



Balancing Safety, Process Performance, and Costs

PNWS AWWA Conference

Vancouver, Washington

May 1, 2019

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Common
Workplace
Hazards in Water
Treatment Plants

Hazard	Mitigation Strategy
Confined Equipment Spaces	Open plan layouts eliminate confined equipment spaces
Ladders and Pits	Replace ladders and pits with flat floors and scissor lifts
Difficult Equipment Access	Improve equipment access to lower construction costs
Noise above 80 dbA	Reduce noise exposure with mufflers or isolation rooms
Chemical Spills, Drips, and Fumes	Eliminate operator contact with spilled or leaking chemicals

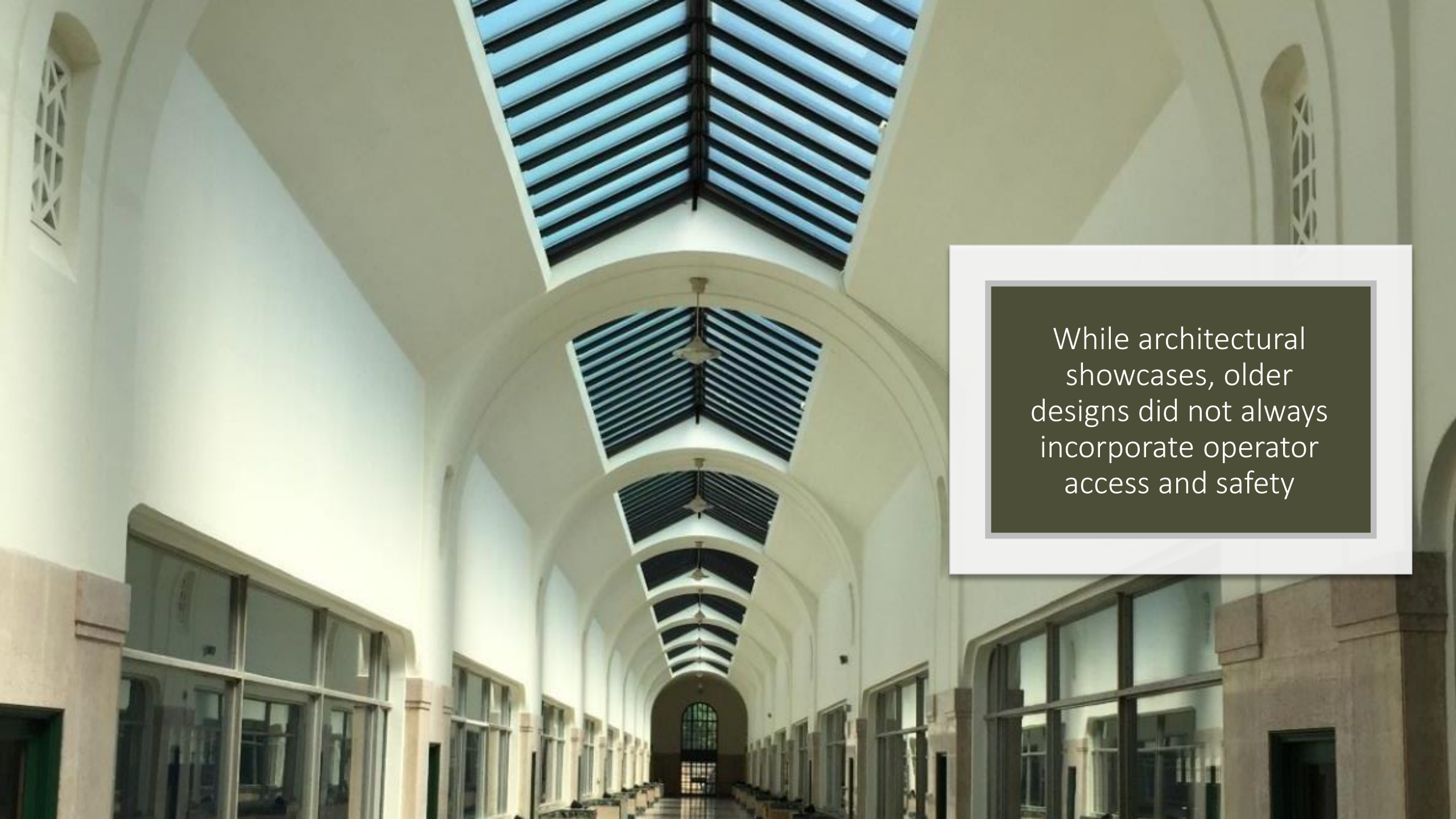
Hierarchy of Controls for Worker Safety

1. **Elimination** – relocating a gage outside of a hazard area
2. **Substitution** – buying pre-mixed solutions, rather than mixing on-site
3. **Engineering** – installing local exhaust ventilation system, rather than full room ventilation
4. **Administrative** – pipe labeling for chemical content, worker training
5. **Personal Protective Equipment (PPE)** – issuing workers respirators





Water Treatment Plants of the Past



While architectural showcases, older designs did not always incorporate operator access and safety



Confined spaces and difficult equipment access are common

Eliminate Hazards – Confined Spaces, Ladders, and Pits

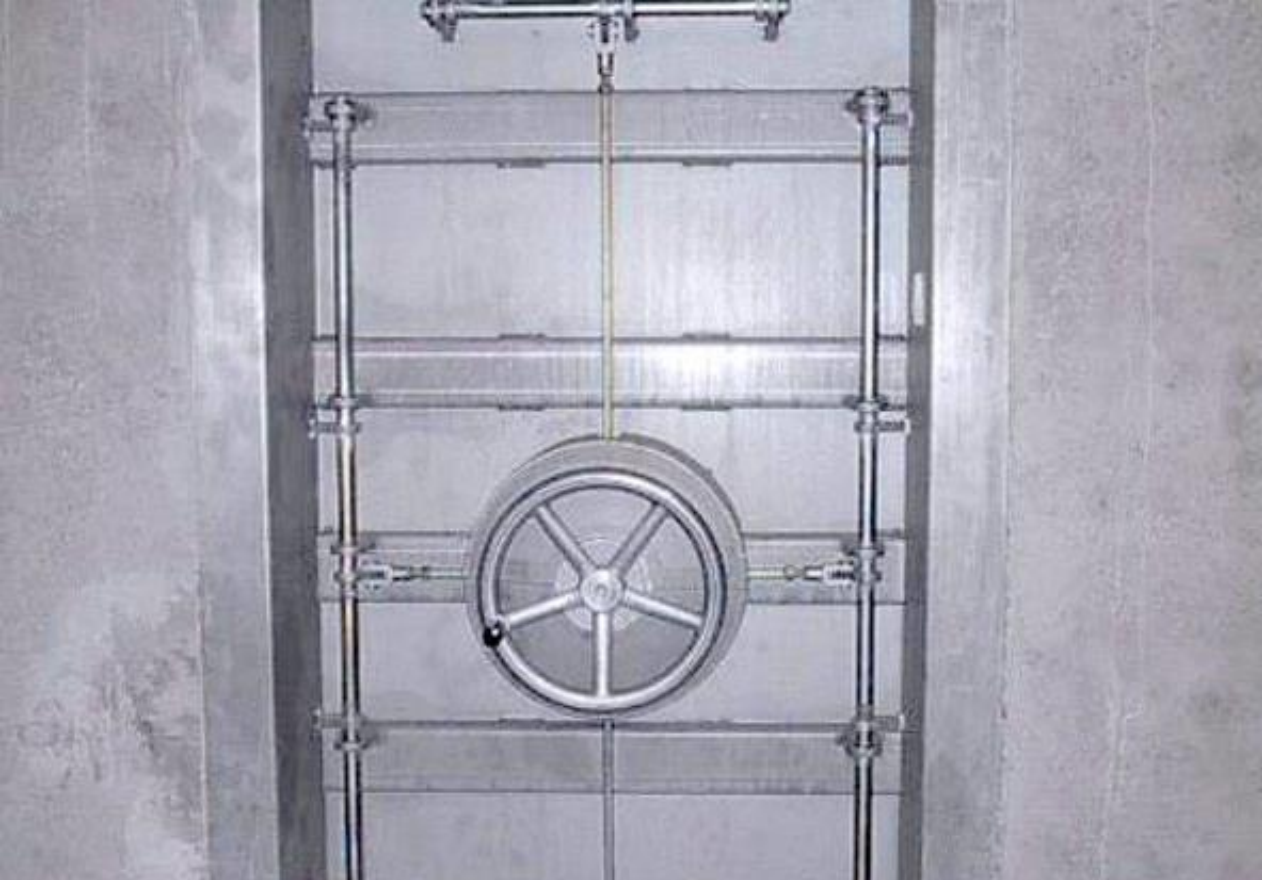
Confined spaces result in extra time and cost, and endanger staff

- Vaults for valves, flow meters, and equipment.
- Pipelines and concrete pressurized water conduits
- Ozone contactors
- Tanks



Vaults with
stairs





Provide side access to tanks and basins

Ladders

- Three points of contact required at all times: try the designer coffee challenge!
- One approach is to replace ladders with stairs... but this increases footprint and capital cost.
- Alternate approach: design facilities that eliminate pits and platforms, with flat floors and layouts that accommodate scissor lifts.



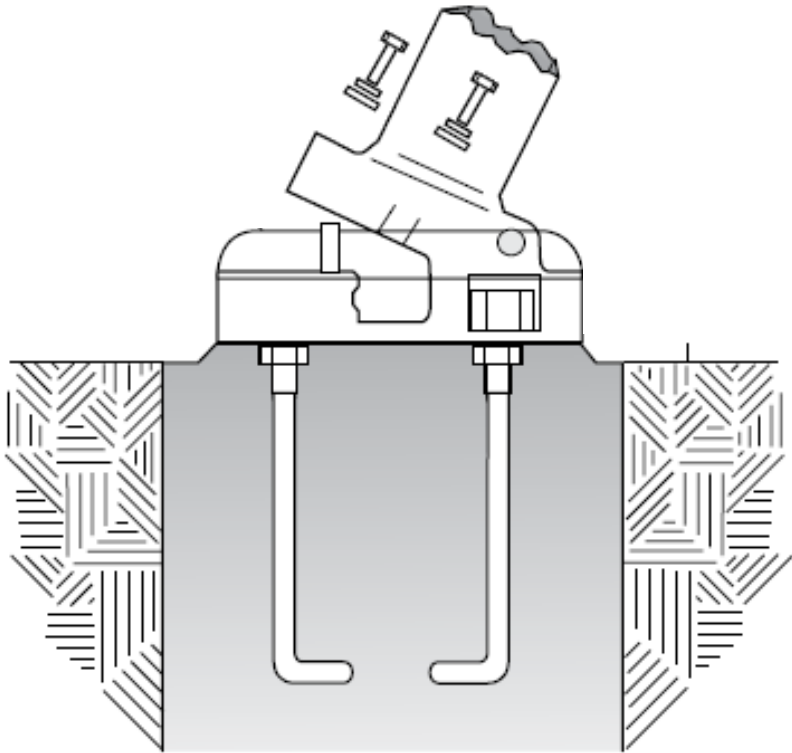


Replace ladders with stairs

A man in a plaid shirt and blue jeans is sitting on a blue portable ladder. To his right is a blue scissor lift. A dark blue speech bubble is overlaid on the image, containing white text.

Replace need for portable ladders
by making accommodations for
scissor lifts

How to change a light bulb.... re-design for safety



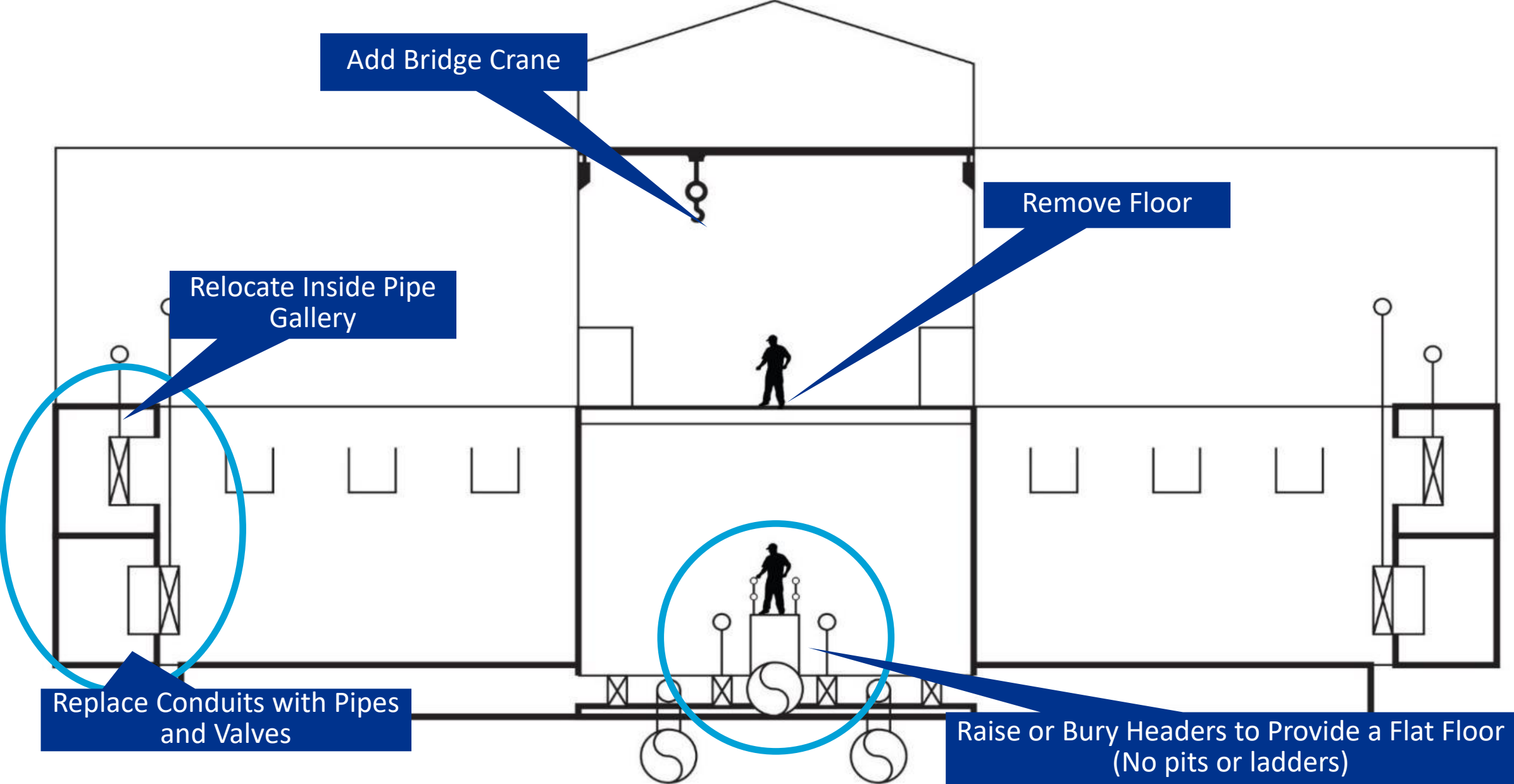
Eliminate Hazards – Equipment Access

Access to equipment

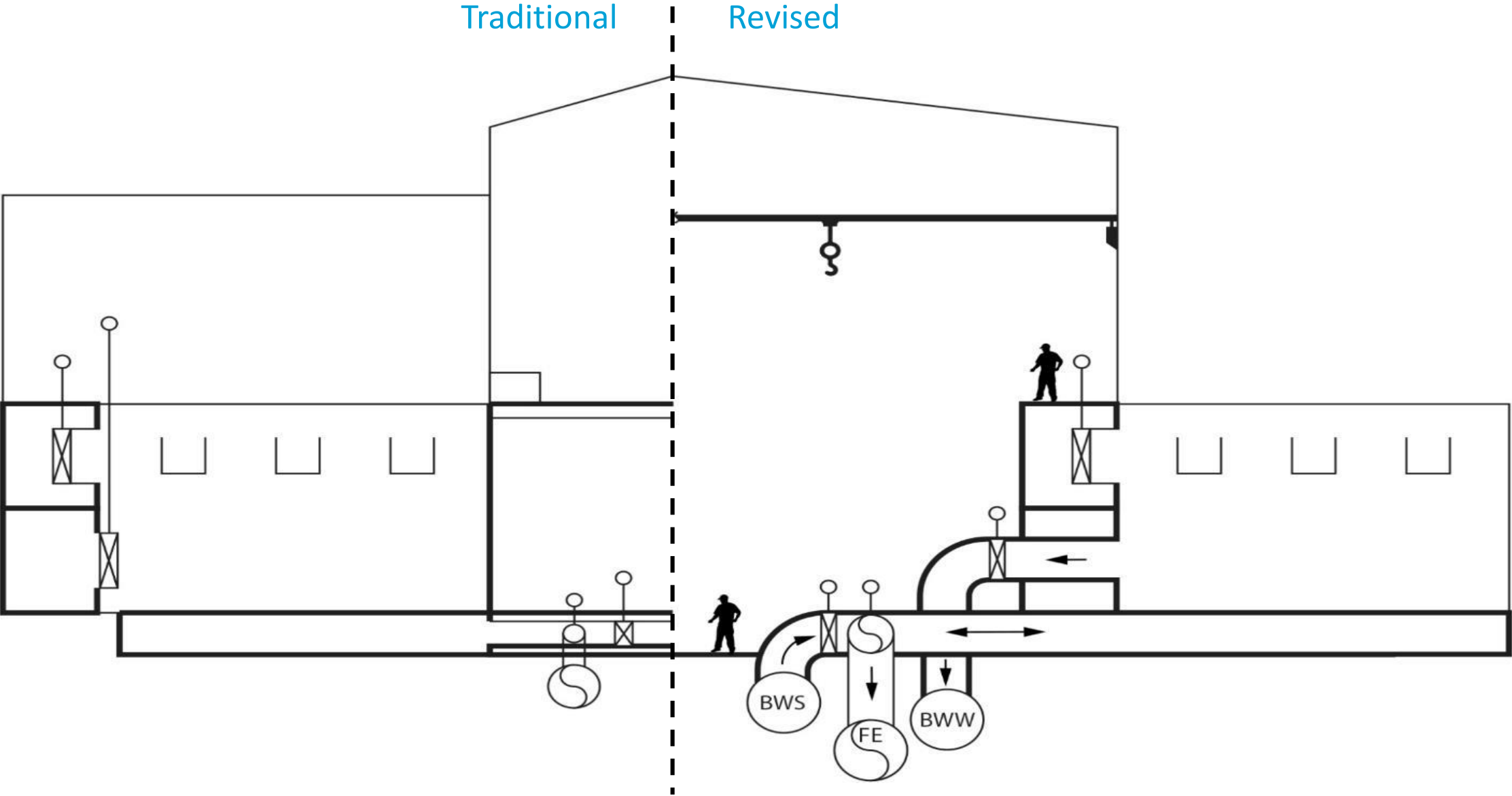
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- Regular access is needed for maintenance of pumps, valves, motors, blowers, and anything that moves. Also items with consumables like **light fixtures**.
 - Poor accessibility greatly increases the cost of maintenance and elevates risk of injuries.
 - Update design standards: heavy pieces of equipment (weighing more than 50-100 lbs) should be removable via overhead crane. Consider construction benefits.
 - Add natural lighting. The only lights on a high ceiling should be skylights.



Approaches to eliminate traditional plant layout hazards

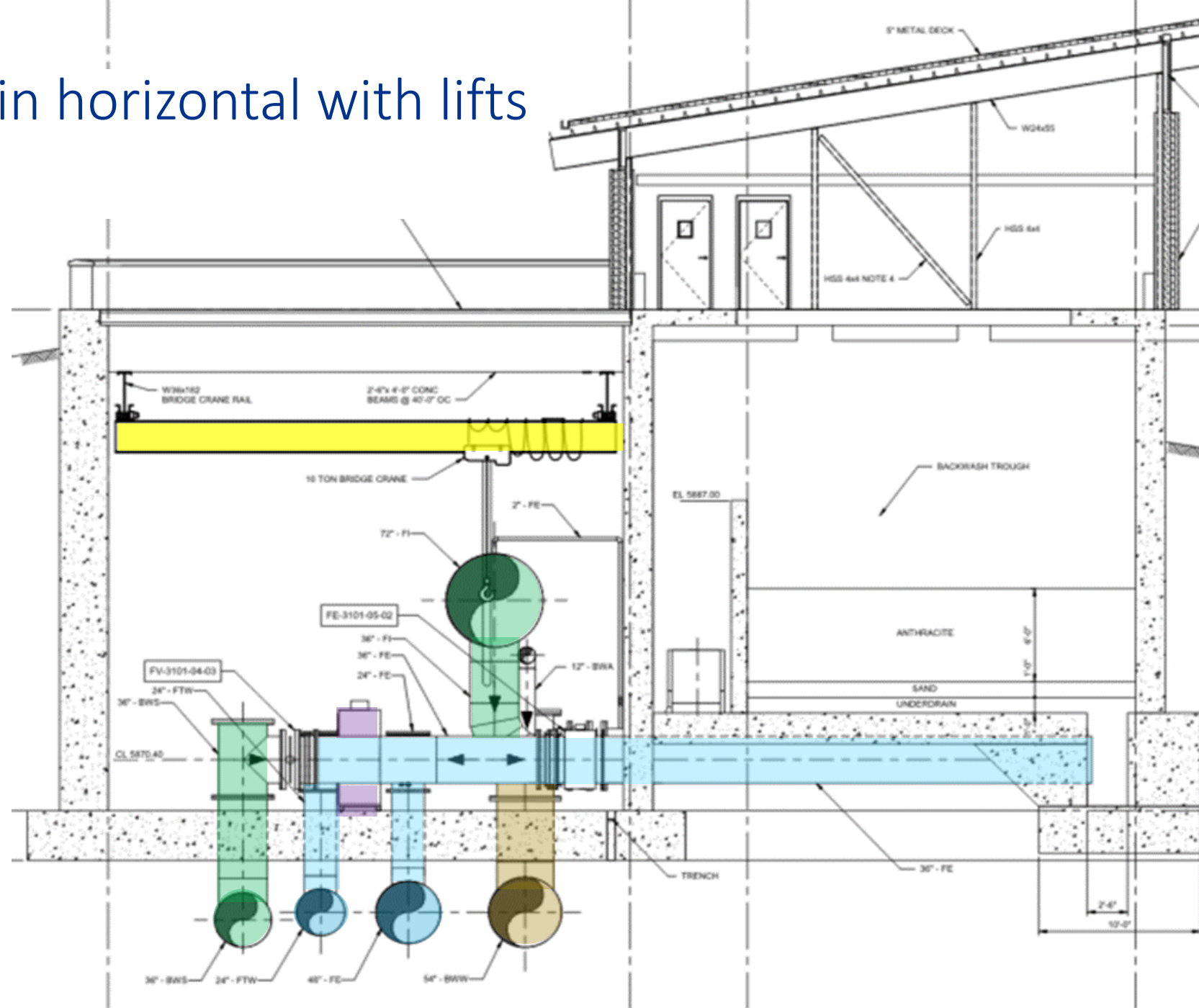


Revised filter facility layouts promote safety and reduce costs



Valves and equipment in horizontal with lifts

- Revised approaches keeps valves low and in the horizontal
- All valves and equipment can be picked by a bridge crane



Open Layout with Natural Light

- Large windows at the gallery ends and skylights above provide natural light adequate for typical working conditions.
- All equipment can be picked with the bridge crane.
- Insulated pipes reduce heating demands and eliminating condensation drips on the floor.







Materials Selection for long life and easy maintenance

Life cycle cost of stainless steel
may be less than painted and
lined carbon steel.



Eliminate Hazards – Chemical Storage and Feed



Consider safety in chemical selection

- It's not possible to eliminate all hazardous chemicals, but consider safety in chemical alternative selection
 - **Chlorine:** bulk hypochlorite vs. on-site sodium hypochlorite generation vs. chlorine gas
 - **Ozone or chlorine quenching:** sodium bisulfite vs. calcium thiosulfate vs. hydrogen peroxide

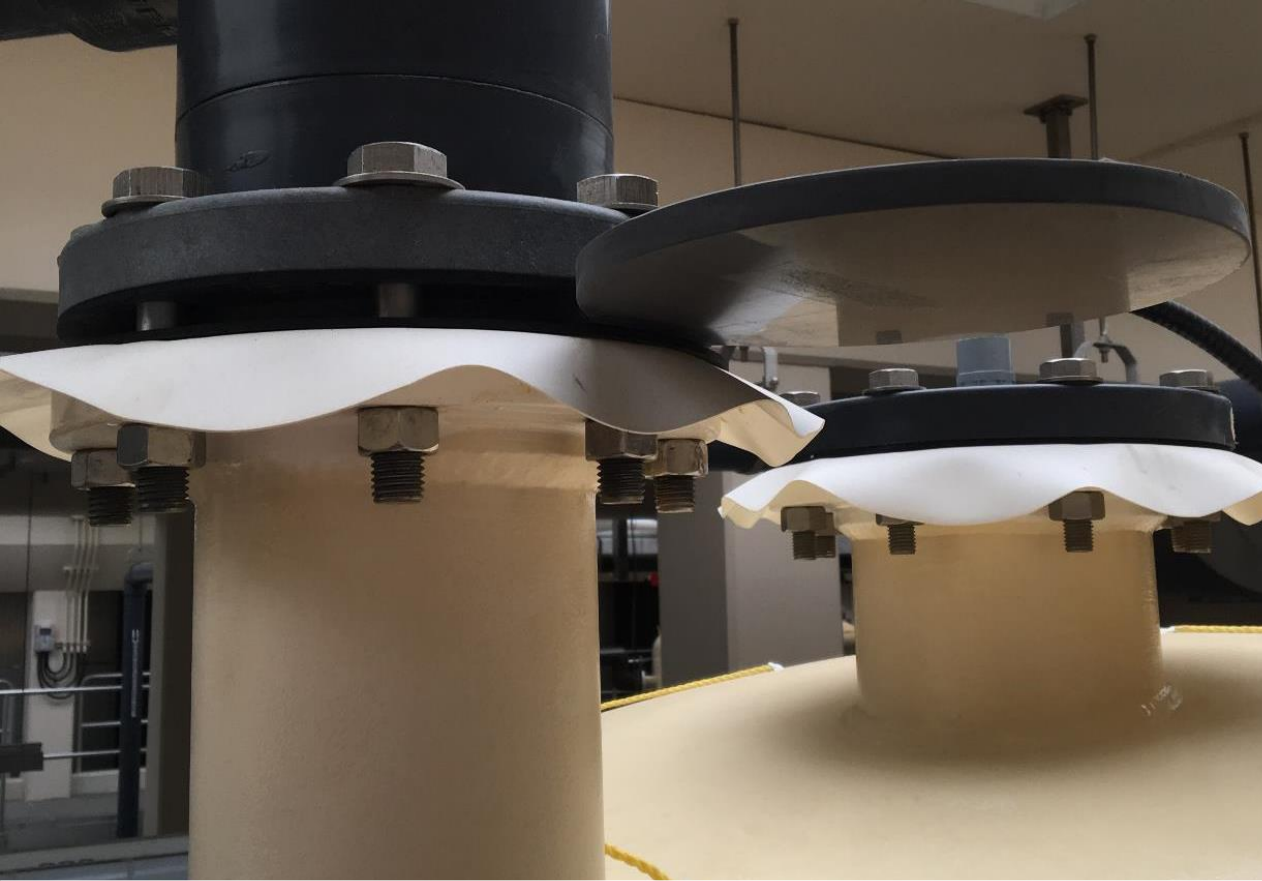
Traditional design concepts for chemical storage and feed systems

- Locate chemicals in separate areas (in many cases individual rooms), each with separate spill containment and ventilation systems. Often, the spill containment walls are uncomfortably high.
- Mount level sensors and fill valves on top of tank and provide ladders on side of tank to provide access for calibration and maintenance, which is not safe.
- Heavy ventilation to control fume concentration, especially when filling tanks or when doing metering pump maintenance. This can amount to a lot of energy.
- Use inexpensive diaphragm metering pumps. Chemical flowrate are calculated not measured, and pressure pulses are hard on pipe joints.
- Use plastic or FRP tanks which become brittle over time.

Consider tank material options

- Steel tanks provide excellent seismic resiliency
- Liners can last 20 years and are easily replaced in place





Isolate odors during operation and maintenance



Provide stairs
and elevated
walkways for
easy access to
upper tank
surfaces and
equipment



Chemical Delivery and Tank Filling

- Truck Off-Loading Station
 - Must accommodate full range of chemical delivery vehicle sizes
 - Spill pad containment
 - Hoist or forklift with loading dock required for chemical totes and drums
- Dedicated fill lines to prevent accidental filling of the incorrect tank



Consider how interior equipment can be removed and replaced, particularly large items such as tanks

Removable skylights



Removable wall panels and rollup doors





Chemical storage considerations

- Cluster storage tanks of compatible chemicals together inside a common spill containment wall
 - Sodium hydroxide and sodium hypochlorite are very similar, with no inter-reaction
 - Generally group acids and neutrals together; or alkali and neutrals together
- Tank clustering provides two advantages:
 1. Spill containment walls are low; chemical pump skids are within the spill area, yet easy to access
 2. Tanks of varying volumes can be made of different diameters, but of similar heights... this means that access to the top of the tanks can be provided by a common platform and a single set of stairs rather than multiple ladders



Tank pads

Support tanks on dedicated concrete bases about as high as the spill containment wall. Spill do not end up between the tank base and the tank, which is hard to clean.

Large concrete pads also provides for secure seismic anchoring.



Minimize contact with chemicals – provide grating over containment areas

Protect operators from chemical leaks at pumps

- Plexiglass splash guards
- Use non-pulsating metering pumps with VFD, such as peristaltic or mag-coupled gear pumps
- Mount a mass meter on the discharge of each pump so operators have an exact indication of flow
- Provide hose-type purge connections upstream and downstream of pumps, with associated valves, so that service water (low-pressure) can be flushed through the pump before pump and valves are removed from service for maintenance:
 - Interior of pumps and valves contain water, not chemical
 - No fume release during pump maintenance
- Locate disconnects away from likely chemical leaks
- Locate pumps in containment area but within reach from outside of containment area



Contain chemicals in transit

Pipe trays



Single-walled pipe with transparent shell



Double-walled pipe



Conclusions

- Safety in design is a priority for new facilities. Avoid blindly copying old designs.
- Most cost effective to address safety issues early in the design process. Prepare safety standards to address common issues.
- Establish standards and methodologies to evaluate safety alternatives and requirements during design.
- Every safety feature that can be designed in reduces employee and operator safety risks.



**Designed
for Safety**

Safety features provide benefits for years to come

- Better monitoring of equipment and process given easier access
- Faster operations and maintenance response
- Less risk to staff resulting in fewer injuries and fewer lost hours
- Less time spent preparing for tasks (job hazard analysis)
- Fewer personnel required to complete each task, so more tasks can be completed
- More satisfied O&M staff which leads to easier hiring and better retention



Thank you

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May 9, 2019

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