White Paper
January 2021

DeltaV SIS™ Fire and Gas Capabilities

Executive Summary

Fire and Gas Systems (FGS) are mitigation systems that are employed after an incident occurs. An FGS should lessen the effect of the incident to give time for people to evacuate the area, contain the incident from escalating, and allow for response teams to assess and deal with the emergency.

DeltaV SIS™ is a process safety system that can be used in multiple safety applications including fire and gas detection or mitigation systems. DeltaV SIS enables an integrated approach and can interface the FGS with the Emergency Shutdown (ESD) system to initiate a plant shutdown if hazardous events occur. It also enables integration with the Basic Process Control System (BPCS). An integrated system can alert personnel in a fast, accurate, and structured way, giving employees time to decide which course of action to take, while bringing the plant to a pre-determined state.

The scalable, modular, and distributed architecture of DeltaV SIS, paired with integration of smart field devices delivers a platform that meets the needs for FGS applications.

The purpose of this whitepaper is to provide an overview of DeltaV SIS's capabilities for fire and gas detection, alarm signaling, notification, extinguishing agent release or deluge operation.

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FGS Requirements Overview

The purpose of an FGS is different from that of ESD systems. While ESD systems are designed to prevent incidents from occurring, FGSs are designed to mitigate the impact after an incident occurs. As a result, considerations for installing and configuring an FGS differ from those of ESD systems.

Challenges to the user when specifying and implementing an FGS may include:

- Attempting to define a Safety Integrity Level (SIL)
- Avoiding potentially dangerous spurious trips and safe state should they occur
- Ensuring the system availability with a normally de-energized system
- Implementing complex logic
- Constructing operator displays
- Compliance with codes and satisfying local authorities

SIL Ratings for FGS

The DeltaV SIS CHARMs Smart Logic Solver (CSLS) is rated for SIL3 applications. However, care should be taken when evaluating risk reduction for FGS. For instance, incorrect placement of detector could reduce the ability of the FGS to detect or respond regardless of the SIL rating of the hardware components.

Spurious Trips and System Availability

For an FGS, a spurious trip can have dangerous results. Consider the effect of actuating a fire suppression system as a result of a false alarm. The deluge system could cause damage to equipment and be hazardous to personnel. In addition, chemical fire suppression in enclosed spaces can be dangerous to personnel and too many false alarms could cause site personnel to ignore them. The FGS should not initiate mitigation actions when there is no actual demand or incident.

To avoid spurious trips, it is common to design an FGS as normally de-energized. With this design, the FGS loops are only energized if there is a true demand and system failures cannot cause a trip of the field device. However, this also means that loop failures, such as loss of power or connectivity between components, are covert failures unless there are adequate diagnostics to detect them. Therefore, line monitoring is essential to detect open and short circuit failures in wiring.

FGS Logic and Display Requirements

A typical ESD Safety Instrumented Function (SIF) is quite simple when compared to logic implemented in an FGS. FGS logic can be very complex and highly distributed, with voting for several detectors located throughout a unit, process, or plant area. An FGS may also be configured to interact with the ESD system to initiate unit- or site-wide emergency shutdowns.

FGS operator display requirements may also be more complex than those of ESD systems. Operators should be able to assess status and event information for the FGS at a glance. An FGS may also require additional displays to include general fire zone layout, site overview, Fire- Fighting (FiFi) systems, voting logic, and FGS logic.

Codes and Local Authorities

No matter what standard you follow, whether prescriptive or performance-based, DeltaV SIS can help you comply. DeltaV SIS is certified to IEC 61511, EN 54-2, NFPA 72, EN 50156-1 and EN 298.

For some users, corporate policies dictate the use of traditional, prescriptive, standards such as those from the National Fire Protection Association (NFPA). Such application does not preclude end users from establishing performance-based standards as well. As indicated in the *Performance-based Fire and Gas System Engineering Handbook*, performance-based design principles have been successfully used in ESD design through IEC 61511 and numerous users apply performance-based concepts to FGS.

Integrating performance-based concepts is not more expensive than using traditional methods, and in fact, provides a balance among the availability, safety, and lifecycle aspects of the system. It is thus by ensuring the requirements for the entire safety lifecycle of FGS are given their proper consideration that end users derive a singular benefit of performance-based standards.

DeltaV SIS change management supports regulatory requirements and automates IEC 61511 compliance. With the version control feature enabled, all changes in the DeltaV SIS logic are captured with graphical and textual details of the change, who made it, and when it was made. Similarly, the DeltaV SIS system also documents the changes to existing SIS logic, showing the nature of the change and the identity of the person changing it. Where required by the standard, editing and verification are required to be performed by appropriately qualified personnel. DeltaV SIS provides built-in functionality to track modifications and helps ensure the modifications have been made by the right people.

Flexibility to Meet FGS Project Needs

Scalability and modularity are a major benefit of the DeltaV SIS architecture used in FGS applications. This architecture is well suited for distributed systems. Each DeltaV SIS logic solver provides I/O processing, SIL 3-capable logic solving, and diagnostics. Logic solvers can communicate with each other via the safety-rated local safety network (LSN) and can be deployed in field enclosures. Further, I/O modules (CHARMs) can be located in smaller field enclosures away from the logic solvers.

ESD and FGS on Same Platform

For installations where the DeltaV SIS is used as FGS and EDS, there are considerable benefits in implementing the two systems in the same platform, while maintaining functional and physical segregation. Using this architecture, DeltaV SIS has been applied for the FGS and ESD systems on some of the largest floating production, storage, and offloading (FPSO) projects in the world. FGS and ESD applications are required from bow to stern in these massive, floating oil and gas production facilities. DeltaV SIS enables full interaction between ESD and FGS while maintaining the required separation between these two independent protection layers.

For small systems requiring a few logic solvers, the ESD and FGS can be implemented in different CSLSs within the same LSN (as shown in figure 1). Up to 16 CSLSs could be used within a single LSN. Even when using the same LSN, DeltaV can provide the required functional segregation due to separate logic solvers for ESD and FGS while allowing communication on a dedicated peer-to-peer safety-rated network. Due to the modular design of DeltaV SIS, each CSLS could have from a dozen of I/O up to 96 I/O each, with each CSLS able to access any input in other CSLS within the same LSN. DeltaV SIS can even segregate user privileges per physical node if needed, so a user has access to ESD nodes but not FGS nodes.

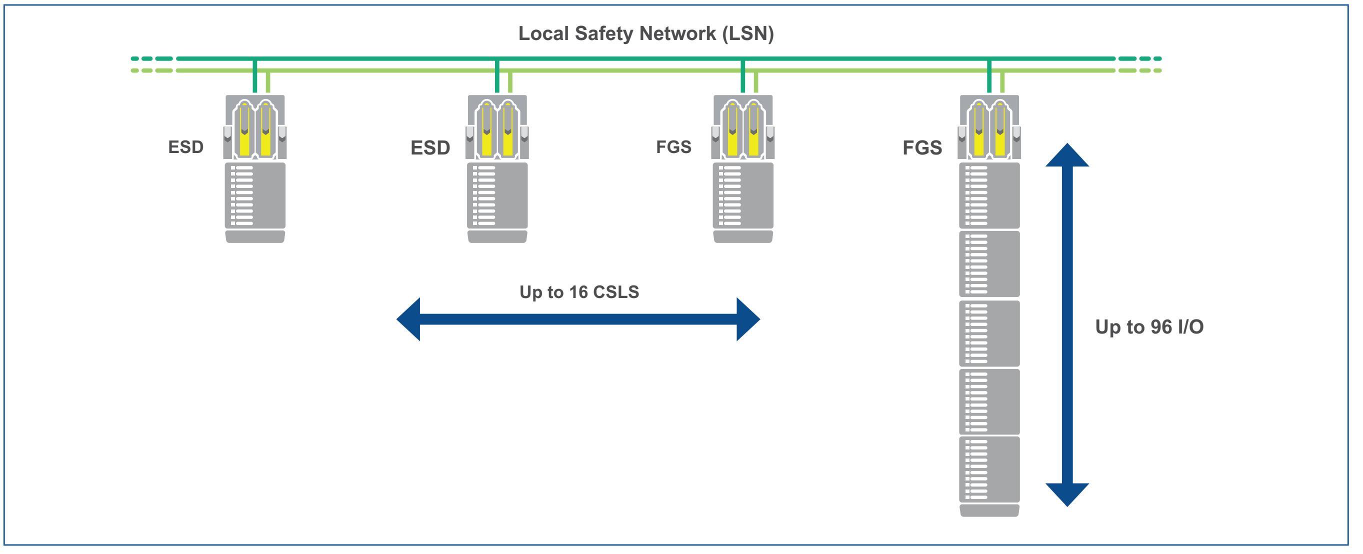

Figure 1. Different Logic Solvers within Same LSN.

For larger systems requiring multiple LSNs, the ESD and FGS can be implemented in different LSNs (figure 2). Safety-rated communication among LSNs is enabled by the global safety network (GSN). Up to 100 LSNs could be use within a single DeltaV SIS system.

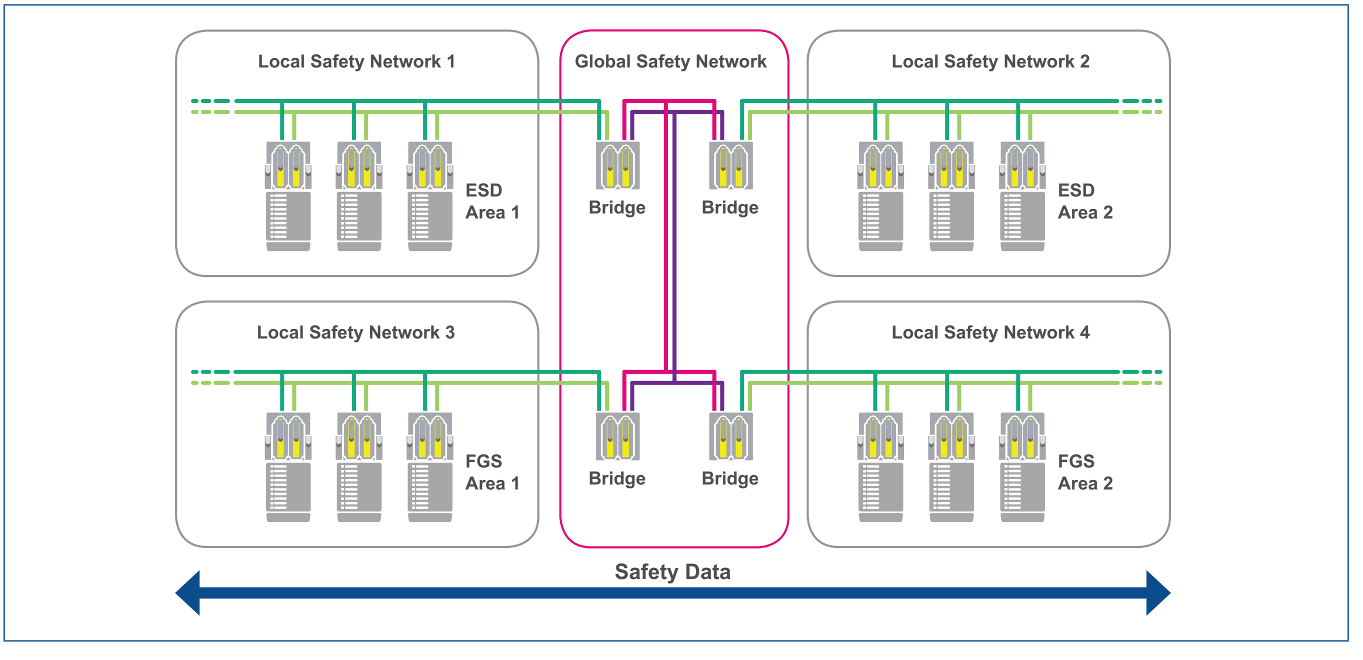

Figure 2. Different LSNs for ESD and FGS.

DeltaV v14.3.1 expanded the number of GSN domains from one domain to up to 16 domains. A domain is a logical segmentation of the GSN that simplifies the implementation of large system requiring LSNs distributed in different physical locations. An example of a large highly distributed system is the implementation of ESD and FGS on a FPSO. Both ESD and FGS can be deployed in multiple equipment rooms with requirements for electrical isolation among those equipment rooms.

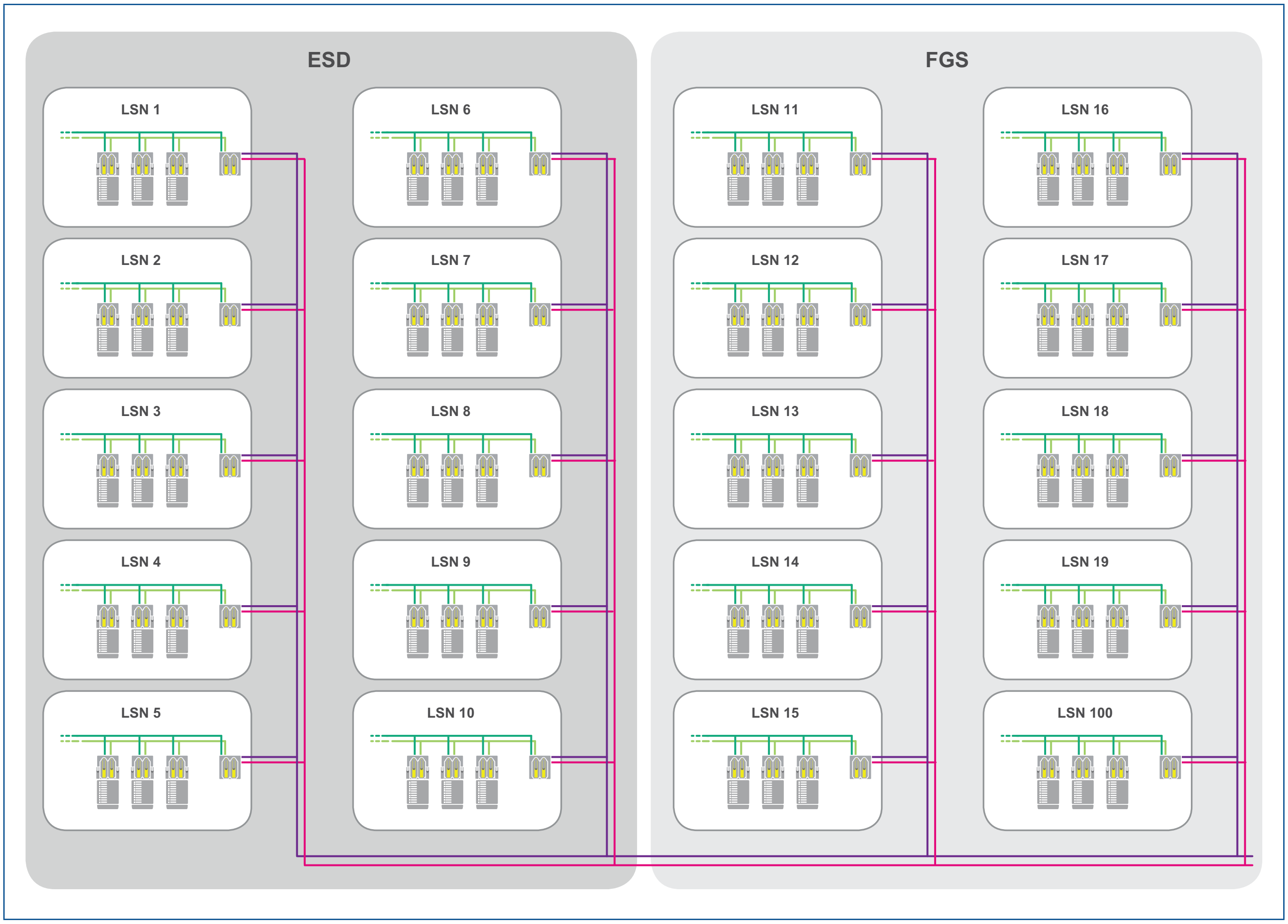

Figure 3. – Segregation of ESD and FGS in Different Domains.

Standalone FGS

While DeltaV SIS enables the integration of ESD and FGS, it is also possible to deploy DeltaV SIS as a standalone FGS interfaced to a third-party ESD or third-party BPCS.

All the benefits of scalability, modularity, reduced engineering, and efficient integration of HART devices are still available when DeltaV SIS is deployed in this form. For more details on the standalone capabilities of DeltaV SIS, please refer to **whitepaper DeltaV SIS Standalone**.

Reduced Engineering

The TÜV-certified function blocks deliver powerful functionality out of the box, providing faster configuration, testing and troubleshooting of FGS logic. These advanced function blocks reduces the amount of custom code needed for the often complex FGS logic.

One of the advanced function blocks is the analog voter function block, which allows end users to easily implement M out of N voting functions of up to 16 inputs. For example, the block can be configured as 2oo16 (two out of sixteen) voter, where two of the sixteen inputs must exceed the trip limit before the output is tripped. What used to take considerable programming using AND and OR logical gates, is now replaced by a standard function block configured using radio buttons and check-boxes. All the traditional programming required for implementing an analog voting function has been replaced with a few configuration settings. Likewise, a discrete voter function block provides an easy means to program discrete inputs.

As explained, FGS applications are typically configured using normally de-energized logic. In DeltaV SIS, changing from normally energized behavior (used in ESD) to normally de-energized behavior (used in FGS) is as simple as checking one check box within the function block. This ability to define the logic direction simplifies the handling of restarts.

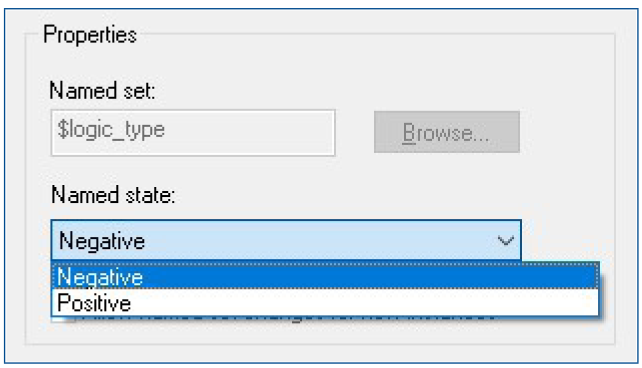

Figure 4. Logic Direction.

Implementing a cause and effect relationship can also be carried out using advanced function blocks. A best practice with FGS applications is to use the monitor and effect function blocks since these blocks support definition of the logic direction. The monitor function block defines interlock and permissive logic that associates as many as 32 inputs (causes) and 8 outputs (which are normally connected to different effect blocks). The block's MATRIX parameter defines the causes that produce each effect to trip.

Properties

Values: Effects (outputs):

Causes (inputs)	1-OUT_D1	2-OUT_D2	3-OUT_D3	4-OUT_D4	5-OUT_D5	6-OUT_D6	7-OUT_D7	8-OUT_D8
1-IN_D1	X							
2-IN_D2		X						
3-IN_D3			X					
4-IN_D4				X				
5-IN_D5					X			
6-IN_D6						X		
7-IN_D7							X	
8-IN_D8								X
9-IN_D9	X							X
10-IN_D10	X							X
11-IN_D11	X							X
12-IN_D12	X							
13-IN_D13		X	X				X	
14-IN_D14		X		X	X		X	
15-IN_D15		X	X	X	X		X	
16-IN_D16		X	X	X	X			
17-IN_D17		X	X	X	X		X	
18-IN_D18		X	X	X	X		X	
19-IN_D19	X			X				
20-IN_D20	X			X				
21-IN_D21	X			X		X		
22-IN_D22	X					X		
23-IN_D23	X							
24-IN_D24	X	X						
25-IN_D25	X							
26-IN_D26	X							
27-IN_D27		X	X	X	X			X
28-IN_D28		X	X	X	X			
29-IN_D29		X	X	X	X			
30-IN_D30	X							X
31-IN_D31	X					X		X
32-IN_D32	X			X	X	X		X

Figure 5. Defining Trip Actions Through the Matrix Parameter of the Monitor Block.

Figure 5 shows a 32x8 cause and effect matrix. Defining the trip logic is done by selecting the proper intersections in the MATRIX parameter and then connecting the outputs to effect blocks.

The effect block provides additional output processing such as reset functionality. There is no set limit for the number of causes or effects that can be implemented combining the new blocks.

Simpler Wiring of 3- and 4-Wire Devices

Many FGS detectors are 3- or 4-wire devices. These detectors can be connected directly to DeltaV SIS without the need of external interface components or external power distribution. This enables the use of standard field enclosures which simplifies engineering design and reduces costs.

Significant Savings in I/O Wiring

The CSLS can be installed in the field closer to field devices which considerably reduces wiring costs; for further savings, using the DeltaV v14 distributed CHARMs, the logic solver (LS) CHARMs can be installed in even smaller field enclosures containing 12 LS CHARMs. These remotely installed set of LS CHARMs enclosures can be connected to the logic solver on a star or ring topology. The use of distributed CHARMs provides similar benefits to those of an addressable fire and gas system when use in process areas. For more information about distributed CHARMs, please refer to the **product data sheet**.

Addressable I/O Benefits with Any Type of Sensor

Addressable FGS has been promoted as a superior solution to traditional fire alarm systems (fire panels with point-to-point connections to sensors). One reputed advantage of these systems is the ability to detect the exact detector that was triggered using the unique address in the field device and cost reductions in field wiring.

As shown in Table 1, DeltaV SIS offers a complete solution that matches and often surpasses addressable fire and gas systems' performance at a lower total cost of ownership.

	Addressable FGS	DeltaV SIS with (distributed) CHARMS
Ability to quickly identify the exact detector that was triggered	Yes	Yes – Each I/O signal has an associated Device Signal Tag (DST) and a description
Reduced wiring and low installation cost	Yes	Yes – even more when using distributed CHARMs
Ability to monitor integrity of the system with detector health checks	Yes	Yes
Fault-tolerant loop for device connection	Yes	Yes
All devices can be individually monitored and checked for faults	Yes	Yes
Ability to handle non-addressable devices	Yes – via I/O block	Yes
Easy and simple connection of non-addressable 3-wire devices	Sometimes	Yes
Speed for processing signals	Fast	Faster
Ability to handle HART devices and pass HART information to an Asset Management system	Limited. An external multiplexer might be needed	Yes – Native integration
SIL rating of fire panels	SIL 2	SIL 3 for logic solver SIL 2 or SIL 3 for CHARMs
Integration with ESD	Via gateways	Native
Integration with BPCS	Via getaways	Native

Table 1. Comparison Between Addressable Fire and Gas Systems and DeltaV SIS with Distributed CHARMs.

Reduced cabinet design

The DeltaV Configure-To-Order (CTO) field enclosures provide an off-the-shelf solution for faster project execution and reduced installed costs. These CTO enclosures are pre-engineered and factory tested. For more information please consult the **product data sheet**.

Optimized Reliability

DeltaV SIS uses device HART information to increase the reliability of safety loops. HART diagnostics and variables from HART FGS devices can be used to identify faults and take corrective steps before device failure causes the system's operation to degrade, resulting in higher availability or lower operational cost. The use of HART diagnostics varies with the type of device used.

I/O Diagnostics

LS CHARMs incorporate additional circuitry to monitor the integrity of the field wiring from the field enclosure to field device, enabling the detection of open loops and short circuits.

Most capital project investments are run-rate based, meaning a certain number of people work on the project until it is completed. As a result, project costs are highly correlated to cycle time: If the cycle time is reduced, project costs are lower.

DeltaV SIS offers several tools to reduce cycle time. With DeltaV SIS, multiple HART devices may be commissioned simultaneously while the system automatically generates documentation for each device commissioned. Further, the FGS automatically identifies devices as HART-equipped, eliminating the painstaking task of configuring devices one by one. For more information about DeltaV SIS commissioning capabilities, please consult the **Smart Commissioning whitepaper**. A DeltaV SIS fire and gas system does not require the operator to know a device's ID and to configure it in the right order to deploy auto-addressing. Rather, both HART and non-HART devices have an associated identification tag, providing a unique identifier within the system.

Reduced project costs are not the only the result of faster installation and commissioning. Resources saved through increased productivity can be reinvested in additional upgrades for a process plant. Shorter cycle times result in better resource utilization.

Increased Visibility to FGS Information

The DeltaV SIS operator interface can be configured to meet the requirements of FGS applications. Operator displays can provide overviews of the FGS, with links to more details or layouts. This section shows some typical FGS graphics which, due to the ease of use of the DeltaV HMI, can be easily developed and show all the required information the operator would need.

Figure 6 provides an example of an FGS overview display. Through this display the operator can have, at a single glance, a complete overview of the health of the FGS system. Any condition in the underlying fire zones will be highlighted. These highlighted conditions would for instance be a single fire or gas detected, a confirmed fire or gas detected, tripping of one or more executive actions, one or more detectors in override or having a bad signal, etc. With these indications the operator will be able to assess whether an incident is being contained or not, and using the weather vane and wind speed shown, how to safely approach and address the incident.

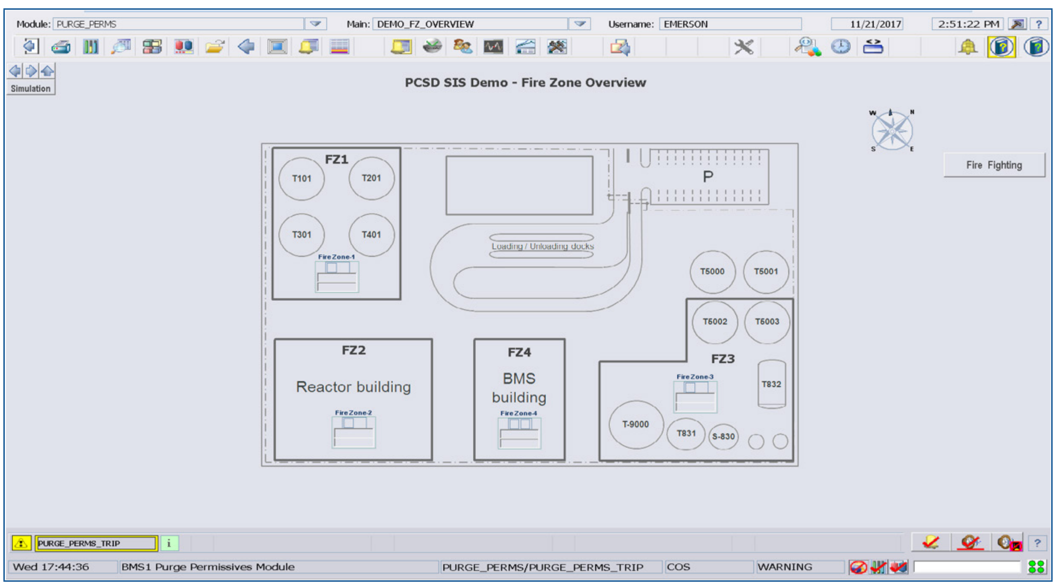

Figure 6. Example of FGS Overview Display.

Figure 7 shows an example of a typical FGS layout graphic for a given fire zone. This type of graphic provides the operator with a very easy means of determining what detector is indicating a failure or alarm condition. It shows all the major physical boundaries and barriers. The weather vane again allows the operator to determine the optimum egress/ingress routes. Through the miniaturized plan overview (top-right), the operator has an immediate awareness of the fire zone relative to the complete site. Additional buttons can be added to provide navigation links to graphics for the Fire Fighting systems and fire zone logic.

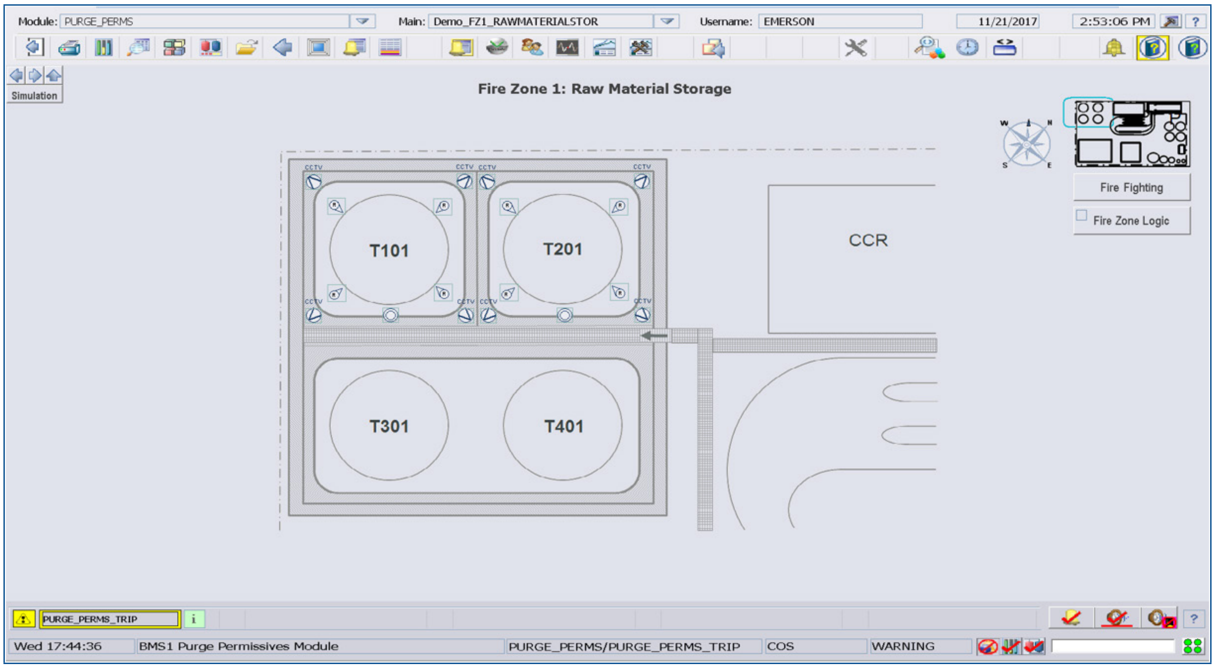

Figure 7. Example of Fire Zone Layout Display.

Figure 8 shows an example of typical FGS logic, one or more MooN voters will determine whether there is a single or confirmed fire or gas. Is also shows other initiating inputs such as manual call points and the associated outputs. Share FGS outputs such as starting of the firewater pumps are also highlighted. Links for initiating a unit or plant wide trip through the ESD are also shown.

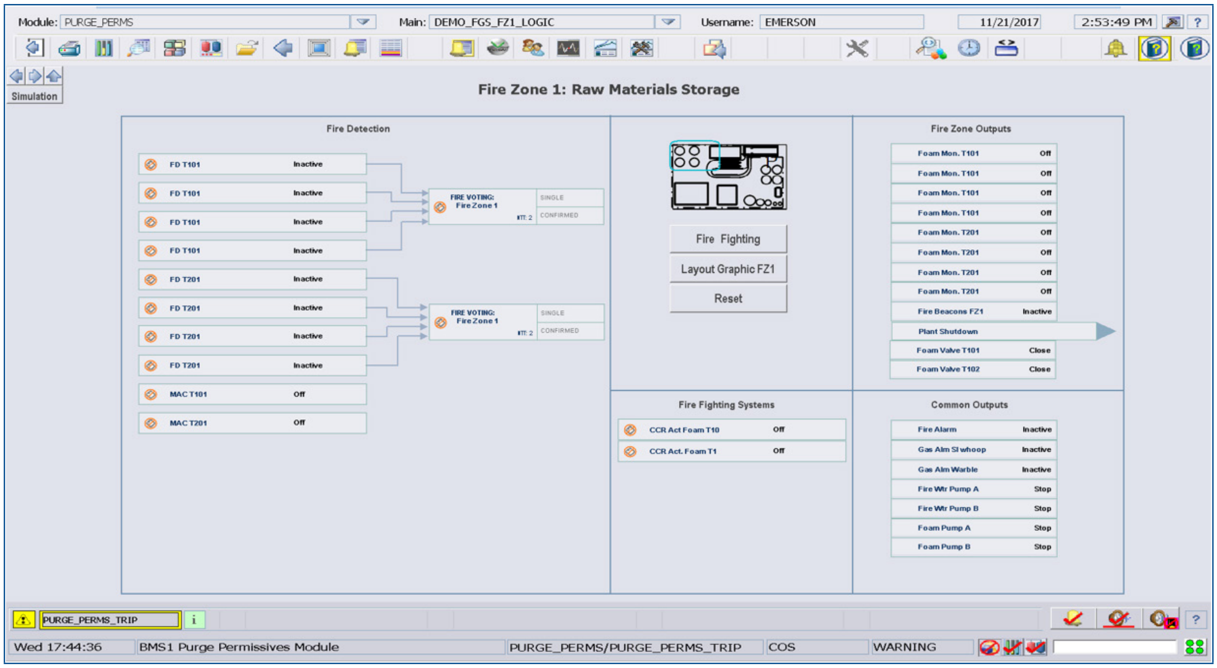

Figure 8. Example of Fire Zone Logic Display

The DeltaV system has a single HMI database allowing all the data points in the DeltaV and DeltaV SIS systems to be shown on any graphic as desired without any additional data mapping needed. FGS and ESD information can be displayed together on a single graphic. If the DeltaV automation system is used as the BPCS, then process information can also be included on the displays. One advantage of integrating DeltaV as BPCS is the increased security on writes from BPCS graphics to the FGS. The DeltaV SIS Secure Write Mechanism (TÜV-certified) provides the validation of messages from operators substantially reducing the risk of sending an invalid message to the FGS. Secure writes are the only way that an user can send write requests from workstations.

Increased Cybersecurity Protection

The Secure Write Mechanism is only an example of cybersecurity features. DeltaV SIS provides proper counter measures against cybersecurity threats including isolation of the safety network, multiple layers of protection against unauthorized access, and comprehensive approach to prevent virus infection resulting in a fully integrated control and safety system that is easier to secure. Most of the DeltaV SIS cybersecurity features are also available when deployed as standalone FGS. For more information please consult the **DeltaV SIS and cybersecurity whitepaper**.

Conclusions

DeltaV SIS provides a scalable, modular and distributed architecture that can deliver a state-of-the-art FGS detection or mitigation system, delivering savings in installation and reducing total cost of ownership. The built-for-purpose advanced function blocks simplify engineering, the HART commissioning capabilities reduce commissioning cycle times and the ability to locate the I/O subsystem closer to field devices significantly installation costs. DeltaV SIS can be deployed as a standalone FGS interfaced to any third-party ESD or an integrated ESD and FGS that maintains proper separation between protection layers.

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