ISA Montréal Section

Setting the Standard for Automation™

Fundamentals of Process Engineering

Sessions #1 : Tanks

TANKS USAGE

Influences types of controls

Storage conditions

• Long term storage	Days or weeks
• Day tank	Hours, 1 shift, 1 day
• Reaction time	Depends on kinetics
• Pump suction tank	3 to 5 minutes or more
• Buffer time for repairs	4 to 8 hours
• Expansion tanks	Depends on pipe contents

TANK CONTENTS

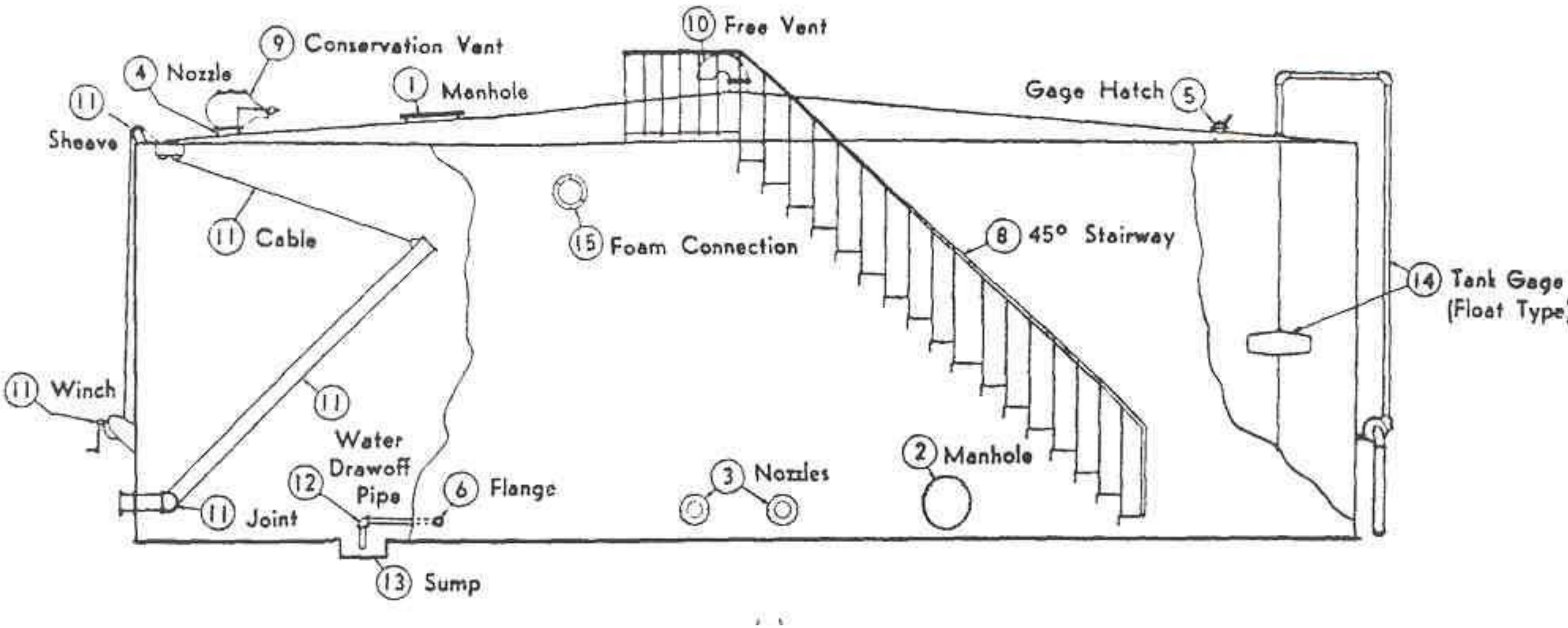
Influences types of level transmitters

Contents

- Liquids
- Slurries or suspensions of solids in liquids
- Pressurised gases
- Liquefied gases
- Emulsions
- Solids (tanks called bins or hoppers)

Tank shapes
Tall metal tanks

Tank shapes
Large storage tank



From S.M. Walas: Chemical Process Equipment

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Tank shapes

Conical bottom tank for slurries

Tank shapes
Spherical tank

Tank shapes

HIGH DENSITY PULP STORAGE TANK

Tank shapes
Floating roof

TANK CONFIGURATION

Typical tank connections (also called nozzles)

- Feed inlets
- Discharge outlets
- Overflow nozzle / pipe
- Drain nozzle
- Vents
- Agitator entry
- Manways or manholes
- Instrument connections
- Utilities connections to internal coils

TANK CONFIGURATION

Feeding methods

- Pipes end at top of tank
- Pipes end at side (above/below liquid level)
- Pipes immersed in tank
- Solids dropped in tank
- Solids sluiced with recycled liquid
- Conveyors bring in solids
- Gases usually immersed into liquid bottom

TANKS NOZZLES

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TANKS CONFIGURATION

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Specific operating conditions

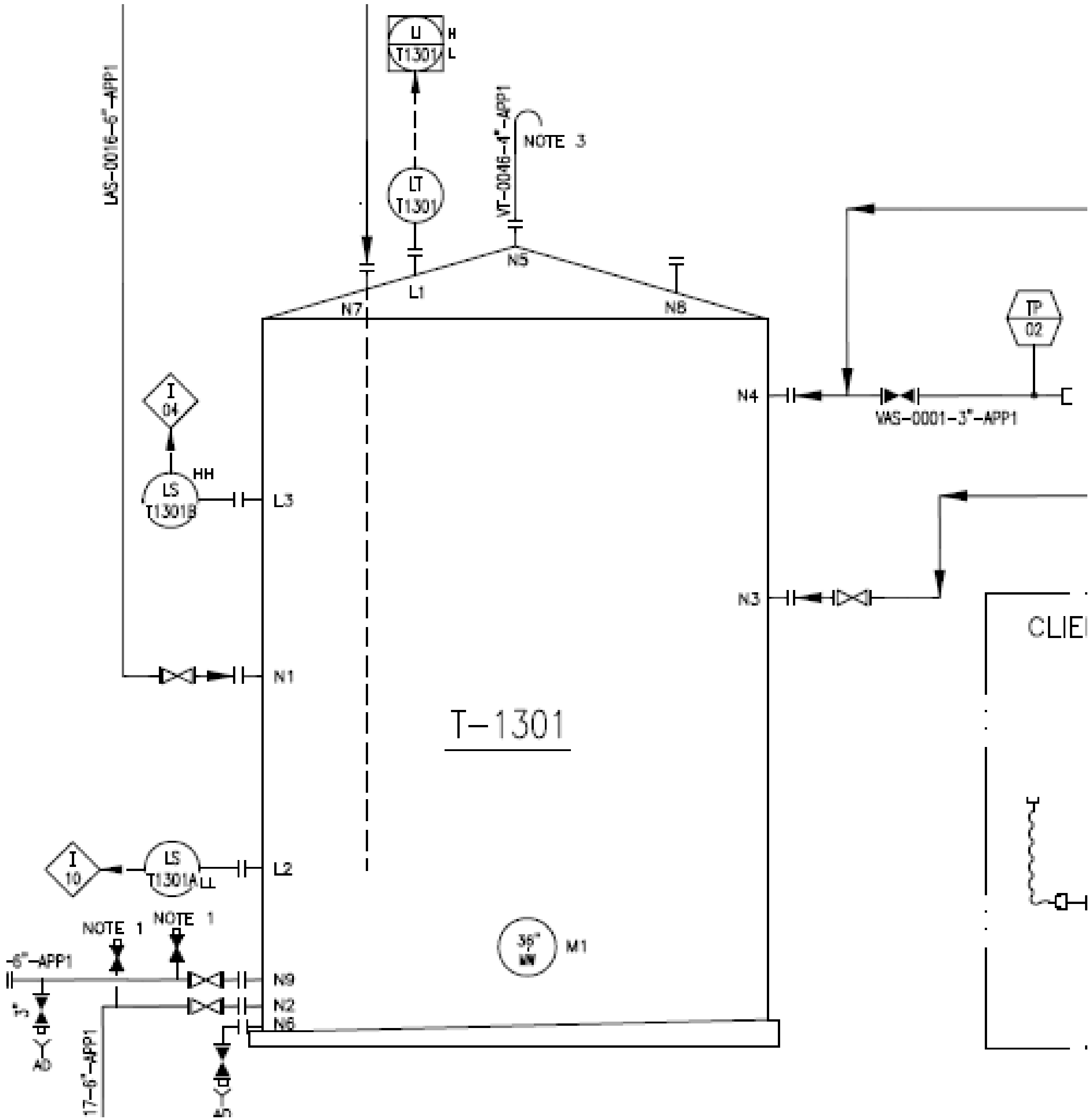
• Stirred/agitated	Maintains homogeneity.
• Internal baffles	Promoted better blending.
• Batch or continuous	Mainly for reactors.
• Pressurised/vacuum	No spurious opening.
• Atmospheric	No constraint on openings.
• Open top	Small indoor tanks, cheaper.
• Closed top / Sealed	External tanks, hot or volatile.
• Blanketed	Volatile or corrosive chemicals.
• Insulated	Maintain temperature.

TANKS CONFIGURATION

Specific operating conditions (Cont'd)

• Jacketed	To heat or cool and maintain T
• Immersion heaters	To heat or cool and maintain T
• Sprays	To clean, suppress foam or kill runaway reaction
• Sloped bottom	To drain easily large tanks
• Conical	To prevent accumulation of dirt
• Spherical top/bottom	Stiffer construction
• Painted	Carbon steel tanks for corrosion Other metals not painted

ATMOSPHERIC TANK DETAILS ON PIDs



TANKS DESIGN PARAMETEES

Important parameters in tank design

- Volumetric flowrate of all IN flows.
- Volumetric flowrate of all OUT flows.
- Both must be equal except for raw material and product storage tanks.
- Temperature of all IN flows to calculate OUT flow Temp.
- Pressurized tanks for liquids close to boiling point.
- Viscosity of product to select proper pump.
- Safety features to avoid problems.
- Material of construction to avoid corrosion and holes.

TANK RELATED CALCULATIONS

Typical calculations

- Flowrates in / out of tank.
- Residence time.
- Volume and dimensions (Height to diameter ratio).
- Nozzle sizes.
- Weight of tank (flooded / operating / empty).
- Internal configuration.
- Agitation requirements.
- Operating level / temperature / pressure.

TANK CALCULATIONS

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Typical calculations

- Typical usable tank volume:
  - 85% to 90% of tank physical volume
  - Higher (95%) for very tall tanks

- Dead space ABOVE highest liquid level for:
  - Overflow pipe
- Dead space BELOW lowest liquid level for:
  - From pump nozzle location to tank floor
  - NPSH considerations may limit lower level from which liquid can be pumped

TANK CALCULATIONS

Parameters for defining tank volume / dimensions

- Type of tank
- Shape of tank
- Retention time
- H/D ratio
- Typical usable volume (85% to 90% of physical volume)
- Normal operating level (if applicable)
- Location of connections
- Size of all connections

TANK CALCULATIONS

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Parameters for defining a tank (Cont'd)

- Operating and Design Temperature/Pressure
- Material of construction
- Access to tank internals
- Instrumentation required
- Insulation requirements
- Walls and roof thickness

TANK SPECIFICATIONS

Definition of DESIGN conditions

Design temperature =

50 Degrees Fahrenheit (28 degrees Celsius) ABOVE maximum possible operating temperature.

Design pressure =

10% ABOVE maximum possible operating pressure (in absolute units).

For atmospheric tanks Design Pressure = 2.5 psig.

Test pressure =

50% to 67% ABOVE the Design pressure (in absolute units).

TANK CAR IMPLOSION

CAUSED BY CONDENSING STEAM

COLLAPSED TANK

VACUUM BREAKER COVERED WITH PLASTIC SHEET

TANK MATERIALS

Materials of construction

• Carbon steel	Cheapest for large sizes
• Stainless steel	Most common in industry
• Titanium	For special corrosive chemicals
• Fiberglass	Same, but low temperature
• Concrete	Large chests inside buildings
• Wood	Old way of building large tanks
• Plastics	Small tanks for specialties
• Glass lined metal	Small tanks/reactors where corrosive

TANK CONTROLS

Red parameters are more important ones

CONTROLS ON TANKS

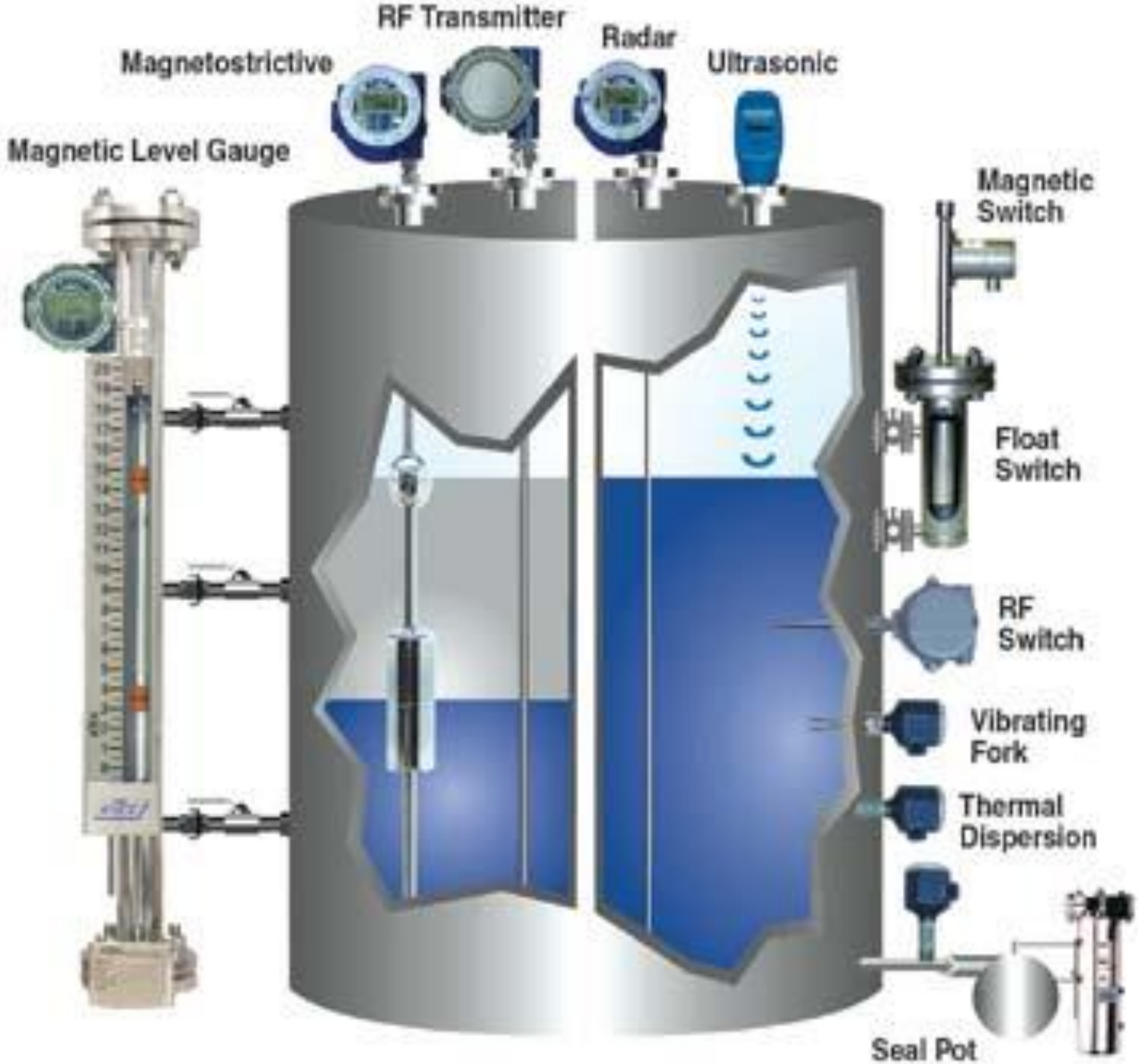
- **Level**
- **Temperature**
- *Pressure*
- *Mass*
- *Flow In*
- *Flow Out*

TANK CONTROLS

INSTRUMENTS ON TANKS

- Level elements/transmitters.
- External level gauges on short tanks.
- Level switches.
- Pressure/vacuum breakers (some applications).
- Pressure relief valves (pressurized tanks).
- Temperature elements/transmitters.
- Weight elements/transmitters (for small/batch tanks).

LEVEL ELEMENT : All types



TANK CONTROLS

ALARMS ON TANKS

- Usually on High and Low levels.
- Provide sufficient time for operator to react after alarm triggered and interlock activated
- Allow at least 3 minutes between High and Low alarms for small tanks.
- High-High and Low-Low switches used for interlocking.

TANK CONTROLS

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RETENTION TIME IN TANKS

All retention times are between Low and High alarms.

- Small tanks on pump suction = 3 minutes.
- Large raw material and product tanks =
  Daily consumption x Days between delivery.
- Small raw material and product tanks =
  1.5 x Delivery truck/railcar size.
- Buffer tanks between sub-processes =
  8 hours x Product volumetric transfer rate.

TANK CONTROLS

RETENTION TIME IN TANKS

Retention times between Low alarm and Low-Low interlock.

- Small tanks may not provide sufficient volume for interlocks.
- Large raw material and product tanks =
  1 day requirement in case of late arrival of truck.
- Small raw material and product tanks =
  1 hour for operator to fix problem.
- Buffer tanks between sub-processes =
  1 hour for operator to fix problem.

TANK SAFETY

- Dykes around tanks in open spaces.
- Pressure/vacuum relief valves on closed tanks.
- Vents/Overflows on atmospheric tanks for breathing.
- Heat control to prevent freezing/boiling in tanks.
- Blanketing of volatile/harmful fluids.
- Electrical grounding and electrical connections around flanges for tanks with flammable liquids.
- No control valves on pump suction pipes.

TANK DYKES

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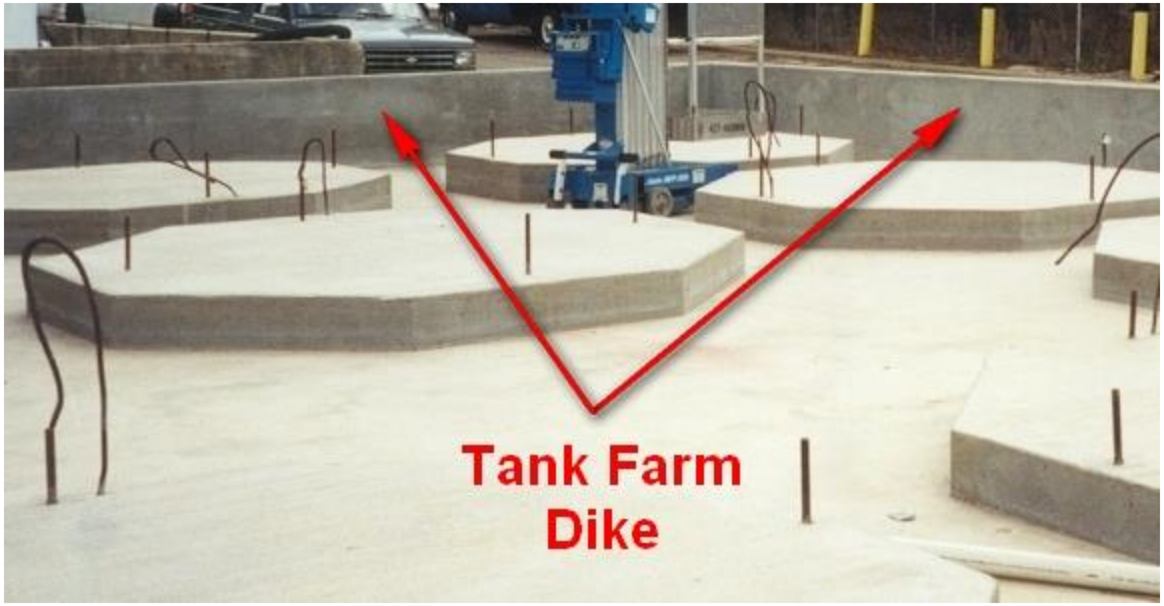
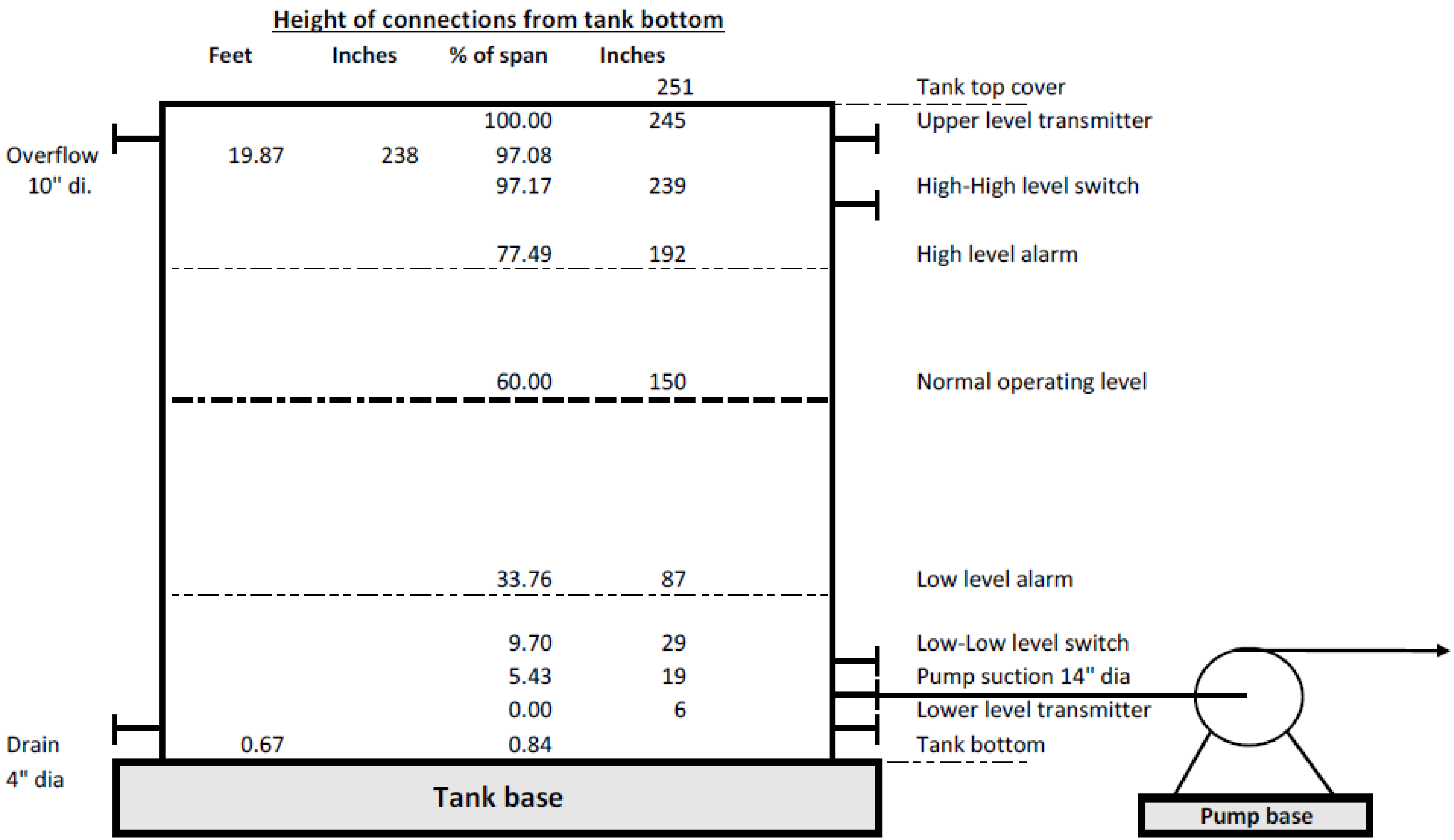
Dyke:

- Containment to prevent tank leaks/ruptures from spilling contents to the ground and to the environment. Keeps leaks within the walls of the dike
- Dyke may contain more than one tank.
- Pumps attached to tanks can be IN or OUT of dyke.
- Contains 115% of the contents of largest tank enclosed in dyke.
- Dykes have no doors, drains, open holes, overflows, etc.
- Access is by steps/ladders up and down the containment walls.
- Distance from tanks to dyke walls usually = half the nearest tank height.
- Volume of space occupied by other tanks in dyke must be subtracted from available containment area.

TANK DYKES



TANK LEVEL ALARMS



WHAT ARE BATCH SYSTEMS

- All ingredients introduced in **same vessel** and stay till end of process.
- All process steps occur in the same vessel (heating, cooling, reaction, separation, etc.)
- Then, vessel is emptied, cleaned and **operation repeated**.
- The vessel is of a **fixed size**.
- **Limited quantity** of product is made at every batch.

WHAT ARE BATCH SYSTEMS USED FOR

- Small production quantities.
- Seasonal products.
- Different products that require different operating conditions but similar operating steps.
- Developmental type processes.
- Processes that require constant operator supervisions and intervention.
- Delicate or expensive products (pharmaceuticals, cosmetics).
- Pipes would be too small if process was continuous.

WHAT ARE CONTINUOUS SYSTEMS

- All ingredients pass through **different pieces** of equipment.
- Each process step occurs in a different equipment (heating, cooling, reaction, separation, etc.).
- Flow of ingredients is continuous and **never stops**.
- Maximum **production rate** is set at design time but can be **modified** by controlling the flows.
- Pipes are large.

WHAT ARE CONTINUOUS SYSTEMS USED FOR

- Large production quantities.
- Same products produced year-round.
- Products that require the same operating conditions.
- Processes require less operator intervention.
- Mature type processes.