Toxic Gas Monitoring Systems - Design & Integration
One Approach Fits All... Large or Small = Same Requirements
Who We Are

Engineering / Integration
Established 1981:
75 employees, 5 office locations
- Massachusetts
- North Carolina
- Vermont
- Virginia
- New York

Multi-disciplined:
- 35% Engineering
- 35% Integration
- 30% Commissioning

Affiliations:
- ASHRAE
- ISA
- SESHA
- UL

Partial TGMS Client List:
- Analog Devices
- Axcelis Technologies
- Binghamton - (SUNY)
- Cornell University
- Draper Laboratory
- GE Global Research
- Global Foundries
- Harvard University
- IBM
- JSNN - Nanotech Labs
- Kopin
- Micron Technologies
- MIT
- MIT-Lincoln Laboratory
- National Semiconductor
- Nortel Networks
- Northrop Grumman - ATL
- RTI International
- Skyworks
- University of Maryland
- University of Pennsylvania
- Varian Semiconductor (AMAT)
TGMS Design to Validation

USER REQUIREMENTS SPECIFICATION
("What?")

FUNCTIONAL SPECIFICATIONS
(SRS Functional matrix)
("How” in concept)

DESIGN SPECIFICATION
DRAWINGS & DOCUMENTS
("How to Build Details")

PERFORMANCE TESTING
(Overall system testing)

FUNCTIONAL AND INTEGRATION TESTING
(SRS Verification)

INSTALLATION QUALIFICATION
(Construction Checks)

CONSTRUCTION

DESIGN

VALIDATION

Confirms

Confirms

Confirms
Introduction

• Hallam-ICS - has a dedicated Toxic Gas Monitoring System (TGMS) design, fabrication, integration and validation team with over 15 years of experience.
  ▫ Our TGMS experience includes working closely with researchers, facility engineers and EH&S stakeholders in the design, installation, integration and validation of toxic gas monitoring safety platforms in both the SEMI fabrication and research facility environments.
  ▫ We have similar SEMI tool accommodation and tool fit-up experience for both small and very large applications.
  ▫ We have a UL508A panel fabrication and provide UL labeled control panels for all of our installations. We can also provide “factory acceptance testing” of TGMS hardware and software prior to delivery and installation at your facility, to reduce start-up time on-site.
TGMS Purpose & HPM Definition

TGMS Purpose:

- A “Toxic Gas Monitoring System” as described here - could also be described as a Safety Instrumented System (SIS):
  - A Safety Instrumented System (toxic gas monitoring system) is comprised of sensors, logic solvers, visualization nodes, and final control elements provided for the purpose of alarm notification and taking the research or manufacturing process to a safe state when predetermined conditions are violated.
  - “Predetermined” hazardous conditions may occur, in addition to detected HPM gas hazards, which directly contribute to unsafe gas storage, delivery and use.
    - A primary example is a loss of exhaust ventilation.

Hazardous Production Material (HPM) - IFC Definition:

- A solid, liquid or gas associated with semiconductor manufacturing that has a degree of hazard rating in health, flammability or instability of Class 3 or 4 as ranked by NFPA 704 and which is used directly in research, laboratory or production processes which have, as their end product, materials that are not hazardous.
  - Exceptions to this basic gas monitoring target rule; may include other gas sources such as NF3, a toxic oxidizer with a health rating of 2.
Basis of Design: Code Requirements + Best Practices

- Adopted codes are only minimum requirements, they sometimes conflict and they cannot be used alone as assurance that they are providing a good, safe design.

- “Regulations are for the obedience of fools and for the guidance of wise men (and women)” - RAF motto

- We recommend an approach that will reference, consider and harmonize overlapping codes and utilize all resources “and” best practices available.

- Attention to detail is critical throughout the entire design, installation, integration and validation process!
TGMS - Basis of Design

Basis of Design: Code Requirements + Best Practices

- There are many different TGMS code requirements. Examples include:
  - International Building Code (IBC)
  - International Fire code (IFC)
  - International Mechanical Code (IMC)
  - National Fire Protection Association (NFPA)...

- Local Jurisdiction requirements
  - City Fire Department
  - State Amendments...

- Insurance/Best practices
  - FM Global Property Loss Prevention
  - SEMI Guidelines
  - ACGIH TWA-TLVs...

- Sometimes - adopted codes will require compliance with other standards.
  An example:
    - IFC - Pyrophoric Materials : 6405.3 Silane Gas. The use of silane gas, and gas mixtures with a silane concentration of 1.37% or more by volume, shall be in accordance with CGA G-13 (Storage and Handling of Silane and Silane Mixtures).
Basis of Design: Code Requirements + Best Practices

- Sometimes... codes conflict with each other.
  - For example:

- **NFPA 70 - 500.5 Classifications of Locations**
  - A. Classifications of Locations... “Where pyrophoric materials are the only materials used or handled, these locations shall not be classified.”

- **CGA G-13 Storage and Handling of Silane and Silane Mixtures**
  - 16.1...Regardless of the provisions in the NEC that allow the use of unclassified electrical equipment where pyrophoric materials are used, electrical equipment shall be classified in accordance with the requirements of Tables 7 and 8 (e.g., pressurizing & Z-purge, Class 1, Division 2 wiring requirements...)
  - 11.1 Gas Monitoring - required for enclosure exhaust ventilation
  - 11.2 Flame detection - required for gas cabinets, VMBs and open manifold assemblies with un-welded fittings...
Basis of Design - TGMS Reference (samples)

- The following listings are sample references of code and best practice resources that are each considered and applied (as applicable) - for providing safe and complete TGMS designs:

<table>
<thead>
<tr>
<th>IBC</th>
<th>International Building Code</th>
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<tbody>
<tr>
<td>Chapter 2</td>
<td>Definitions</td>
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<tr>
<td>Chapter 3</td>
<td>Use and Occupancy Classification</td>
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<td>Chapter 4</td>
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## Basis of Design - TGMS Reference (samples)

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2012 NE SESHA Conference
Basis of Design - TGMS Reference (samples)

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<th>NFPA</th>
<th>National Fire Protection Association</th>
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<tbody>
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<td>NFPA-1-2012</td>
<td>Fire Code Handbook (Massachusetts will require future compliance as the primary Fire Code)</td>
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<td>NFPA-2-2011</td>
<td>Hydrogen Technologies Code</td>
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<td>NFPA-3-2012</td>
<td>Recommended Practice for Commissioning and Integrated Testing of Fire Protection and Life Safety Systems</td>
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<td>NFPA-30-2012</td>
<td>Flammable and Combustible Liquids Code</td>
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<td>NFPA-45-2011</td>
<td>Standard on Fire Protection for Laboratories Using Chemicals</td>
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<td>NFPA-55-2010</td>
<td>Compressed Gases and Cryogenic Fluids Code</td>
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<td>NFPA-70-2011</td>
<td>National Electrical Code</td>
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<td>NFPA-70E-2012</td>
<td>Standard for Electrical Safety in the Workplace</td>
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<td>NFPA-72-2010</td>
<td>National Fire Alarm and Signaling Code</td>
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<td>NFPA-318-2012</td>
<td>Standard for the Protection of Semiconductor Fabrication Facilities</td>
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<td>Hazardous Materials Code</td>
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<td>NFPA-496-2008</td>
<td>Standard for Purged and Pressurized Enclosures for Electrical Equipment</td>
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<tr>
<td>NFPA-497-2012</td>
<td>Recommended Practice for the Classification of Flammable Liquids, Gases or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas</td>
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<tr>
<td>NFPA-750-2010</td>
<td>Standard on Water Mist Fire Protection Systems</td>
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<td>Oxygen</td>
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<td>G-5-2011</td>
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<td>G13-2006</td>
<td>Storage and Handling of Silane and Silane Mixtures</td>
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<td>G14-2010</td>
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<td>Inert Gases: Argon, Nitrogen and Helium</td>
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<td>P-19-2009</td>
<td>CGA Recommended Hazard Ratings for Compressed Gases</td>
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<td>P-20-2009</td>
<td>Standard for Classification of Toxic Gas Mixtures</td>
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<tr>
<td>P-22-2007</td>
<td>Responsible Management and disposition of Compressed Gases and their Cylinders</td>
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<td>Standard for Categorizing Gas Mixtures Containing Flammable and Nonflammable Components</td>
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<td>P-34-2001</td>
<td>Safe Handling of Ozone Containing Mixtures Including the Installation and Operation of Ozone Generating Equipment</td>
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<td>P-39-2008</td>
<td>Oxygen Rich Atmospheres</td>
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<td>Fire Hazards of Oxygen Enriched Atmospheres</td>
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<td>Specification and Guideline for Hexamethyldisilazane (HMDS)</td>
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<td>Specification and Guideline for Tetraethylorthosilicate (TEOS)</td>
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<td>C47-0706</td>
<td>Guideline for Trans 1,2 Dichloroethylene</td>
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<td>C52-0301</td>
<td>Specification for the Shelf Life of a Specialty Gas</td>
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<td>C54-1103</td>
<td>Specification and Guidelines for Oxygen</td>
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<td>C56-0305</td>
<td>Specification and Guidelines for Dichlorosilane (SiH2Cl2)</td>
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<td>C65-0308</td>
<td>Guideline for Trimethyilsilane (3MS), 99.995% Quality</td>
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<td>Test Method for Determination of Particle Contribution of Gas Delivery Systems</td>
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<td>Test Method for Performance and Evaluation of Metal Seal Designs for Use in Gas Delivery Systems</td>
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<td>F106-0308</td>
<td>Test Method for Determination of Leak Integrity of Gas Delivery Systems by Helium Leak Detector</td>
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<td>S1-0708&lt;sup&gt;E&lt;/sup&gt;</td>
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<td>Environmental, Health and Safety Guideline for Semiconductor Manufacturing Equipment</td>
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<td>Safety Guideline for the Electrical Design of Semiconductor Manufacturing Equipment</td>
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<tr>
<td>OSHA 29 CFR 1910.1000-Table Z-1</td>
<td>Limits for Air Contaminants, Permissible Exposure Limits for various chemicals</td>
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<td>OSHA 29 CFR 1910 Subpart H</td>
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<td>Standard for the Protection of Semiconductor Cleanroom Facilities</td>
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Design Development - Information Gathering

User Requirements - Information Gathering:

• HPM Gas Targets
  ▫ Gas family, Gas formula, synonyms, CAS#, MSDS’, %Mixtures, gas properties...
• O₂ deficiency Areas
• Storage Locations - User Locations
  ▫ Gas cabinet configurations and controllers
  ▫ VMB configurations and controllers
  ▫ Gas isolation box arrangements
  ▫ Tool cabinet arrangements
  ▫ HPM exhaust duct sizes...
• HPM piping plans
  ▫ One-line distribution routings
  ▫ HPM piping secondary containment monitoring...
Design Development - Information Gathering

**HPM Gas Storage, Distribution and Handling**

- Where and how will HPM gas be stored and how will it be sourced and delivered to tools?
  - Gas room/s with gas cabinet sources?
  - Outdoor PAD (e.g., silane with open manifolds)?
  - Local service chase locations?
  - DCS - heat tracing required?
- Will VMBs be used?
  - Equipped with individual stick shutdowns?
- Will Gas isolation Boxes (GIBs) or Gas PODs be used?
  - Equipped with manual isolation valves, mass flow meters, etc.?
What are the Gas Cabinet/VMB - Integral Controller Safety Monitoring Controls? (example):

- Excess Flow
- Secondary containment piping failure
- Loss of cabinet exhaust ventilation
- Emergency Power Off
- Z-purge failure (where applicable)
- UV/IR fire/fault (where applicable)
- High Delivery Pressure
- High Outlet Pressure
- Low Cylinder Pressure
- High Manifold Pressure
- Low Manifold Pressure
- Low Purge Pressure
- High Purge Pressure
- High Vent Pressure
**I/O Interface configurations of gas cabinet / VMB controllers**

- What are the controller safety interlock inputs and status outputs available - to and from - each gas cabinet and/or VMB controller... for TGMS monitoring, safety actions, local and remote notifications? (example):

**Interface to TGMS from gas controller/s:**
- Gas available / unavailable
- Excess Flow
- Secondary containment piping failure - (per gas cabinet outlet or VMB stick)
- Loss of cabinet exhaust ventilation
- Emergency Power Off - (local controller)
- Z-purge failure (where applicable)
- UV/IR fire/fault (where applicable)

**Interface from TGMS to gas controller:**
- Gas Shutdown interlock/s - gas cabinet ESOVs and VMB stick outlet ESOVs
- Loss of N₂ trickle purge in silane vent header - suspend controller purging (CGA G-13)
TGMS - Design & Integration Safety Goals

Reliability:

• A Toxic Gas Monitoring System is composed of sensors, logic solvers, and final control elements designed for the purpose of taking the HPM process gas system to a safe state when predetermined conditions are violated.

• A TGMS requires absolute reliability to ensure that all safety aspects of the system are operational and “available” at all times.
  • No “covert” or “fail-danger” faults are permitted

• All gas sensors and gas detection instruments are continuously “supervised” - to ensure continuous gas monitoring “availability”.

• Sensor/instrument/field device/control system diagnostics are utilized throughout the design, combined with “fail-safe” wiring practices.
  • TGMS faults - issue immediate local and remote notification alerts.
TGMS - Reliability

TGMS and Process Control/Building Management System (BMS) Separation:

- Safety Control is:
  - Passive
  - Dormant
  - Controlled (limited accessibility)
  - In need of Periodic Testing (similar to a FAS)

- Safe failures are:
  - Initiating
  - Overt
  - Spurious (Trips due to hardware/software fault, transients)
  - Dangerous failures are:
    - Inhibiting
    - Covert
    - Potentially dangerous
    - Must be found by testing
TGMS - Reliability

TGMS and Process Control / Building Management System (BMS) Separation:

• A guiding TGMS design principal (as the case for a Fire Alarm System) is that the TGMS must continue to protect personnel and the facility in the presence of a partial or total failure of the facility BMS.

• Design standards such as the Application of Safety Instrumented Systems (SIS) for the Process Industries “ISA 84.01” - state that it is generally necessary to provide separation between basic process control (BMS) and SIS functions.

• The BMS is a dynamic control system responding to input signals from the equipment under control (e.g., temperature) and/or from an operator - and generates output signals, causing equipment under control to operate in a desired manner.
TGMS - Reliability

TGMS and Building Management System (BMS) Separation:

• Referencing FM Global 7-45 Property Loss Prevention Data Sheet: “Instrumentation and Controls in Safety Applications”
  ▫ Design and Selection for Safety:
    • Base the Safety Instrumented System (SIS) design on recognized standards such as the Instrument Society of America (ISA), the International Electrotechnical Committee (IEC) or other equivalent national standards and this data sheet.
  
• IEC 61511 (Safety Instrumented Systems)
  ▫ Clause 11.2.4 requires that the basic process control system (BPCS), i.e., the BMS - shall be designed to be separate and independent to the extent that the functional integrity of the SIS (Safety Instrument System) is not compromised.
Gas Detection

User Requirements

Gas Detection Technology Assessment -

• For each target gas consider:
  ▫ Sensor/instrument full measuring range
  ▫ LDL & Lowest Alarm Level
  ▫ Known interferences
  ▫ Cross sensitivities for possible sensor consolidation
  ▫ Sensor response
  ▫ Sensor/instrument diagnostics
  ▫ Power requirements
  ▫ Extractive - FEP tubing sample line limits
  ▫ Diffusion - sensor cell extension cable limits...

• Consumables:
  Sensor cell life, Chemcassette tape life, cost per point...

• Integration Options
  Relay, Analog, Ethernet/CIP, Modbus/TCP, ControlNet, PoE...
Gas Detection

Gas Monitoring Locations - Ambient Breathing Zones:

- Ambient gas monitoring of corresponding HPM gas targets - provides added employee protection and assurance (at selected breathing zone gas sampling locations), which confirm the effectiveness of the exhaust ventilation being applied to HPM tool gas cabinets and HPM enclosures.

- SEMI S6-0707E (EHS Guideline for Exhaust Ventilation of Semiconductor Manufacturing Equipment) - defines the exhaust ventilation performance requirements that protect personnel, property and the environment from health and safety risks. This guideline also provides test methods to confirm the exhaust systems ability to capture and contain any potential fugitive gas leaks.

- Effective ambient gas monitoring also provides supplemental notification alerts to employees involved in periodic activities (e.g., chamber cleaning, implant source housing cleaning, etc.); where potentially hazardous exposures, which cannot reasonably be controlled by other means, may occur.
Gas Detection

Gas Monitoring Locations - Ambient Breathing Zones (continued):

Ambient gas sensor mounting locations are selected in part - with consideration given to:

- Target gas properties (i.e., relative vapor density)
- Optimum locations related to the potential / possible leak points (e.g., near tool gas cabinet enclosure service openings periodically required during maintenance activities).
- Area ventilation and ambient airflow streams and the potential changes to ventilation flows created by equipment location changes.
Gas Detection

Gas Monitoring Locations - HPM cabinet exhaust:

- Gas cabinets
- VMBs
- Gas isolation boxes (GIBs) / Gas Pods
- Tool cabinet gas box
- Vacuum pump housings
- Any exhausted enclosure containing un-welded fittings of HPM gas.
- Sensor placements (diffusion or extractive) should be located up in the exhaust duct (not inside the cabinet) to consider mixing and duct airflow behavior - to ensure ideal gas leak detection.
  - If possible - locate sensor 4 duct diameters downstream from the source cabinet.
  - Locations should be upstream (below) any isolating mechanical blast gate (as should exhaust ventilation differential Pressure or airflow sensors).
- Extractive sample tubing should extend at least 2” into the exhaust duct.
TGMS - Design & Integration Safety Goals

Flexibility:

- The ability to easily - and quickly - schedule periodic sensor maintenance, sensor additions and sensor removals, without compromise to operational gas safety monitoring or interruptions are very important.

- Scheduled periodic testing of the TGMS - similar to the facility Fire Alarm System (FAS) are performed to eliminate the presence of any passive safety system fault - to ensure TGMS availability.

- A TGMS in a research or manufacturing environment, requires the flexibility to accommodate changes in target gas and the corresponding changes in alarm settings, safety actions and alarm notification. Changes are typically required “on-line” in the manufacturing environment.

  - Management of Change (MOC) is critical to the integrity of the TGMS.
  
  - Functional changes to the TGMS require “reacceptance testing” to verify hardware/software changes are valid.
TGMS - Design & Integration Safety Goals

Visualization:

Emergency Control Station & View Node Presentations -

• Emergency Responders, ERT and Security personnel require fast, detailed and accurate gas alarm information. Visual information should be provided at selected safe locations (e.g., ECS) to aid and facilitate a safe response and fast alarm recovery (content example):

• Overall facility site floor plans, depicting all building levels

• Each floor plan includes information illustrating or linking to the following information:

• Alarm location; specific alarm point location and tag name
  • Ambient breathing location (room / area)
  • Contained exhaust location (gas cabinet, VMB, tool cabinet, pump housing...)

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TGMS - Design & Integration Safety Goals

Visualization:
Emergency Control Station & View Node Presentations (continued)

• Gas Hazard Type -
  ▫ Toxic
  ▫ Flammable
  ▫ O₂ Deficiency

• Target Gas name -
  ▫ Chemical formula, CAS #, synonym
  ▫ Gas mixture (if applicable)

• Target Gas Alarm Level - (in %LEL, ppm or ppb)
  ▫ Low level (set-point)
  ▫ High Level (set-point)

• Gas concentration -
  ▫ Real time measurements (presented in %LEL, ppm or ppb units)
Software Design Development

“Argus” Visualization - TGMS Software Safety Logic - Capabilities and Features include:

- Simplified graphic screens
- Public access to the system overview screen only
- User groups - with authorized Login’s (owner assigned) provide different levels of secure access and can include:
  - System Administrators (Developers), EH&S, ERT, and Supervisors, etc.
- All tabular device pages available after appropriate login
- 'Tabbed' device detail pages include:
  - PLC status information - available with device detail pop-ups [Equipment Health tab]
  - Matrix configuration utility (functional matrix) via Microsoft Excel
  - Alarm page uses “Tabbed” navigation to show active alarms and alarm histories
Software Design Development

“Argus” TGMS Software Safety Logic - Capabilities and Features (continued):

- MIDAS “web-pages” with detailed diagnostics data are available directly from the sensor detail pages (if applicable)
- Matrix configuration for each input device accessible from the detail page 'Matrix' tab
- Inhibit Groups added for all input devices. Inhibit tab via detail pop-ups
- Gas Trend shown on the sensor popup overview tab
- Gas cabinet and sensor details include corresponding target gas NPFA 704 “hazard ranking” information for emergency responders.
- Device tags in the PLC support tabbed navigation, Midas web-pages, and PLC hardware diagnostics
- PLC matrix processing provides very high performance (millisecond scan times)
- PLC device add-on instructions provide Inhibit groups and PLC hardware diagnostics logic
Security:

A TGMS and its security is configured depending upon owners' needs and requirements. A TGMS network - (in coordination with the Owners IT group) may be configured with:

- VLAN/s (Virtual Local Area Networks) - broadcast domains defined within and between switches, used to allow control of broadcast, multicast and unicast data.
- VLANs are assigned numbers for identification within and between switches.
- VLAN structure and how many are VLANs are assigned depend upon each system and area switch port counts.
- The primary server could include a “Kiwi Syslog Server” - to issue an alert if any interface changes state, such as - a device goes offline, or if any uplink port fails.
TGMS - Design to Validation Safety Goals

Security:

• The syslog server also provides automatic alerts if a switch port changes state or if someone attempts to gain access into a network component - including logging the username of the individual accessing the device.

• A “Firewall” provides limited connectivity between the gas monitoring system network and the outside network, and to protects the gas monitoring system network should the outside network be compromised.

• The firewall is configured to log all messages to the Syslog server, which will trigger an alert should any packet be blocked by the firewall for any reason.

• All TGMS switch access ports are configured with port security - to code the MAC address(s) of the legitimate device(s) that connect to each port. This will prohibit the switch port from talking to anything other than the legitimate device for which that port is configured.
Security:

- Should anyone attempt to plug any other device into a port the Syslog server will automatically perform actions based on alerts, including sending email and forwarding messages, triggering audible alarms, sending SNMP trap messages, and paging assigned IT and TGMS staff.

- Switch ports not in use will be configured as disabled (shutdown).
Remote Notifications:

- Automatic E-Mail notifications for predefined alarms or status conditions can be sent to assigned (selected and authorized) groups or persons (e.g., Cleanroom managers, EH&S, ERT, Gas Support Tech’s, Facilities, etc.) for any corresponding upset condition as defined in the Safety Requirement Specification (SRS) - functional matrix.

- For example: “WEB-911 Xtools” allows users to modify and apply configuration changes to WIN-911 across the network environment. These tools can be used to:
  - Modify contacts
  - Modify connections
  - Display alarm group settings
  - Modify alarm group contact lists
  - Modify duty schedules
  - Apply configuration changes to Scan & Alarm
  - Switch Scan & Alarm to Active or Standby mode
TGMS - Remote Visualization and Access

TGMS Example
Local & Remote Visualization and Remote Access

A secure VPN firewall connection could be configured to use the facilities public access to the internet. Once this connection is configured, a Remote View Access server could host up to five remote desktop users. Each user will require a Rockwell View license. This arrangement allows authorized remote viewing and control of the TGMS via any internet connection.

The secure VPN connection could also be configured to allow remote programming and service support access for Hallam-ICS.

ECS – Emergency Control Station
SOC – Security Operations Center

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Safety Requirement Specification

TGMS - Safety Requirement Specification:
The TGMS safety requirement specification development requires participation of cross-functional disciplines (EH&S, Facilities, FAB Engineers, Management) - the goal being - consensus with no surprises!
Safety Requirement Specification

Safety Requirement Specification (SRS):
Comprised of:

1. Functional Requirement Specifications
   • Safety monitoring, safety interlocks, alarming, notifications... (Cause & effect matrix)

   AND

2. Integrity Requirement Specifications
   • Availability, Probability of failure, Diagnostics...

The #1 Danger to TGMS safety... is an incorrect “Safety Requirement Specification” (44%)...

• Primary causes for an incorrect SRS include:
  • Lack of participation during SRS development with key multidisciplinary personnel (stakeholders):
    • Example: Project leader/s, EH&S, Facilities - (Electrical/Mechanical/Instrumentation), Researchers, Process and Operations personnel.
  ▫ Complacency, incomplete documentation, responsibilities not well defined... etc.
Safety Requirement Specification

SRS Benefits:

- The TGMS SRS provides the Owner with a functional specification that illustrates all monitored hazards, their locations, alarm set-points and the actions taken when predetermined limits are exceeded.
- Can be provided to the local AHJ as a review document to illustrate and address any concerns during the design phase.
- Used as a validation/commissioning test document to record system performance during startup.
- Becomes a “living record document” used as an auditable record of system functionality throughout the life of the system.
- The SRS provides a basis and control document for implementing future change - becoming a critical component to procedures required to maintain and manage changes to the TGMS.
SRS Benefits:

Changes to a TGMS’ are inevitable:

- The # 2 Danger (20%) to TGMS safety... are unauthorized and/or incorrect changes occurring after Initial TGMS validation, commissioning and acceptance.

- Any proposed functional changes or added sensors and their actions should be reviewed with all responsible stakeholders, documented and recorded in the SRS - prior to being implemented.

- Changes should be followed with reacceptance (hardware & software) testing procedures - which should be outlined in the Owners “Management of Change” (MOC) procedures for the TGMS.

- The SRS becomes a critical record document and tool that can be used to help manage and record all future changes to the system.

  ▫ NOTE - We recommend gas sensor “bump testing” following new sensor additions - including after periodic sensor change-outs to ensure the “availability” and proper performance of each new sensor.
Safety Requirement Specification

TGMS Responsibilities

• To ensure operational integrity - the TGMS requires an inspection, testing and maintenance program.

• The SRS can be used as the basis of initial, periodic and reacceptance functional testing - providing records of testing results and any corrections applied.

• The property, building or system owner or the owner’s designated representative is responsible for the inspection, testing, and maintenance of the safety system and for alterations or additions to the TGMS.
  ▫ Inspection, testing, or maintenance can be performed by the building or system owner or a qualified person or organization other than the building or system owner... if conducted under a written contract.

• System Documentation -
  ▫ Prior to TGMS testing, the updated and approved SRS and any information regarding the system and system alterations, including specifications, wiring diagrams, and floor plans, should be available to the owner or a designated representative performing the testing.
Safety Requirement Specification

TGMS Testing

• Initial Acceptance Testing
  ▫ Should include 100% testing of all monitored hazard inputs and all safety action outputs (as defined in the SRS cause & effect functional matrix) - including “on-line” actions performing actual shutdowns and interlocks as well as local and remote notifications and visualization of the system.

• Initial testing - Gas Sensor points (100% testing):
  ▫ All gas sensor points (diffusion and extractive) should be inspected for proper installations, sample locations and verification of tag names.
  ▫ For extractive tubing sample points - a combination of sample line integrity checks, sample flow measurements and sample flow adjustments to transmitters or equipment should be applied if needed to maximize performance.
  ▫ After proper sample tube flow verification - a combination of live gas sensor “bump checks” (above individual target gas alarm set points) and alarm action verifications (per the SRS) - should be applied for all gas sensors (diffusion and extractive).
Safety Requirement Specification

TGMS Testing

• Reacceptance Testing
  ▫ All functions known to be affected by a change, or identified by a means that indicates changes, should be tested (100%).
  ▫ This includes 100% testing (functional, flow, gas challenging) of all new monitored hazard inputs and all safety actions (as defined in the SRS cause & effect functional matrix) - including “on-line” actions performing shutdowns and interlocks as well as local and remote notifications and visualization of the system.
  ▫ In addition, 10 percent of existing initiating devices that are not directly affected by the change, (up to a maximum of 50 devices), should also be tested with correct system operation verified.
Safety Requirement Specification

TGMS Testing

- Records
  - After successful completion of acceptance tests - witnessed and approved by the authority having jurisdiction...
  - A set of reproducible “as-built” installation drawings, updated SRS, operation and maintenance manuals, should be provided to the building owner or the owner’s designated representative.
  - Records should be retained until the next test and for 1 year thereafter.
TGMS - Safety Requirement Specification

Basis of Design: Code Requirements + Best Practices

• Summary
  ▫ Utilizing and harmonizing required codes, best practices, our experience, the experience of our clients, the experience and knowledge of gas detection technology providers, and the experience and guidance of expert professional safety consultants -
  ▫ ... is the best approach to defining a safety requirement specification for any TGMS application.
  ▫ This is true be it for a small laboratory with a single tool... or a large FAB with 300,000 square feet of ultra-clean manufacturing space.
  • The TGMS safety requirements are virtually the same.
GLOBALFOUNDRIES - Fast Facts:

- **Locations:** Manufacturing Centers in Germany, Singapore and Malta, New York
  - Fab 8 in Saratoga County, New York is currently the largest commercial capital expansion project in the USA.

- **Capacity:**
  - Five (5) 200mm FABs and two (2) 300mm FABs in production, one (1) 300mm fab under construction.
  - Total capacity in 300mm and 200mm wafers is expanding to 7.7 million 200mm equivalent wafers, as described below.
  - Expanding to 2.3 million 300mm wafers annually
  - Installed base of 2.2 million 200mm wafers annually, expanding to 2.5 million

- Global Foundries has recently announced plans to expand the existing FAB 8 building’s ultra-clean manufacturing room by 90,000 square feet for a total of 300,000 square feet to meet growing customer demand.
Toxic Gas Monitoring - GLOBALFOUNDRIES

GLOBALFOUNDRIES - TGMS:

• Hallam-ICS is providing TGMS installation, system integration and validation support for all of FAB 8.
  • I-PADs are used in the field via wireless connectivity with PLCs and SCADA/View Nodes to enable fast functional testing and completion of commissioning documentation (including verification signatures) and saved records in pdf format during tests with multiple testing teams.
Questions?

Thank you!
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