Chemical, Pharma and Laboratory Gas Detection Issues and Answers

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World-wide manufacturer of fixed and portable gas detection solutions

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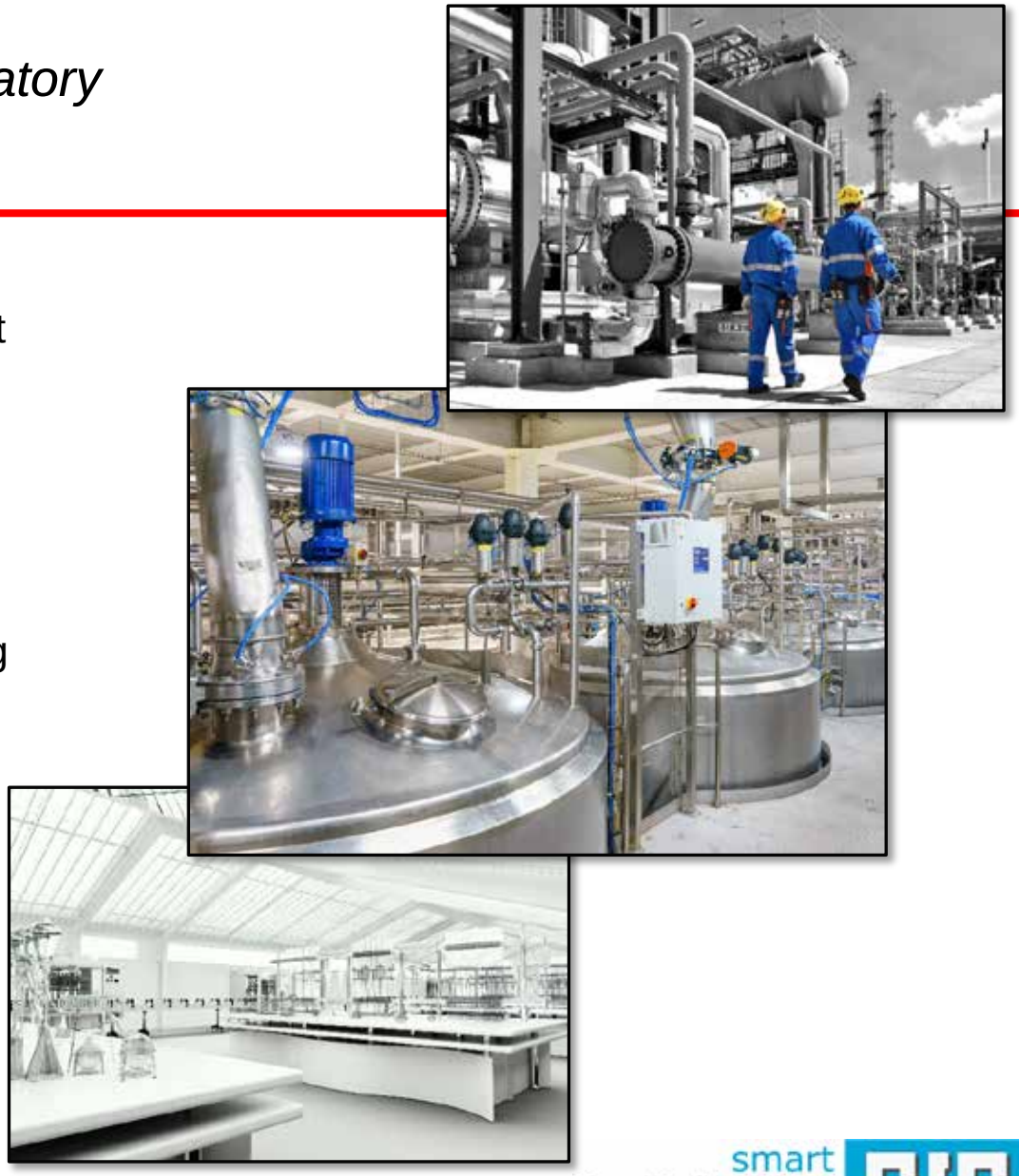
Chemical / Pharma / Laboratory Gas Detection Questions

- Chemical / Pharma / Laboratory sites share some similarities; but are very different from each other
- Safety, hygiene, facilities and production managers deal with an extremely wide range of atmospheric hazards, monitoring applications and activities
- Managers need to anticipate critical requirements ahead of time
- Gas detection equipment must be fit for purpose!



What are your most urgent concerns and problems?

- The more detailed grasp you have of the activities and risks that involve atmospheric hazards, the better.
- Drill down to make sure you understand what is most important.
- Are you currently meeting all requirements?
- Where do you need to make improvements?
- Gas detection issues are not necessarily limited to safety!
  - Toxic exposure limits are getting lower every year!

Chemical and pharma industry managers involved with all types of safety and hygiene gas detection

- Personal exposure monitoring
- Confined space
- Hot work
- Toxic materials, vapors and gases
- Hazmat and emergency response
- Other activity-based monitoring

What are some of the most important chemical industry products?

- Petrochemical plants convert “feedstock” into new products
  - Olefins
  - Aromatic
  - Multitude of additional products
- Other chemical plants specialize in production of inorganic chemicals
  - Sulfur and sulfuric acid
  - Chlorine
  - Ammonia
  - Hydrochloric acid
  - Chloralkali (lye / caustic soda)
  - Phosphorus / phosphates (fertilizers)

Chemical industry gas detection requirements can include

- Personal protection
- Production
- Process
- Facilities
- Industrial hygiene
- Community (such as fence line or nuisance odor)
- Regulatory (EPA)
- Disaster response (explosion, spill or fire)
- Construction (shut-downs)
- Confined space
  - Routine entries
  - Large scale ongoing-entries
  - Entries into inerted vessels
  - Hot work
  - Special procedures (catalyst rebuilding)

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Watch out for presence of hydrogen!

- Petrochemical plants produce olefins and aromatics by catalytic cracking of petroleum fractions
  - Cracking converts high molecular weight HCs to more useful, low molecular weight ones
  - Catalytic cracking uses and produces hydrogen!
- Chemical plants produce ammonia by using natural gas to produce hydrogen, then using nitrogen to produce the NH_3
- Gas detection concerns for H_2
  - IR LEL sensors are unable to detect H_2.
  - H_2 may also interfere with CO sensors.
  - Make sure instrument includes sensor that can detect H_2
  - If using IR LEL sensor, consider adding substance specific EC H_2 sensor.

What are the most common chemical industry atmospheric hazards?

- Oxygen deficiency
- Oxygen enrichment
- Presence of toxic gases
  - H_2S
  - CO
- Presence of combustible gases
- Typically use single-gas H_2S or a 4 gas or 5 gas detector with:
  - LEL
  - O_2
  - CO
  - H_2S
  - PID

Many other site-specific chemical plant hazards

- Chlorine
- Ammonia
- SO_2
- NO_2
- Benzene
- CO_2
- HF
- Ozone
- Cyanide (HCN)
- Phosphine
- Methyl mercaptan (MeSH)
- And <u>many</u> more!

Pharmaceutical industry gas detection issues and concerns

- Industrial-scale synthesis of pharmaceutical drugs
  - Extraction (using solvents and gases)
  - Culturing
  - Fermentation
  - Milling
  - Granulation
  - Coating
  - Tablet pressing
  - Packaging

Largest pharmaceutical plants larger than many chemical plants

- At chemical plants major CS activities occur during shutdowns and planned maintenance procedures
- At pharma plants CS entry often occurs after every batch as part of procedures to sanitize and prepare for the next batch
- Pharma plants have a <u>lot</u> of confined spaces:
  - Mixing tanks
  - Fermenters
  - Bins
  - Pits
  - Autoclaves
  - Sewers
  - Manholes
  - Tunnels
  - Pipelines
  - Equipment housings
  - Water / Wastewater
  - Other enclosed areas

How do you make a vaccine?

- Manufacturing Pfizer COVID vaccine is three stage process
  - First stage:
    - DNA plasmids that code for the spike protein infused into *Escherichia coli* bacteria and cultured
    - Bacteria harvested, and the contents of their cells are purified to recover the desired DNA product
  - Second stage:
    - DNA used as a template to build the desired mRNA strands
    - mRNA purified and frozen in plastic bags and transported (each bag can hold up to 10 million doses)
  - Third stage (Kalamazoo):
    - mRNA combined with lipid nanoparticle to form injectable suspension
    - Vaccine packaged in vials, boxed, frozen and transported to medical centers

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Especially common atmospheric hazards at pharma plants

- Oxygen deficiency due to displacement by nitrogen
  - Pressurized lines, inertion cabinets and glove boxes
  - Nitrogen leaks from large storage vessels
  - Leakage from nitrogen Dewers used for cryo-storage
- Carbon dioxide (toxic as well as displacement hazard)
  - Produced by fermentation
  - Dry ice (especially during transportation of frozen products)
- Alcohols
  - Used in sanitization procedures
  - By-product of fermentation
  - Can be very hard on catalytic LEL sensors!
- Ammonia
  - Refrigeration system and compressor leaks
- Solvents and combustible gases
  - Used in various types of extraction equipment

Laboratories come in all sizes and levels of sophistication!

- Universities, medical centers, hospitals
  - Typical university has hundreds of small labs!
- Types of laboratories
  - Analytical and Quality
  - Classrooms
  - Cleanrooms
    - Need special attention regarding containment and air quality
  - Clinical and Medical
    - Pathology, serology, histology, virology, bacteriology and molecular biology with PCR-technologies
    - Microbiological, cell or tissue culture with controlled temperature, humidity, and O_2 and CO_2 levels.
  - Research & Development (R&D) Laboratories
- Types of atmospheric hazards
  - Extremely wide range!
  - Oxygen deficiency due to displacement
  - Combustible gas and VOCs
  - Alcohols, solvents, and other sanitizing chemicals like O_3, ClO_2, EtO, Cl_2, etc.

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Don't overlook air purification and respiratory protective equipment

- Cleanroom workers often work in supplied air respirators that require Grade D breathing air:
  - Oxygen content 19.5% - 23.5%
  - Hydrocarbon (condensed) content of 5 milligrams per cubic meter of air or less
  - Carbon monoxide (CO) content of 10 parts per million (ppm) or less
  - CO_2 content of 1,000 ppm or less
  - Lack of any "noticeable odor"

Fixed or Portable solution?

- Chemical and pharma industry safety and facilities managers deal with extremely wide range of atmospheric hazards, monitoring applications and activities.
- When hazards are generally present or associated with specific activities (like CS entry) gas detection solutions focus more on portable instruments.
- When hazards are regularly present in specific areas, fixed gas detection should be considered as well.
- Optimal solution often includes both fixed and portable instruments!

What is the best type of LEL sensor?

- It depends on the specific applications!
- There are 4 major LEL sensor options, all have advantages and disadvantages:
  - Traditional catalytic “pellistor” LEL
    - Detects gas by oxidation (heating) pellistor bead in sensor
  - Full size IR LEL
    - Detects gas by absorbance of IR light over longer optical path
  - Miniaturized (low power) MEMS IR LEL
    - Detects gas by absorbance of IR light over extremely small optical path
  - Miniaturized (low power) MEMS Molecular Properties Spectrometer (MPS)
    - Presence of a flammable gas causes changes in the thermo-conductive properties of the air / gas mixture that are measured by the sensor transducer

What are advantages and limitations of catalytic pellistor LEL sensors?

- Advantages:
  - Predictable, well understood technology
  - Predictable cross sensitivities, (most instruments have built-in CF library)
  - Able to detect H_2, acetylene and unsaturated HCs
- Disadvantages:
  - Uses more power
  - Lower and slower response to larger molecules (including alcohols)
  - Easily poisoned (especially by silicones)
  - Exposure to high concentration combustible gas damaging to sensor
  - Can be burned out by chronic exposure to alcohols
  - Must have minimum of 10% O_2 to accurately detect gas

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What are IR LEL sensor advantages and limitations?

- Advantages:
  - Sensor cannot be poisoned
  - Does not require oxygen to detect gas
  - Can be used for high-range combustible gas measurement
  - Responds well to large hydrocarbon molecules that cannot be measured by means of standard LEL sensor
- Disadvantages:
  - Molecule must include chemical bonds that absorb at the wavelength(s) used for measurement
  - Not all combustible gases can be detected!
    - NDIR sensors with short optical path-lengths may have limited ability to measure gases with lower relative responses
    - Cannot detect hydrogen or acetylene!

Performance of IR LEL sensors differs from performance of catalytic LEL sensors

- Read the owner's manual!
- Make sure to verify with manufacturer before attempting to use the sensor to measure unsaturated hydrocarbons, aromatic VOCs or other gases not specifically listed in the owner's manual!

Appendix B

Detectable Combustible Gases

Gas[1]	Expected response at 20% LEL target gas[2]
Methane	20% LEL
Propane	15% LEL to 45% LEL
Butane	15% LEL to 35% LEL
Pentane	15% LEL to 45% LEL
Hexane	8% LEL to 28% LEL
Methanol/Ethanol[3]	6% LEL to 26% LEL
Hydrogen	No response
Acetylene	No response

[1]For any gases not listed, please contact Honeywell Analytics to find the best solution for your application.

[2]The BW Clip4 LEL sensor is optimized to see methane. While the unit can detect and respond to the other combustible gases listed in the above table, the accuracy of the readings may be in-consistent. If the primary need is to detect a specific combustible gas other than methane, please contact Honeywell Analytics to discuss an alternative product.

[3]Please use caution when using the BW Clip4 around Methanol and/or Ethanol. The BW Clip4 CO sensor may become inhibited by prolonged exposure to concentrations of Methanol and/or Ethanol thus causing the unit to alarm. This condition can last up to 12 hours before the CO sensor recovers to normal levels.

What are volatile organic compounds (VOCs)?

- VOCs are organic chemicals or mixtures characterized by tendency to evaporate easily at room temperature
- Familiar VOCs include:
  - Solvents
  - Paint thinner
  - Nail polish remover
  - Gasoline
  - Diesel
  - Heating oil
  - Kerosene
  - Jet fuel
  - Benzene
  - Butadiene
  - Hexane
  - Toluene
  - Xylene
  - Many others

Why use photoionization detector equipped instruments?

- For most VOCs, long before you reach the percent LEL alarm, you will have exceeded the toxic exposure limit for the contaminant
- PID equipped instruments are generally the best choice for measurement of VOCs at exposure limit concentrations
- Whatever type of instrument is used to measure these hazards, it is essential that the equipment is used properly, and the results are correctly interpreted

Combustible sensor limitations

Contaminant	*LEL (Vol %)*	*Flashpoint Temp (ºF)*	*OSHA PEL*	*NIOSH REL*	*TLV*	*5% LEL in PPM*
Acetone	*2.5%*	*-4ºF (-20 ºC)*	*1,000 PPM TWA*	*250 PPM TWA*	*500 PPM TWA; 750 PPM STEL*	*1250 PPM*
Diesel (No.2) vapor	*0.6%*	*125ºF (51.7ºC)*	*None Listed*	*None Listed*	*15 PPM*	*300 PPM*
Ethanol	*3.3%*	*55ºF (12.8 ºC)*	*1,000 PPM TWA*	*1000 PPM TWA*	*1000 PPM TWA*	*1,650 PPM*
Gasoline	*1.3%*	*-50ºF (-45.6ºC)*	*None Listed*	*None Listed*	*300 PPM TWA; 500 PPM STEL*	*650 PPM*
n-Hexane	*1.1%*	*-7ºF (-21.7 ºC)*	*500 PPM TWA*	*50 PPM TWA*	*50 PPM TWA*	*550 PPM*
Isopropyl alcohol	*2.0%*	*53ºF (11.7ºC)*	*400 PPM TWA*	*400 PPM TWA; 500 PPM STEL*	*200 PPM TWA; 400 PPM STEL*	*1000 PPM*
Kerosene/ Jet Fuels	*0.7%*	*100 – 162ºF (37.8 – 72.3ºC)*	*None Listed*	*100 mg/M3 TWA (approx. 14.4 PPM)*	*200 mg/M3 TWA (approx. 29 PPM)*	*350 PPM*
MEK	*1.4%*	*16ºF (-8.9ºC)*	*200 PPM TWA*	*200 PPM TWA; 300 PPM STEL*	*200 PPM TWA; 300 PPM STEL*	*700 PPM*
Turpentine	*0.8*	*95ºF (35ºC)*	*100 PPM TWA*	*100 PPM TWA*	*20 PPM TWA*	*400 PPM*
Xylenes (o, m & p isomers)	*0.9 – 1.1%*	*81 – 90ºF (27.3 – 32.3 ºC)*	*100 PPM TWA*	*100 PPM TWA; 150 PPM STEL*	*100 PPM TWA; 150 STEL*	*450 – 550 PPM*

There are <u>many</u> new developments in gas detection!

- New products
- New sensors
- Wireless communication
- Integrated fixed and portable networks
- Third party support through call centers
  - Emergency response
  - Record keeping and notifications
  - Internet based maintenance programs

What brand(s) and model(s) of gas detection equipment do you currently use?

- Before making a change or investigating new products, make sure you understand your current products and requirements
  - If you are not sure, make sure to find out the brands and models currently in service.
  - Make sure you understand the capabilities; the strong points as well as the weak points, of the products you are currently using.
- Ask the manufacturers or distributors of the products you work with (or are interested in) for help.
  - Download specifications and comparison charts if the manufacturer has them.
  - Discuss ways the manufacturer and distributor can help meeting your needs with regards to product, capabilities or support.

How well is your current equipment performing?

- This is a critical starting point in the conversation.
  - Are you generally happy?
  - Are you experiencing problems?
  - How old is your current equipment?
  - What features have you heard about that you are interested in?
  - What brand(s) and model(s) of gas detectors are you considering?
  - What are the alternatives?
- Distributors are a great source for product information!
- When in doubt, or with regards to advanced technical questions, ask the manufacturer!

Avoid being overly focused on price!

- Eventually, the decision of whether to proceed involves price and affordability.
- However, there is a difference between the initial purchase price and the true cost of ownership.
  - The questioning process is designed to uncover your needs, and what would provide the optimal solution.
  - Once you fully identify the problems and how the new product is going to help, it's easier to understand the costs.
  - Once you have clarified the tradeoff between benefits and costs is when to widen or restrict choices as a function of price.

Identify "cost of ownership" issues

- Are you spending a fortune keeping your current equipment in service?
- Are you being charged a monthly fee for reports and factory support?
- Do you trust your gas detectors?
- Do you have many sensor failures?
  - If so, what kinds of sensors are failing?
- Do you have battery problems?
  - Do the instruments run long enough on a single charge or set of batteries?
- How often do you test and calibrate your instruments?
  - Do you do it yourself or use a service?
- Are there any special conditions or contaminants that are causing problems?
- <u>Do you feel you are currently getting a good deal?</u>

Who is currently looking after your instruments?

- Do you do it yourself, use a third-party service, or work directly with the factory?
- If you like your current instruments, and want to keep them in service, you might want to talk about maintenance agreements or refurbishment programs.
- Ask your local distributor whether they offer calibration or repair services.
- Ask your current manufacturer whether they have factory maintenance programs, or a loaner or replacement instrument policy.
- You should expect excellent after the sale support!

Do you have any plans to update, expand, replace or change the equipment you are currently using?

- If you have relationships with gas detection manufacturers and distributors you trust, get them involved!
  - Distributors generally have more than one manufacturer option.
  - Gas detection manufacturers are happy to discuss issues directly with end-user customers.
  - The Internet and social media are terrific tools for finding out what's new, and what customers have to say.
  - You have multiple sources of information!
- Gas detection decisions are typically made by a group of individuals who have different roles in the decision process, including process or facilities management, safety, hygiene, purchasing, and (often) union representatives.
  - Make sure you don't leave anyone out!
  - The same issue often looks considerably different to a manager with different responsibilities.

Don’t be afraid of considering fixed system solutions!

- Many common solutions based on small standalone single point systems, or small systems with 1 to 4 points of detection.
- Larger systems can be complicated, but your manufacturer partners are there to help you through the specification process.
- Make sure to include everyone with a stake in the outcome in the discussion and selection process!

Make sure you understand company policies and procedures for fixed systems

- Specification and purchase of fixed gas detection systems can be complicated
- Are fixed system decisions made by a third-party design firm or contractor?
- Are fixed system decisions made by managers at the site?
- Are there any open projects?
- Who is involved in the specification and evaluation process?
- Who is responsible for calibration and routine maintenance?

Do you have a "Fixed System Questionnaire" from the manufacturer you are working with?

- The design firm, distributor and manufacturer need the information in this usually simple form to provide the best solution.
- If you do not have a copy, contact the manufacturer ahead of your meeting!
  - Clarifying what you need by means of a detailed questionnaire reduces the chances for specifying or purchasing the wrong equipment.
  - Don't be afraid to ask the manufacturer for help with the answers.
  - Answer as many questions as you can, but don't worry if you can't answer them all.
  - The manufacturer will tell you if there is something that must be nailed down before they can generate a quote.
- Don't go it alone!
  - Don't be afraid to ask the manufacturer for help.

Example Fixed System Questionnaire

- Simple information but critical to know
- The questionnaire will help you to ask the right questions
- Vital to provide the best solution!

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FIXED SYSTEMS APPLICATION QUESTIONNAIRE

Company:
Name and title:
Phone:
E-mail:
Address:
City/State/Zip:
Date:
Salesperson:

The information requested on this survey is for GfG Project Engineers. Exact specifications will help insure proper equipment for your application.

APPLICATION DATA

Describe your application:

Is the area considered ☐ Hazardous/Classified ☐ General purpose

Is the area currently being monitored? ☐ No ☐ Yes, list technology:

TRANSMITTERS

Output ☐ 4-20 mA ☐ Modbus ☐ Two wire ☐ Three wire ☐ Other:

Gas detecting ☐ CO ☐ NH_3 ☐ O_2 ☐ CH_4 ☐ Other:

Calibration gas ☐ Standard ☐ Special

Range required: to PPM ☐ %LEL ☐ %volume ☐

Temperature range: to ☐ °F ☐ °C Humidity: %

Possible background gases / sensor poisons ☐ No ☐ Yes, please list

Climate ☐ Indoor ☐ Outdoor

Voltage input: VDC

Interfacing with PLC? ☐ No ☐ Yes, load: ohms

Display required? ☐ No ☐ Yes

Modifications: (explain)

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What sensor configurations do you currently use for confined space entry?

- Do you have the right configuration, or are you thinking about a change?
- How many / what kinds of sensors are installed in your instruments?
  - Traditional 4 gas (LEL / O_2 / CO / H_2S)?
  - 5 gas with PID?
  - Some other sensor configuration?
- What type of sensor are you using (or interested in using) for LEL?
  - Traditional CC LEL?
  - IR LEL?
  - MPS?
- Does the type of LEL sensor require changes in use or types of the other installed sensors?
  - Do you use different multi-sensor instruments for different activities or types of CS entry?
  - Confined spaces that contain VOC vapors?
  - CS entry into inerted vessels?

Further multi-gas considerations

- Do you have any other contaminants or toxic gas concerns?
  - Chemical and pharma industry sites have a long list of potential contaminants.
  - Consider including additional sensors in your multi-gas instruments, or
  - Use specialty sensors in separate instruments.
  - Watch out for compatibility issues!

It may be better to keep special application sensors in a separate instrument

- Some of the most commonly used personal single gas instruments include:
  - H_2S
  - CO
  - NO_2
  - SO_2
  - Ozone
  - HCN
  - HCl
  - EtO
  - HF
  - MeSH
  - PID
  - As well as many others!

Even more multi-gas questions

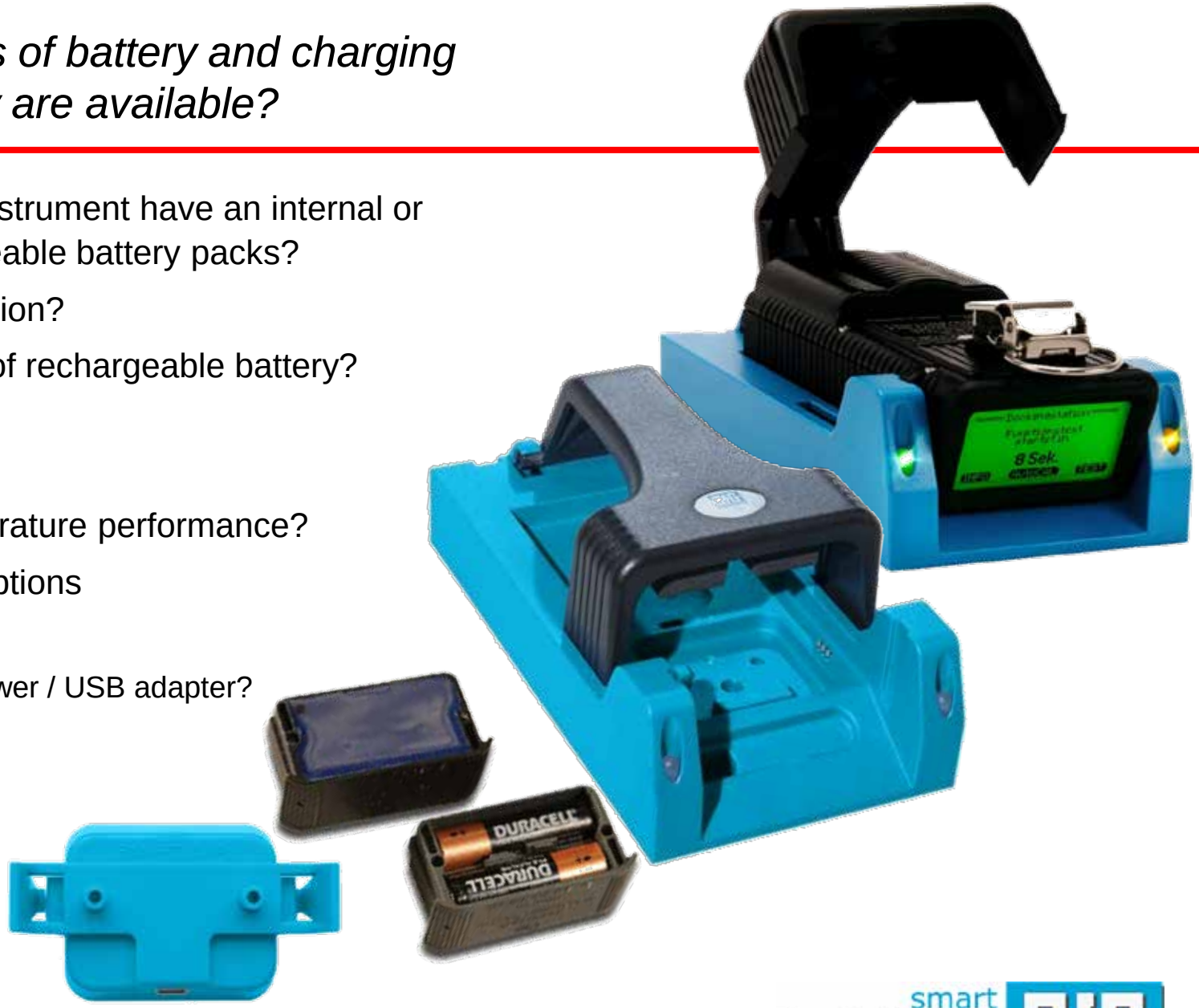
- Do you have alcohol, heavy fuels or VOCs on site?
  - VOC vapors are potentially explosive, but toxic at much lower concentrations.
  - Especially true for VOCs like benzene, hexane, toluene and xylenes.
  - Consider including a PID sensor in multi-gas instruments used for spills and other situations that involve VOC vapor.
- Do you encounter VOCs during confined space entry?
  - If so, your CS instruments should include a PID sensor.

How do you sample the atmosphere from within the confined space?

- Is the instrument a diffusion only design?
- Does the instrument have an attachable sample pump?
- Does the instrument have a built-in pump?
- Does the instrument have the option of switching from diffusion to sampling by means of the built-in pump?

What types of battery and charging technology are available?

- Does the instrument have an internal or interchangeable battery packs?
- Alkaline option?
- What type of rechargeable battery?
  - Li Ion?
  - NiMH?
- Cold temperature performance?
- Charging options
  - Cradle?
  - Wall power / USB adapter?



What about periodic testing and calibration?

- How often do you perform a bump test?
  - Before each day's use?
  - Do you keep bump test kits (with gas) with the instruments?
  - How do you prove your instruments have been bumped?
  - What do you do if you fail a bump test?
- How often do you perform a full calibration?
  - Do you use a docking station for bump tests and calibrations?
  - How do you prove your instruments are properly maintained and calibrated?
  - How do you retain maintenance and calibration records?
- Is your current strategy working?
  - Is it easy?

Are your gas detectors wirelessly enabled (or are you considering this option)?

- Most manufacturers now offer a “wireless” communication option.
  - Each manufacturer has its own strategy, with its own benefits and limitations.
  - Make sure you understand the wireless options and competitive benefits!
- Common communication methods:
  - Blue Tooth
  - Cellular
  - ISM RF
- Do you intend to use wireless communication during CS entry?
  - How do you get the information out of the space?

Have you addressed "third-party" issues?

- Do you intend to use a remote call center service to coordinate emergency response?
- Do you intend to use a third-party rescue service (such as a corporate emergency response team, or the local fire department)?
- How will you coordinate real-time emergency information with all involved parties?

What about after the sale support?

- Satisfaction is a function of ongoing support.
  - Atmospheric monitors and systems are life critical safety equipment.
  - Customers should expect excellent after the sale support.
- Don’t forget to consider:
  - Warranty
    - Sensors
    - Instrument
- Technical support
  - Is your vendor there to provide help?
- Training
  - Videos?
  - In person?
  - Internet resources?

Questions?

Thank you!

For additional information or gas detection help:
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