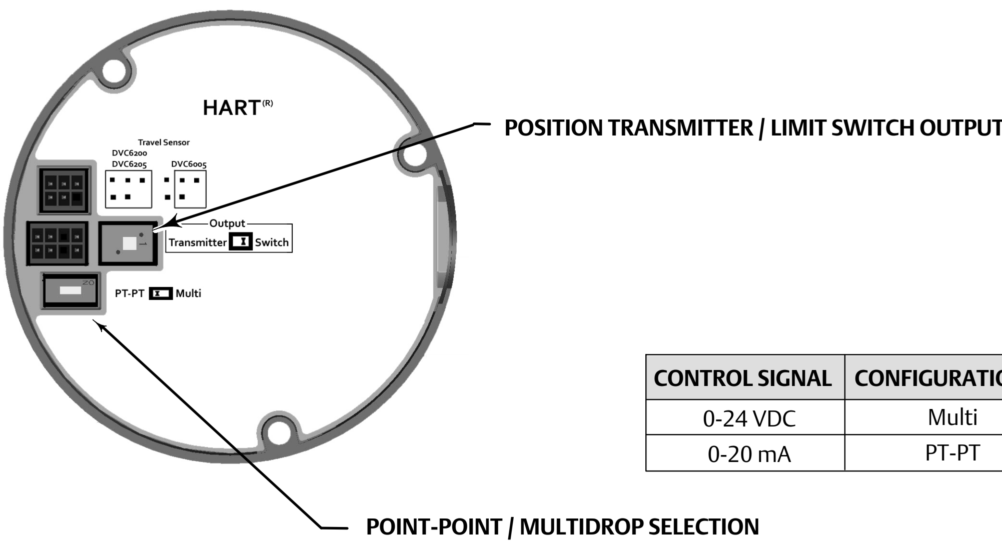
- ☐ Verify that the DVC6200 is suitable for use in this Safety Instrumented Function.

- ☐ Verify that nameplate markings of all the equipment being installed are suitable for the hazardous location (if required).

- ☐ Verify appropriate connections to the logic solver are made by referring to the instruction and safety manual of the logic solver.

- ☐ For maximum availability and benefit of digital valve controller features, the unit must be properly configured and calibrated, the Instrument Mode set to In Service and the protection set to Config & Calib using the Instrument Setup > Change Protection menu. With protection set, calibration and other protected parameters cannot be changed, including the Instrument Mode. Figure 1 below identifies toggle switches on the main electronics board that are configured as determined by the safety function and system application.

Figure 1. Configuration Toggle Switches on the Main Electronics Board



CONTROL SIGNAL	CONFIGURATION
0-24 VDC	Multi
0-20 mA	PT-PT

- ☐ The safety function of the DVC6200 within the final control element subsystem along with the overall SIS safety function must be tested after installation to ensure that it meets safety demand and applicable process safety time requirements.

8. Operation, Periodic Inspection, Test, and Repair

Periodic testing, consisting of proof tests and active throttling control, is an effective way to reduce the PFD_{avg} of the DVC6200 instrument as well as the valve and actuator it is connected to. Results of periodic inspections and tests should be recorded and reviewed periodically.

Note

Any time the SIF needs to be disabled, such as to perform a proof test or to take corrective action, appropriate measures must be taken to ensure the safety of the process.

Note

To ensure corrective action, continuous improvement, and accurate reliability prediction, the user must also work with their local Emerson service representative to see that all failures are reported.

8.1. Test Steps for the DVC6200

Proof tests are full-stroke tests that are manually initiated. As part of the test, the capability of the SIF to achieve the defined safe state must be verified. The proof test interval must be established for the SIF based on the failure rates of all the elements within the function and the risk reduction requirements. The proof test interval has to be at least 2 times more frequent than the demand rate. This determination is a critical part of the design of the SIS. A proof test will detect 79% (DETT) of dangerous undetected failures not detected by the DVC6200 automatic diagnostics. A proof test includes the following steps:

- ☐ Read the digital valve controller alert record using a HART communicating device such as an Emerson Field Communicator, ValveLink software or a DD or DTM based host. Any active alert messages must be investigated and resolved.
- ☐ Bypass the final control element or take appropriate action to avoid a false trip.
- ☐ If applying “with diagnostics” failure rates, verify that the Instrument Mode is In Service, the instrument is in active throttling control, and that the instrument Protection is set to Config & Calib.
- ☐ Trip the DVC6200 to its safe state by de-energization (for DETT).
- ☐ Observe that the actuator and valve move to its safe state within the required safety time through an instrument independent means (visual or other).
- ☐ Restore the DVC6200 to its normal state by energization (for DETT).
- ☐ Observe that the actuator and valve return to its normal state through an instrument-independent means (visual or other).

- ☐ If used, observe that the limit switch is closed through an instrument-independent means (visual or other).
- ☐ Check air filters to ensure they are clean and operating properly.
- ☐ Inspect the unit for any loose screws or other incorrect mechanical condition.
- ☐ Record the test results and any failures in your company's SIF inspection database.
- ☐ Remove the bypass and restore normal operation.

Instrument alerts considered when using the with diagnostics failure rates are evaluated when the instrument is in service and controlling the process. To take credit for the "with diagnostics" failure rates, the user must ensure that corrective action is taken when alerts are annunciated. The alert thresholds can be configured using one of the Emerson interfaces.

Should alarms, alerts, or failures be detected during operation, maintenance or periodic inspection and test, record the alarms, alerts, or failures, and immediately take corrective action. To ensure corrective action, continuous improvement, and accurate reliability prediction, the user must also work with their local Emerson service representative to see that all failures are reported. Table 4 shows the diagnostics that are used to calculate the detected failure rates.

Within table 4, the diagnostics detection time for the failures that can affect the safety function of the DVC6200 instrument is 15 seconds.

Table 4. Assumed Diagnostics for Determining Failure Rates Labeled "with diagnostics"

HART Command 48[1]	Alert Name	Description	Digital Valve Controller Action
Byte 0, Bit 7	Flash Integrity Failure	The flash ROM is corrupted.	Alert[2]
Byte 0, Bit 6	Minor Loop Sensor Alert	The pneumatic relay position reading is out of the valid range.	Alert[2]
Byte 0, Bit 5	Reference Voltage Failure	The electronics has detected a problem with the internal voltage reading.	Alert[2]
Byte 0, Bit 4	Drive Current Failure	The I/P converter should be flowing current but is not.	Alert[2]
Byte 0, Bit 3	Critical NVM Failure	Data is corrupted in the critical section of configuration memory.	Alert[2]
Byte 0, Bit 2	Temperature Sensor Failure	The temperature sensor is reporting a temperature <-60C or >100C.	Alert[2]
Byte 0, Bit 1	Pressure Sensor Failure	One or more pressure sensors is outside the expected operating range.	Alert[2]
Byte 0, Bit 0	Travel Sensor Failure	The travel sensor signal is outside the expected operating range.	Alert[2]
Byte 2, Bit 6	Non-Critical NVM Alert	Data is corrupted in the non-critical section of configuration memory.	Alert
Byte 4, Bit 3	Travel Deviation Alert	The valve travel is not tracking the set point within the configured deviation allowance.	Alert
Byte 4, Bit 0	Drive Signal Alert	The controller servo output is out of the normal operating range.	Alert
Byte 5, Bit 2	Output Circuit Error	The output circuit is not responding.	Alert
Device Status, Bit 2	Analog Input Saturated	The loop current reading is out of the normal operating range.	Alert

1. HART host must be configured to read these alerts and annunciate them.
2. This alert can be independently enabled to force the DVC6200 output to the safe state (shutdown on alert - enabled).

8.2. Maintenance

- The effective time to repair the DVC6200 is approximately 2 hours. This comprises of disassembly, repair, reassembly, and recalibration. This value can be used to determine the total mean time to restore (MTTR).
- Digital valve controller preventive maintenance consists, at a minimum, of replacing all critical elastomeric seals and diaphragms in the device and a visual inspection of moving components to verify satisfactory condition. The SIS Preventive Maintenance Kit includes all elastomeric seals and diaphragms and is available through your local Emerson sales office. Following maintenance, the digital valve controller must be calibrated per the Auto Travel Calibration or Manual Travel Calibration menu. After calibration, the digital valve controller functional safety must be validated.
- A conservative approach is taken in estimating the service interval for the digital valve controller in Safety Instrumented Systems. For SIS applications, preventive maintenance must be performed on the digital valve controller at eight to ten-year intervals from the date of shipment. If the instrument is exposed to the upper or lower extremes of the environmental limits, the interval for preventative maintenance may need to be reduced.

9. Decommissioning Guidelines

When decommissioning a DVC6200 instrument, proper procedures must be followed. Decommissioning includes the following steps:

- ☐ Bypass the final control element or take appropriate action to avoid a false trip.
- ☐ Avoid personal injury or property damage from sudden release of process pressure or bursting of parts. Before proceeding with any decommissioning procedures:
    - Always wear protective clothing, gloves, and eyewear to prevent personal injury or property damage.
    - Do not remove the actuator from the valve while the valve is still pressurized.
    - Isolate and disconnect any operating supply lines providing air pressure, electric power, or a control signal to the DVC6200. Be sure the actuator cannot suddenly open or close the valve.
    - Use bypass valves or completely shut off the process to isolate the valve from process pressure. Relieve process pressure from both sides of the valve.
    - Vent the pneumatic actuator loading pressure and relieve any actuator spring precompression.
    - Use lock-out procedures to be sure that the above measures stay in effect while you work on the equipment.
    - Check with your process or safety engineer for any additional measures that must be taken to protect against process media.
- ☐ Disconnect the electrical wiring to and from the DVC6200 instrument.
- ☐ Disconnect the pneumatic tubing between the DVC6200 instrument and actuator.
- ☐ Remove the DVC6200 instrument and the respective mounting parts and feedback elements from the actuator.

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