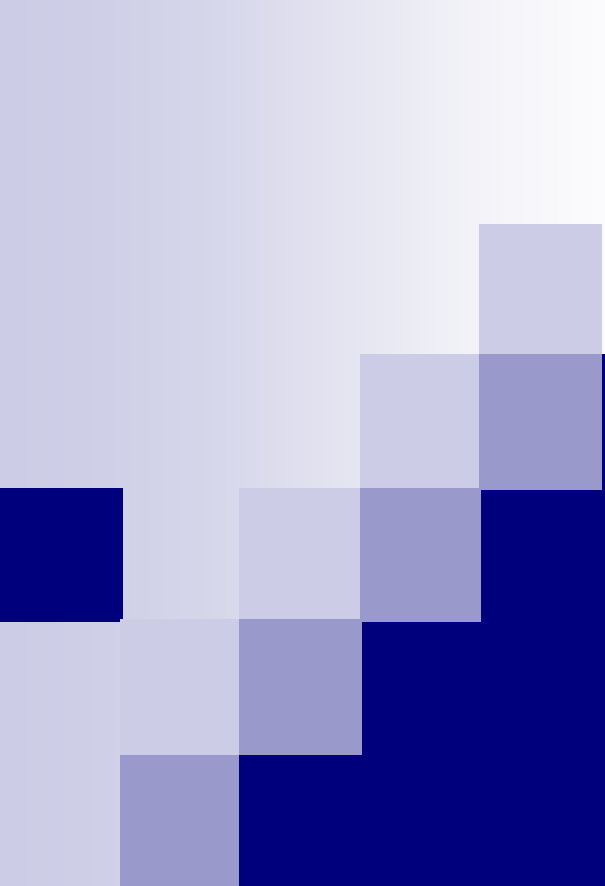




Wastewater Treatment

City of Hamilton, Woodward Ave. Plant

Dennis Moghul

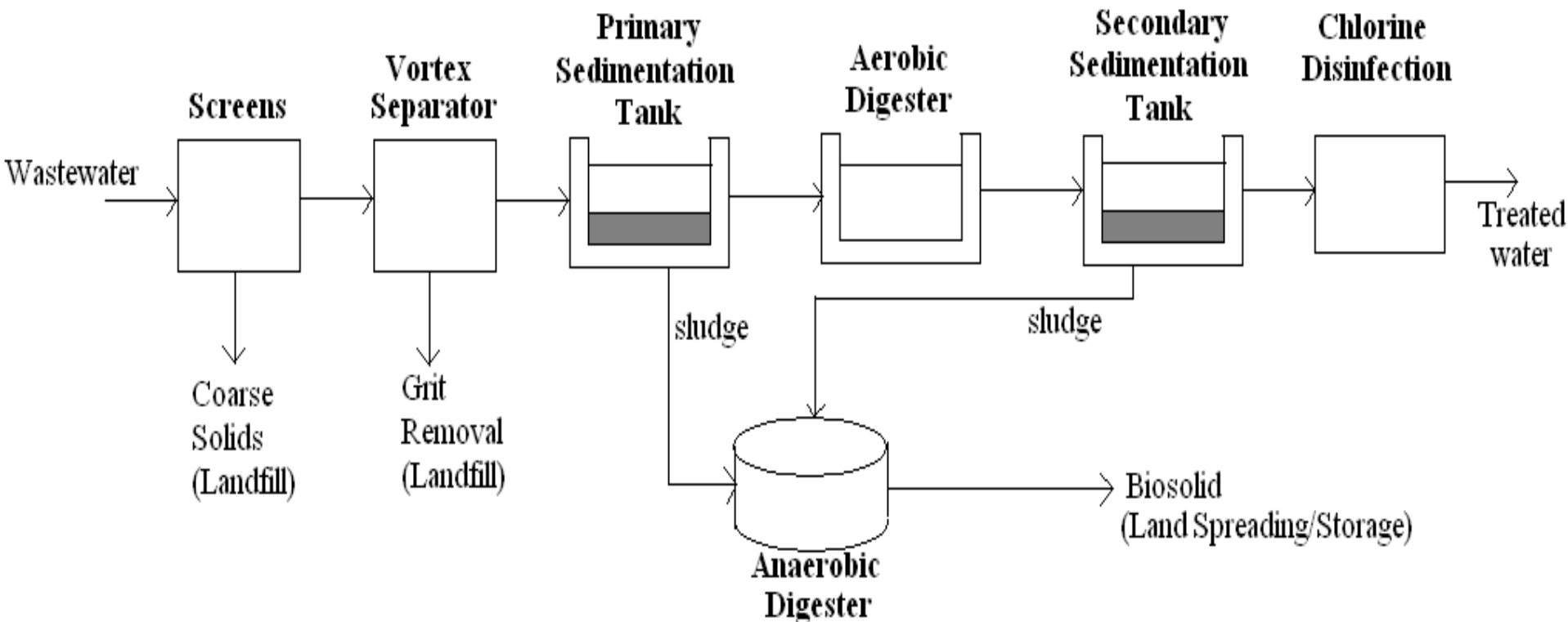
Moiz Rangwalla

Dominic Krakowski

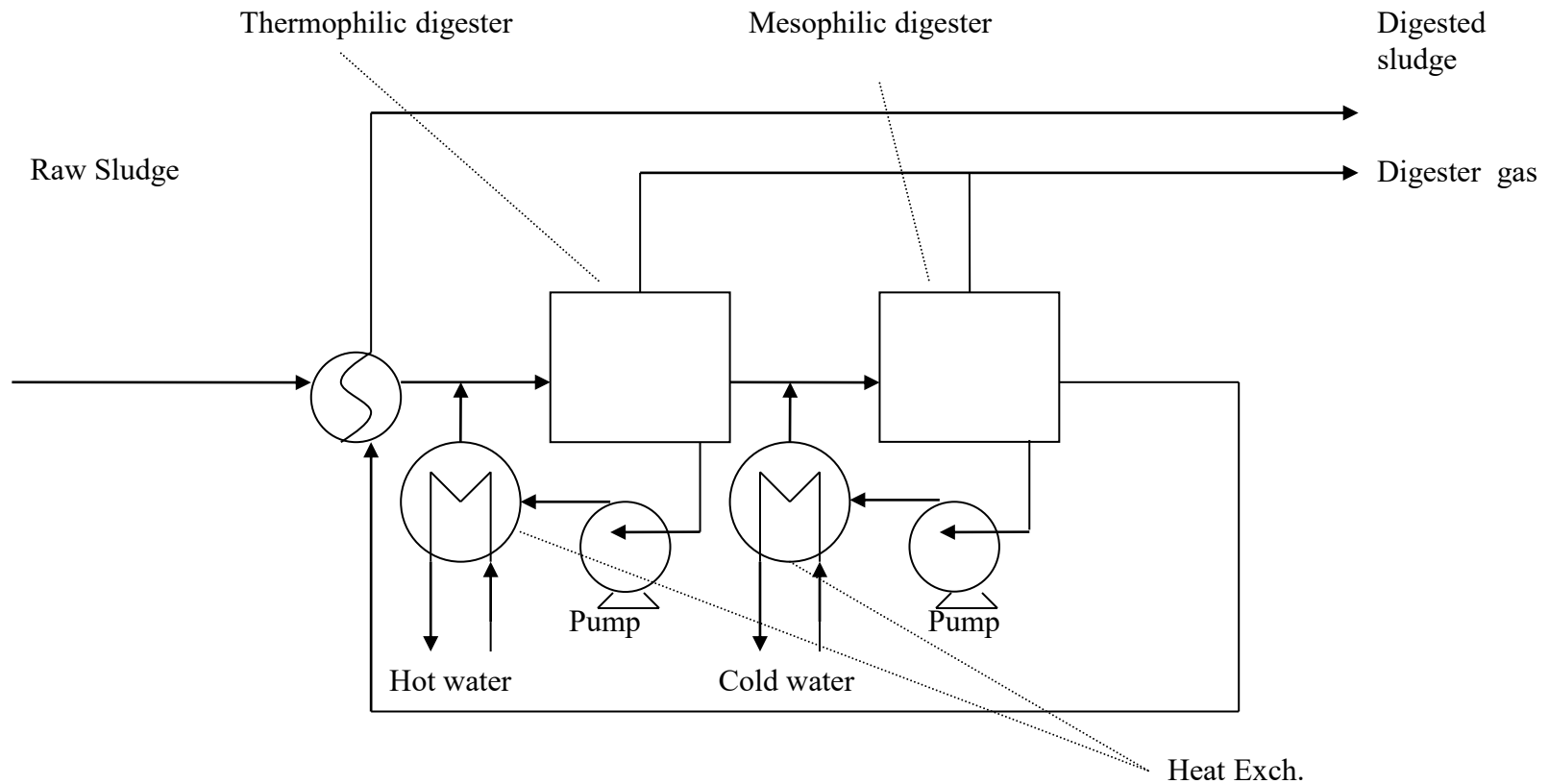
Owen Lee

Vincent Leung

Overall Process



Scope of Process – The Anaerobic Digester





Anaerobic Digestion

Thermophillic digester:

- Operates at 52-58°C with a solids retention time of 3-8 days
- Increased temperature greatly reduces pathogen levels
- 500m³

Mesophillic digester:

- Operates at 32-38°C with a solids retention time of 10-15 days
- Bulk of bio-gas (60-70% methane) formation in this digester
- 2400m³



Anaerobic Digestion

What happens after digestion?

- Bio-gas produced can be used as an energy source (for heat exchangers, to drive pumps/blowers, or generate electricity)
- Un-digested sludge is recycled back into the anaerobic digestion process until the un-digested sludge is classified as a Class A Bio-solid
- Class A Bio-solid is when sludge is pathogen free prior to land disposal

Economics Case study

Renewable Energy Project 2006

- Instead of flaring off the biogas use combustion to generate energy
- Built a 1.6 MW cogeneration facility
- Electricity & Thermal energy are produced



http://www.cleanairalliance.org/files/active/0/chp_institutions.pdf



Profitability Summary

- Initial capital cost of 4.4 million dollars
- Approx. Annual Costs/Revenues
 - \$ 380,000 operation cost
 - \$ 450,000 natural gas savings
 - \$ 1.1 million in electricity generation

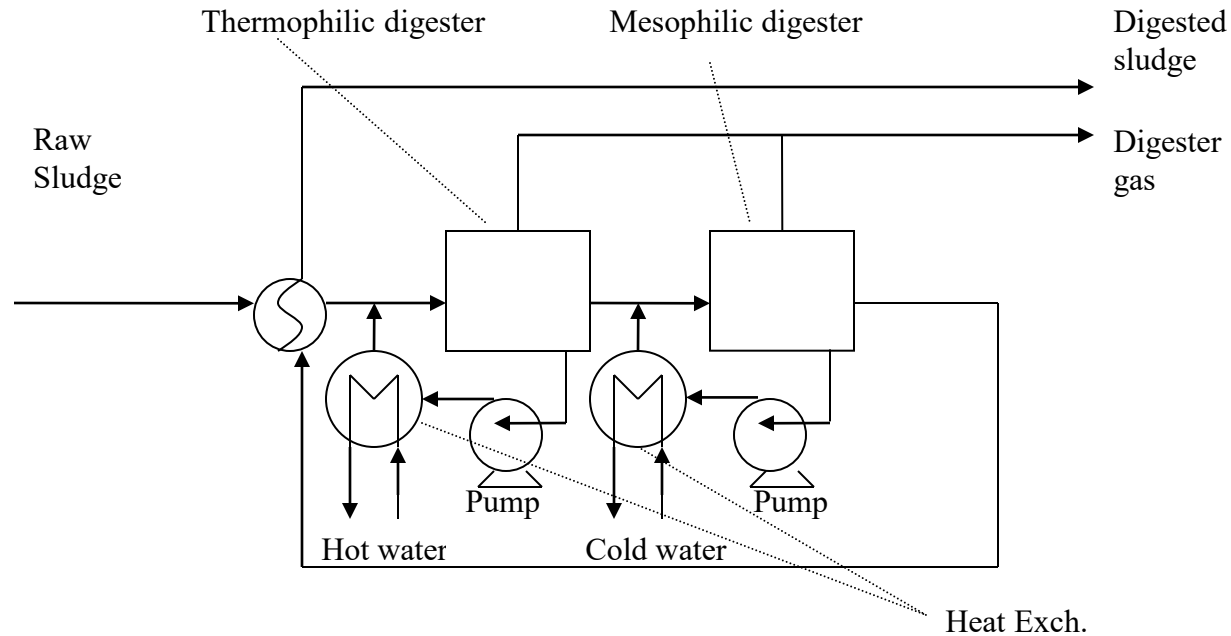
Looks Profitable, let's analyze with NPV calculation

Net Present Value Determination

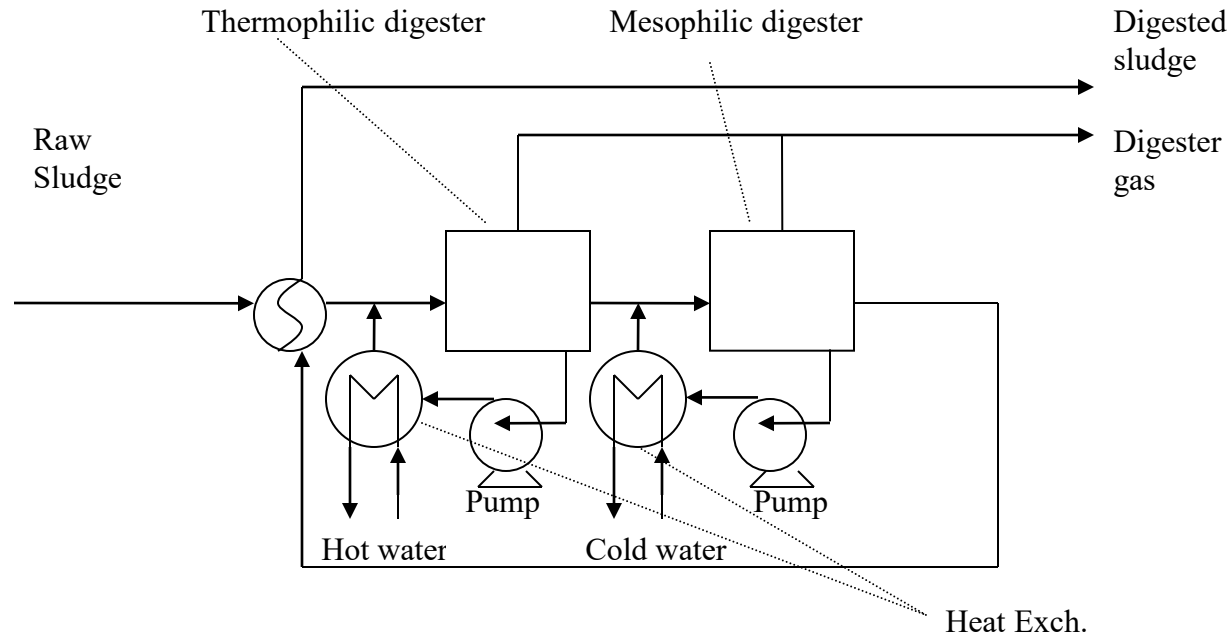
For a ten year period with 10% interest

	Year										
Year	0	1	2	3	4	5	6	7	8	9	10
Capital Cost	-4.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Electrical revenue	0.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Natural gas savings	0.00	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45
Operations Costs	0.00	-0.38	-0.38	-0.38	-0.38	-0.38	-0.38	-0.38	-0.38	-0.38	-0.38
Cash Flow	-4.40	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
PV	-4.40	0.97	0.88	0.80	0.73	0.66	0.60	0.55	0.50	0.45	0.41
NPV =	2.17469	All values are in millions of dollars									

Taking Advantage of Generated Thermal Energy

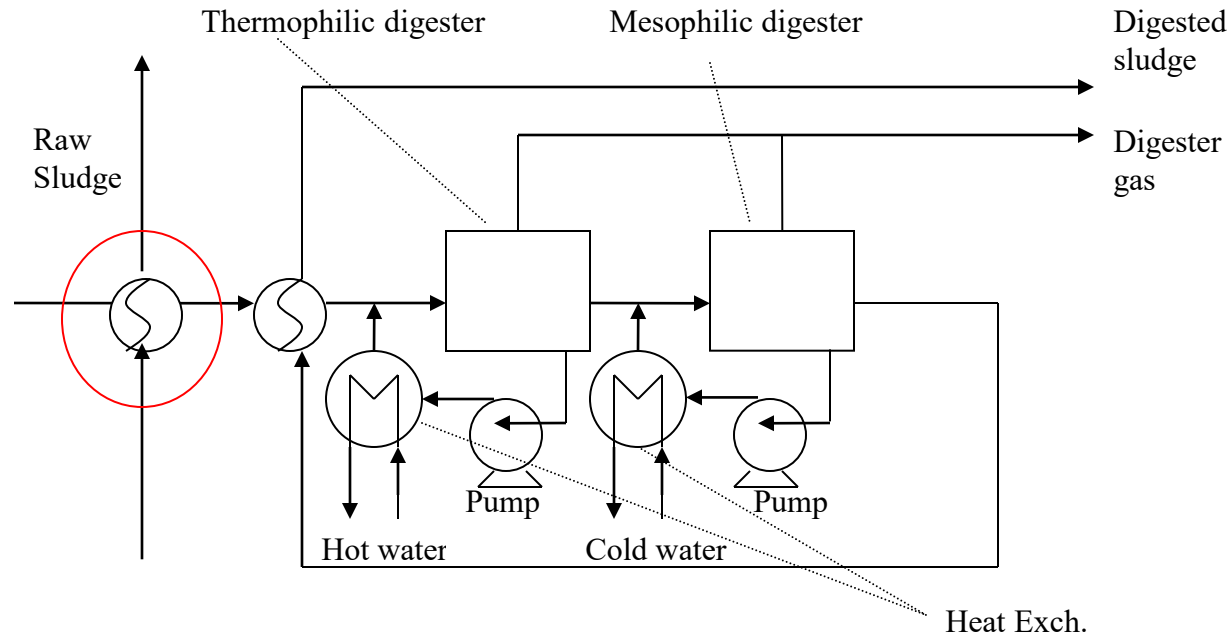


Taking Advantage of Generated Thermal Energy



Add a heat exchanger to use the heated water to warm the raw sludge

Taking Advantage of Generated Thermal Energy



Add a heat exchanger to use the heated water to warm the raw sludge

Cost Estimating Heat Exchanger

50m² Carbon Steel

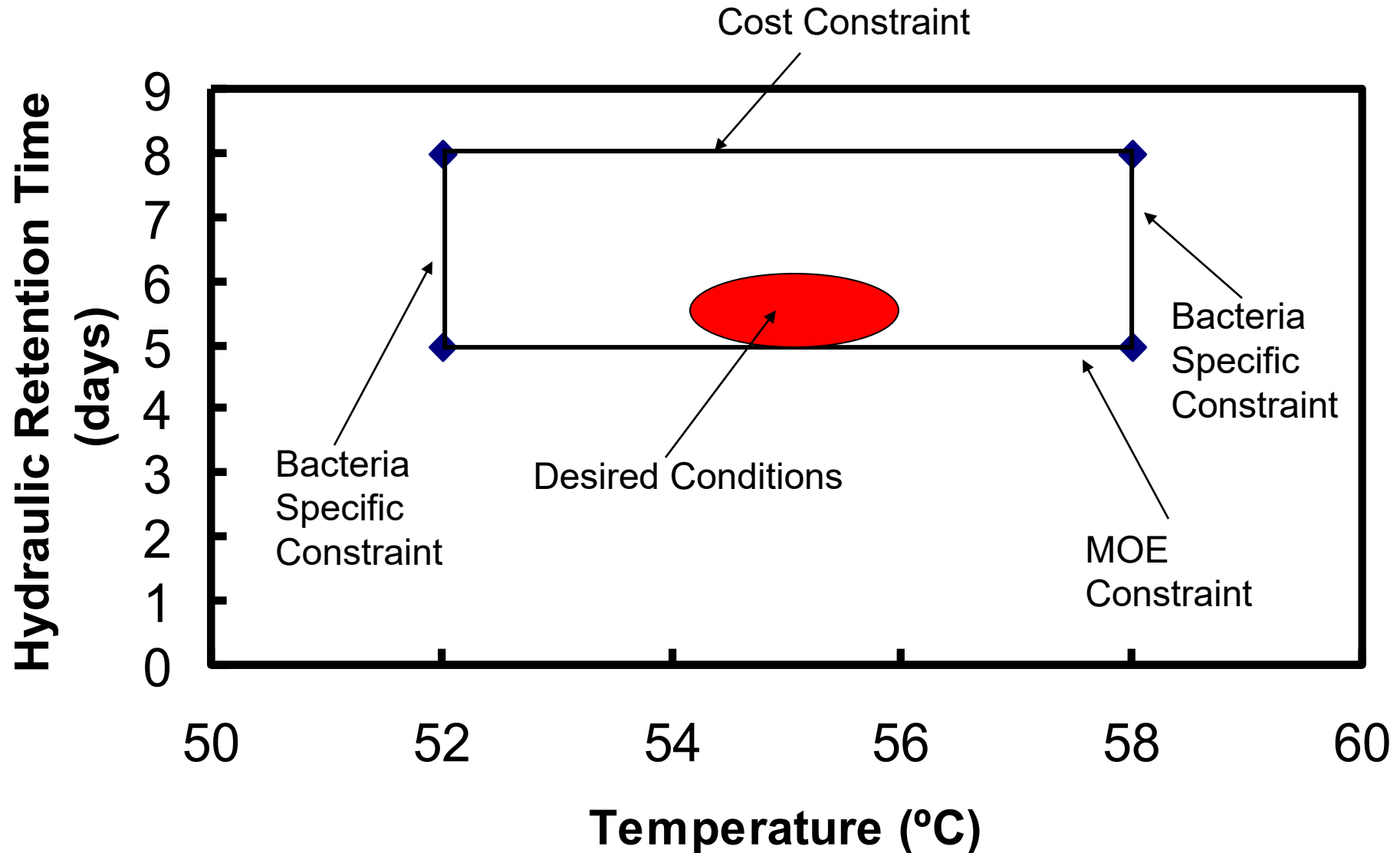


http://www.machineryandequipment.com/featured/images/used_spiral_heat_exchanger.jpg

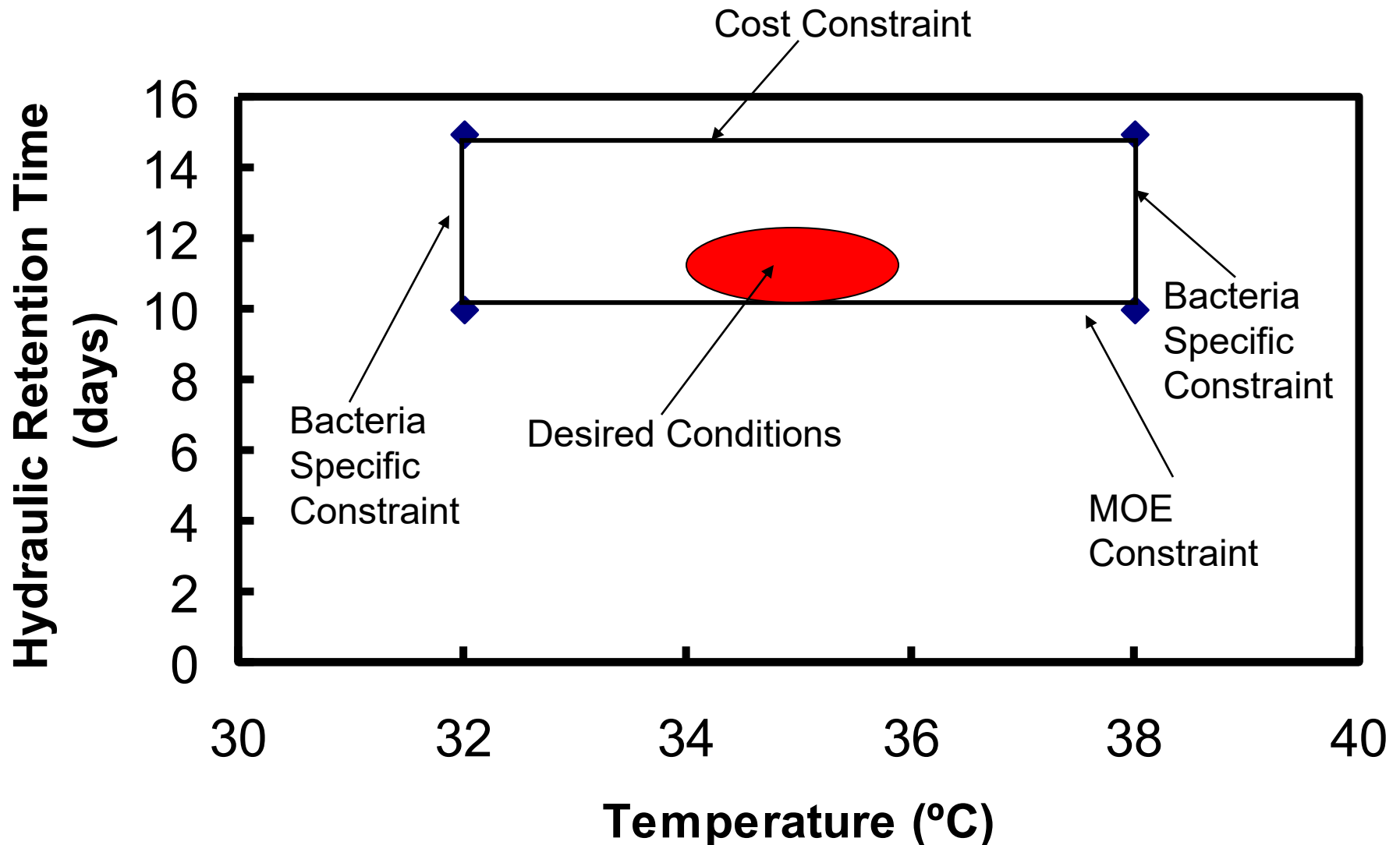
Case	Cost
Free on Board	\$1,184.02 +/- 40%
Bare Module	\$4,144.07 +/- 40%
Total Module	\$4,848.57 +/- 40%
Adjust for inflation	\$23,588.45 +/- 40%

Retrieved from Dr. Woods Book

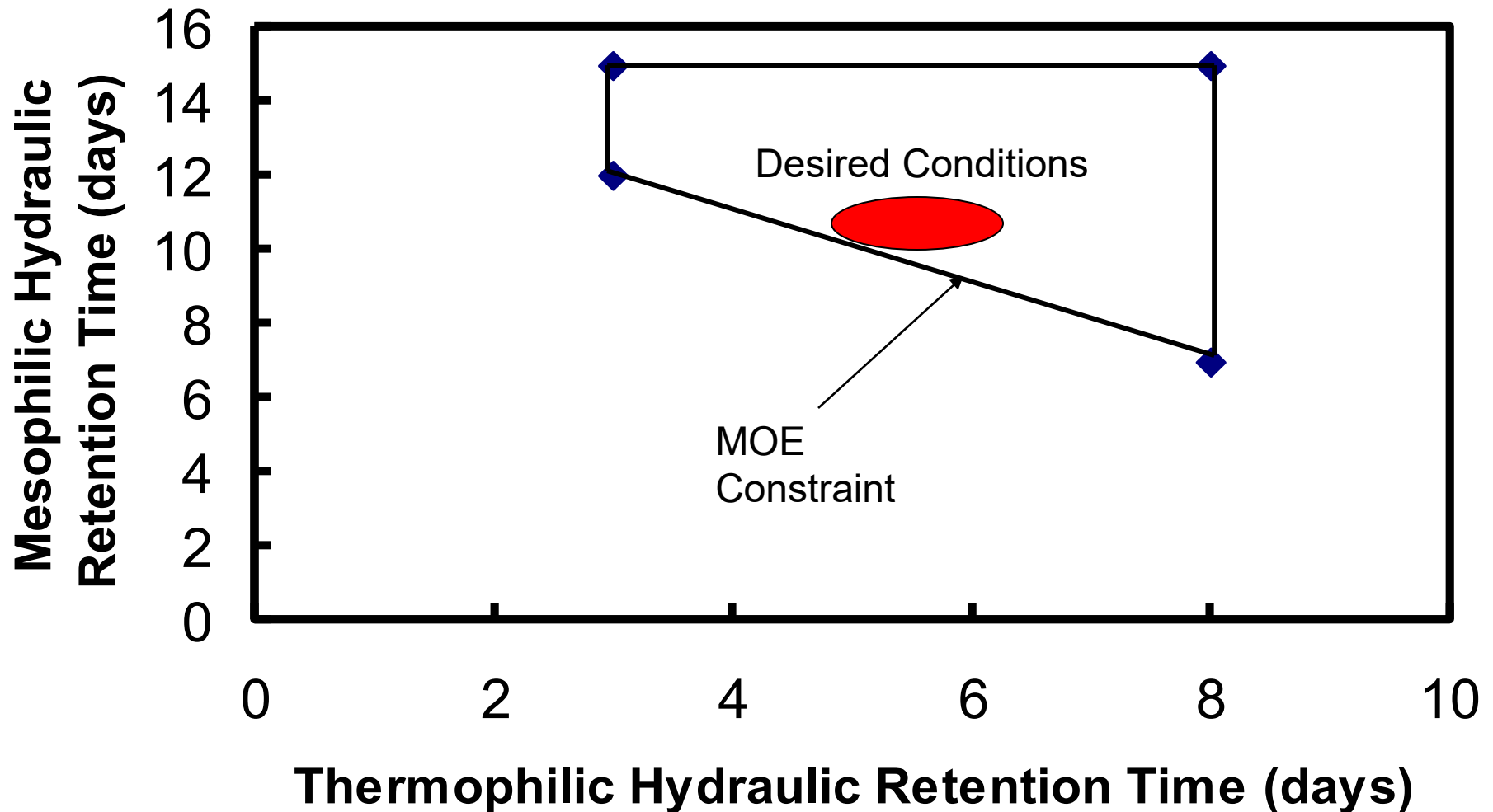
Operating Window for Thermophilic Digester



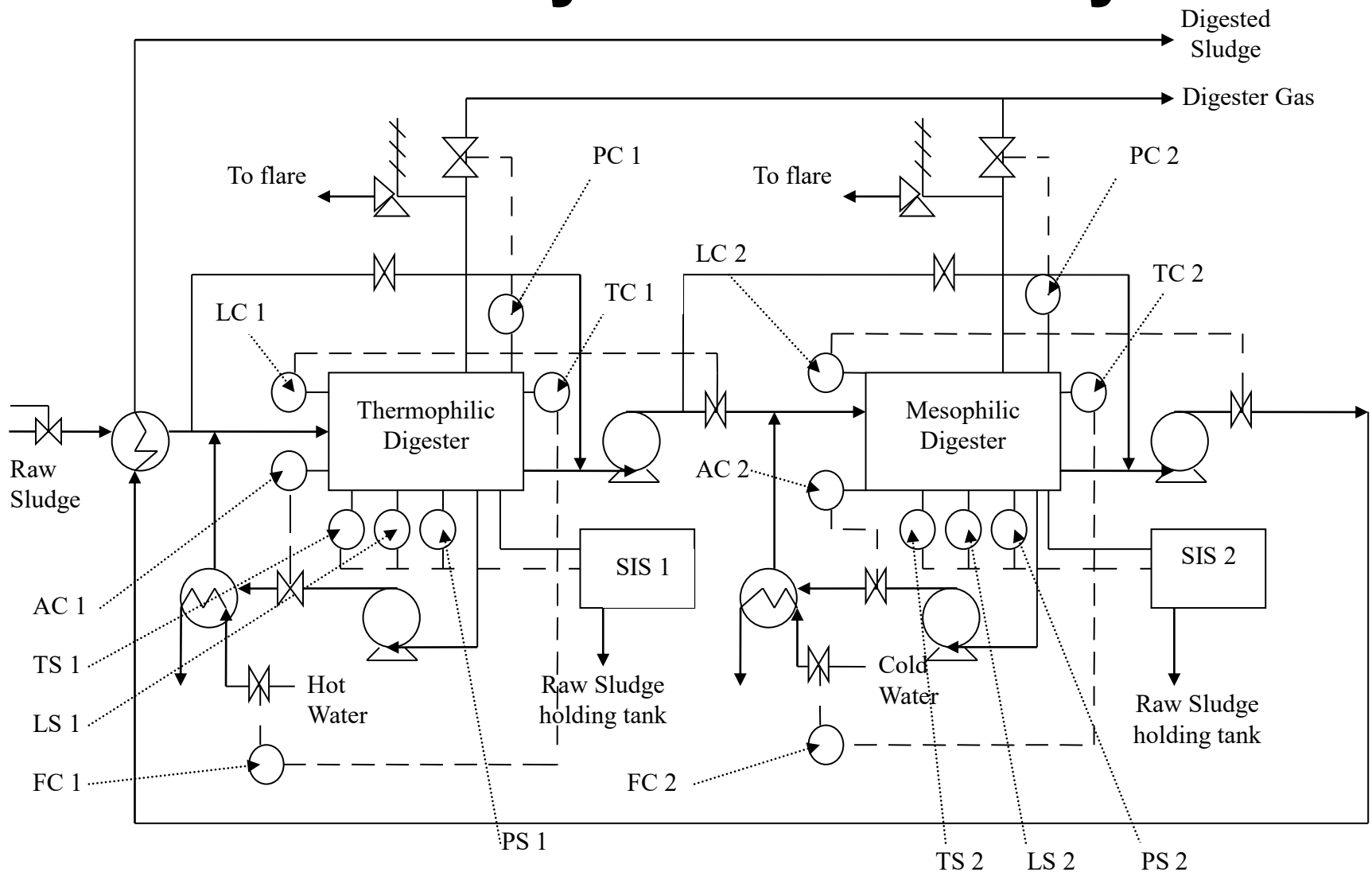
Operating Window for Mesophilic Digester

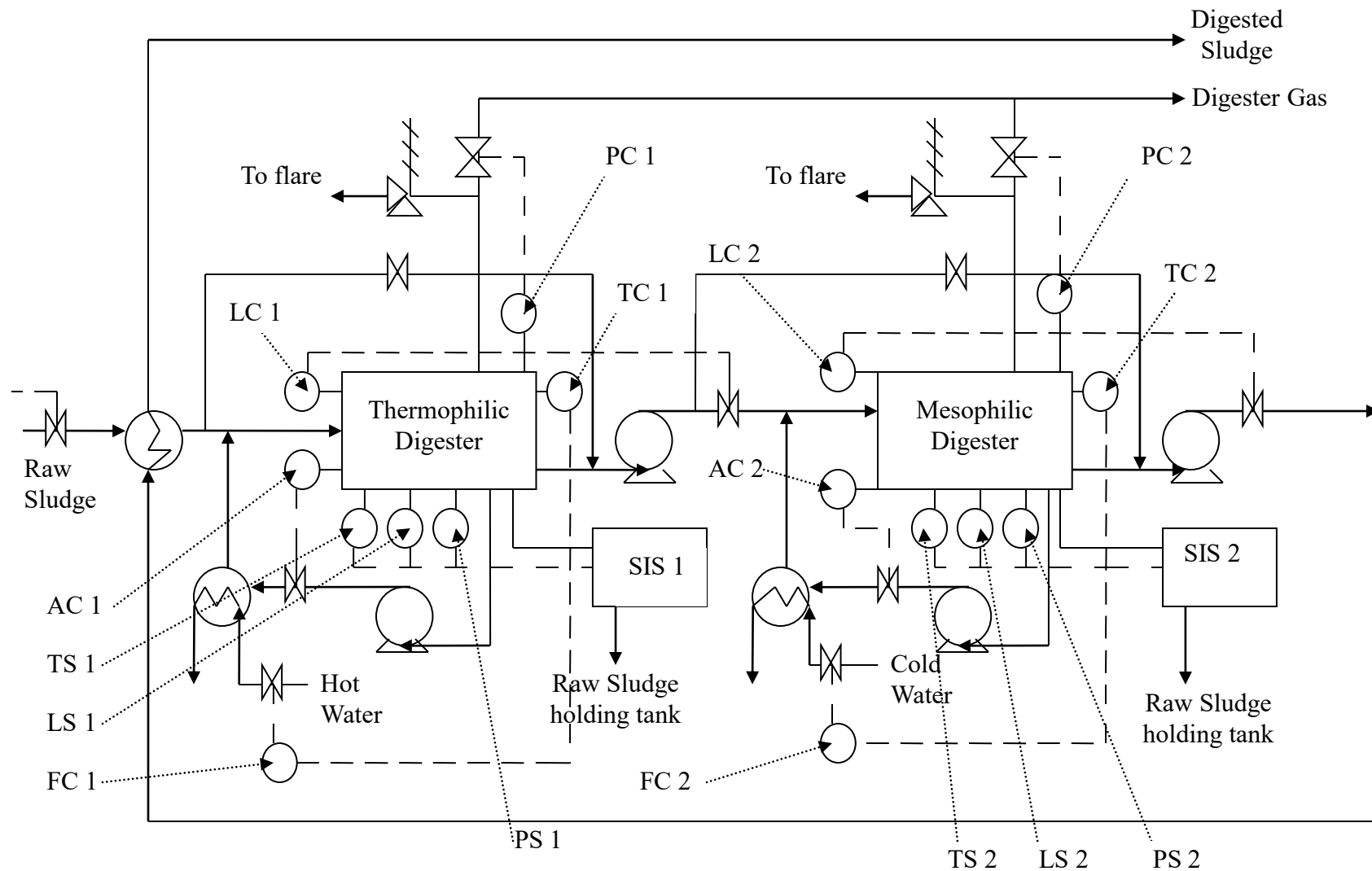


Operating Window for Total Retention Time



Flexibility and Reliability

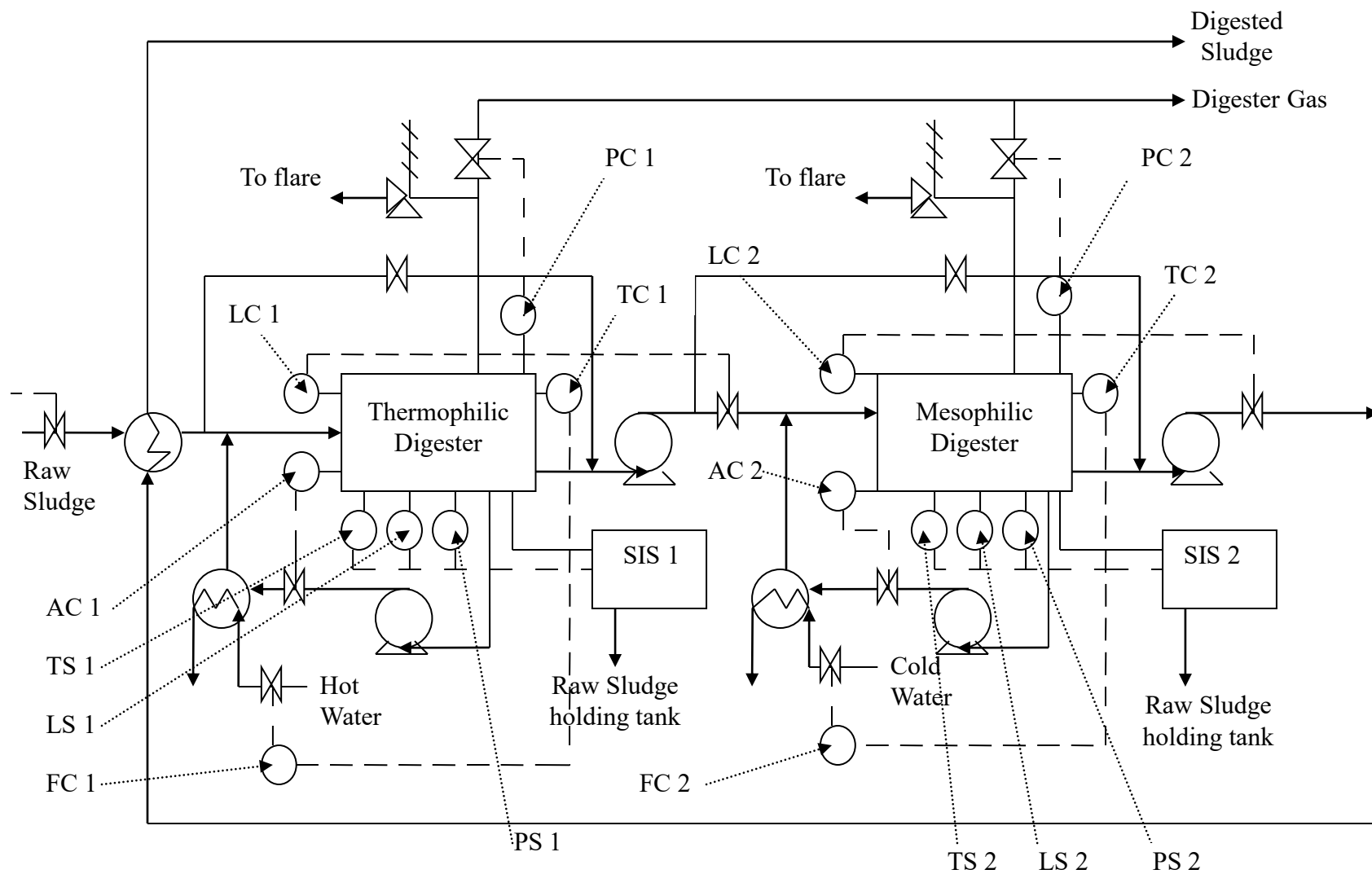






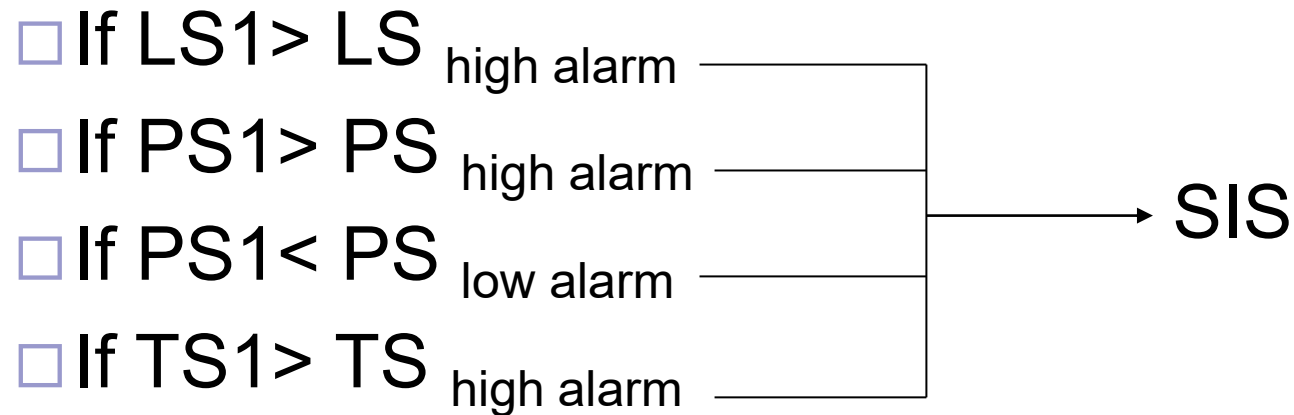
Safety Considerations

- Basic Process Control System (Level 1):
 - Temperature control (TC1, TC2) using cascade system
 - Level control (LC1, LC2)
- Critical Alarms (Level 2):
 - High and Low pressure alarms (backup sensors) sent to operator for immediate action
 - Informs operator of potential explosion or implosion.
 - Other critical alarms: level and temperature

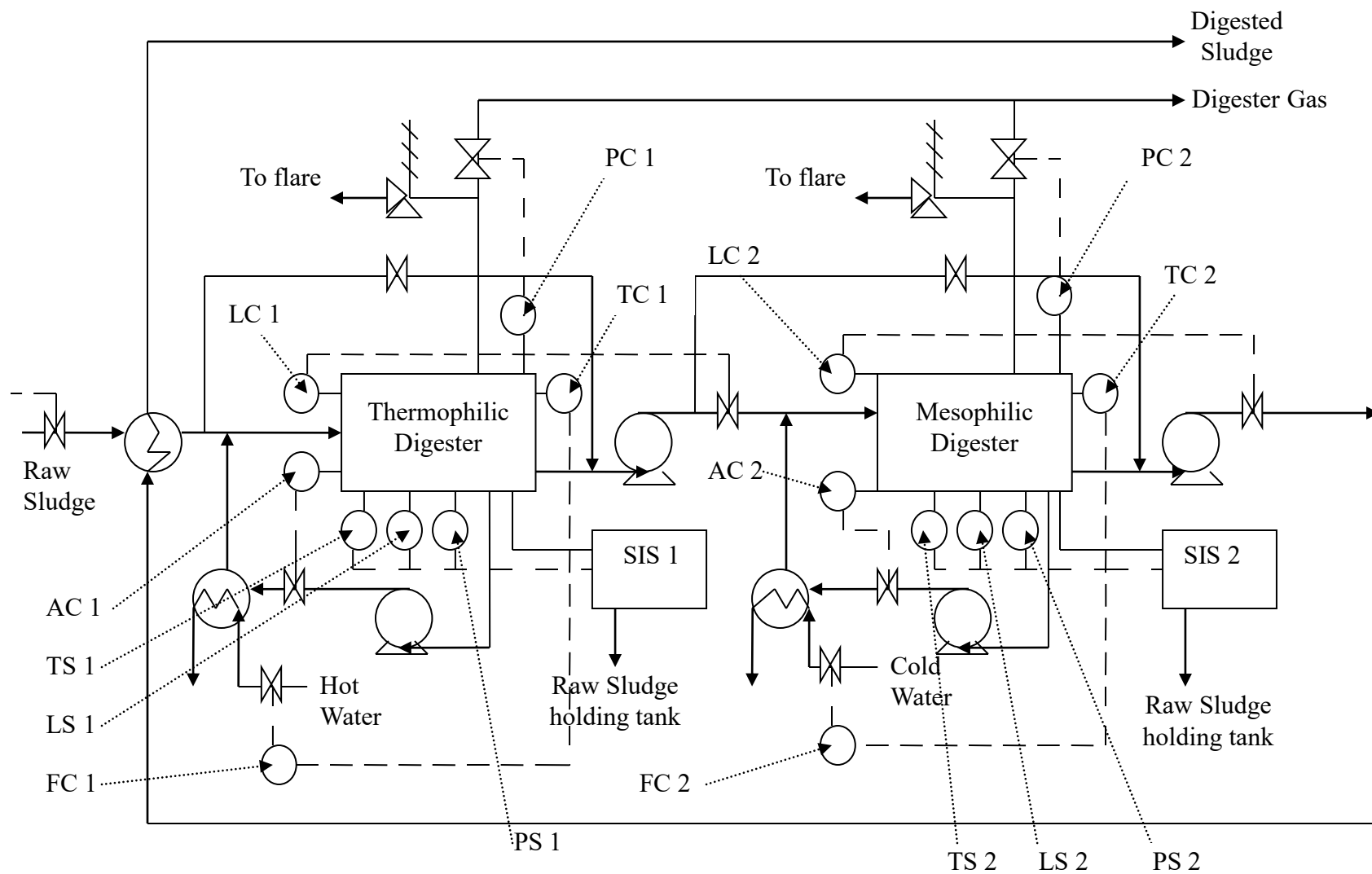


Safety Considerations

■ Emergency Shut Down: SIS (Level 3):



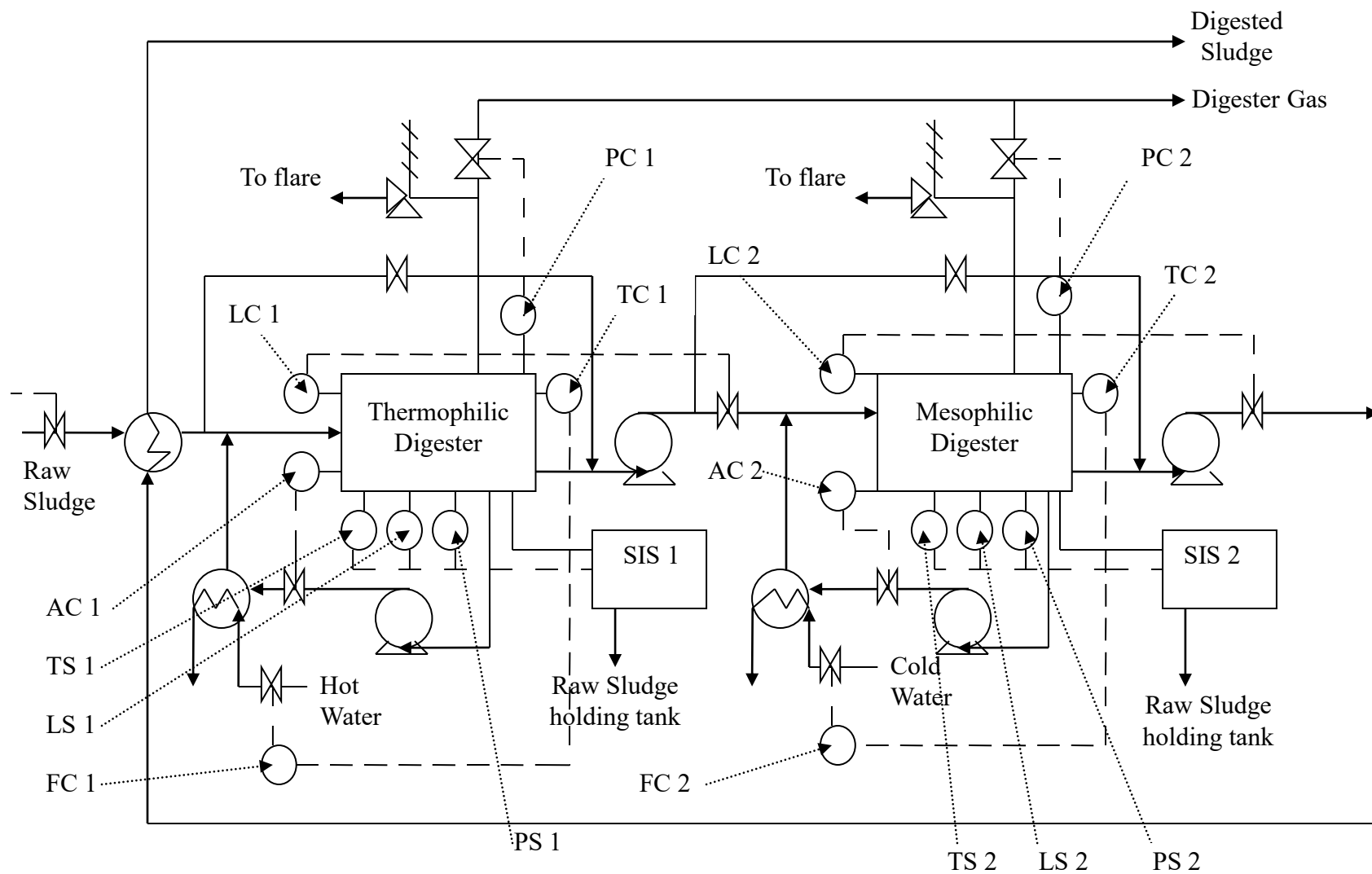
- ☐ Redundant sensors can be used as a failsafe mechanism (sensor failure)
- ☐ Also implemented for the mesophilic digester



Safety Considerations

■ Relief System (Level 4):

- Pressure safety valve: used to relieve off-gas
- Designed for pressures greatly exceeding the high pressure alarm
- Off-gas sent to flare to be combusted
- Can also implement low and vacuum pressure safety valve (make sure **inert** is introduced into system)





Safety Considerations

- Containment (Level 5):
 - ☐ Prevent oxygen from entering system (lining, seals etc).
 - ☐ For start-up: purge system of oxygen
 - ☐ Overflow chambers and drains (send sludge back to holding tanks)
- Emergency Response (Level 6):
 - ☐ Emergency response team/personnel designated
 - ☐ Evacuation of non-required personnel
 - ☐ Authorities are informed of situation immediately

HAZOP Case Study

Unit: Thermophilic Digester

Node: Feed pipe (before recycle pump)

Parameter: Flow Rate

Guide Word	Deviation	Cause	Consequence	Action
No	No feed flow	1. Digester has no sludge	a) Damage to recycle pump b) Potential damage to Heat exchanger c) Low retention time	1) Close LC1 valve 2) Open raw sludge

HAZOP Case Study

Guide Word	Deviation	Cause	Consequence	Action
No	No feed flow	2. Blockage of outlet pipe	a) Damage to recycle pump b) Potential damage to Heat exchanger c) Low retention time	1) Reverse rotation of mixer to change flow pattern 2) Shut down process

HAZOP Case Study

Guide Word	Deviation	Cause	Consequence	Action
No	No feed flow	3. Vacuum pressure in digester	a) Damage to recycle pump b) Potential damage to Heat exchanger c) Low retention time	1) Shut down process

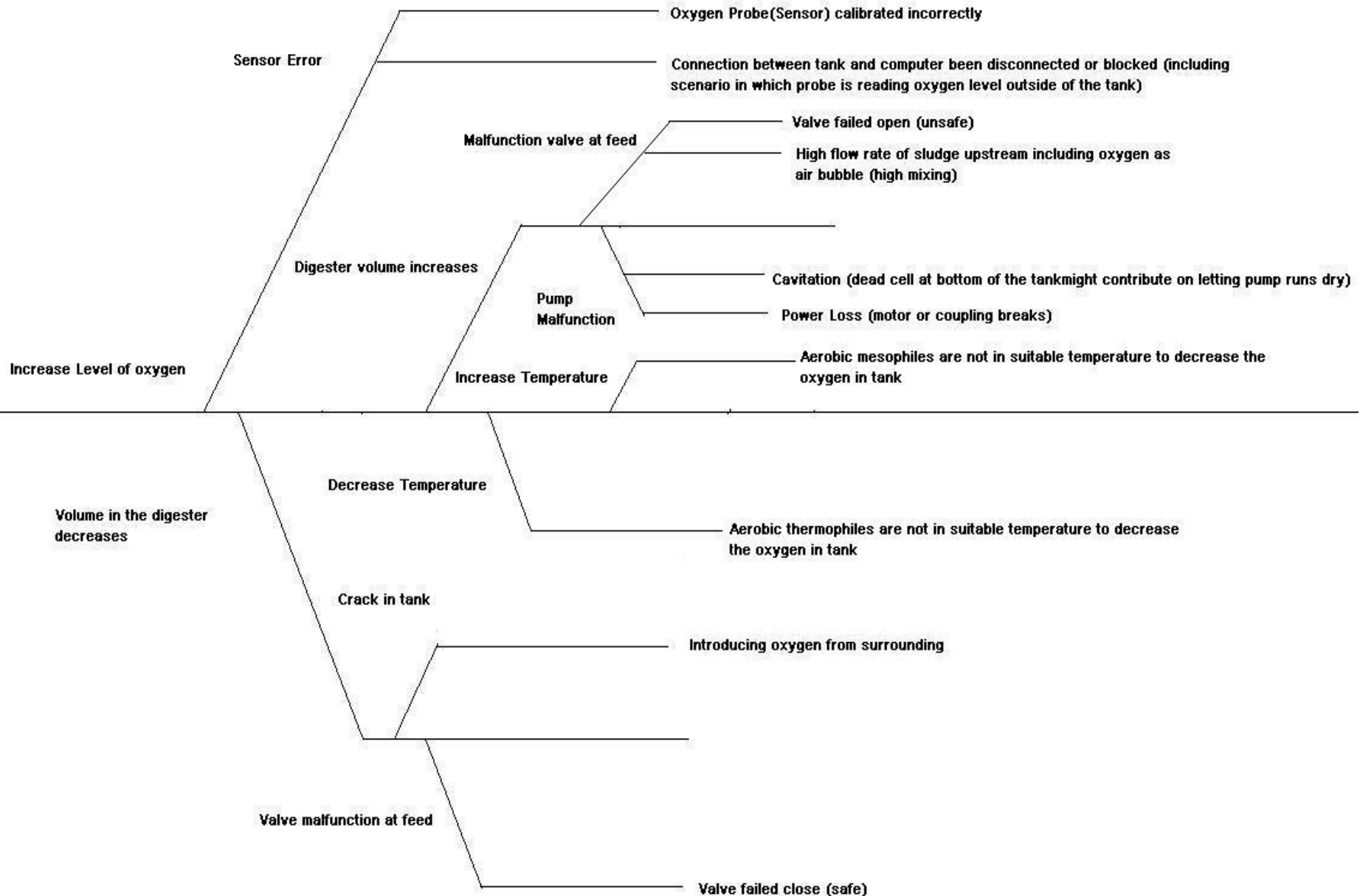


Troubleshooting:

Possible cause for increase oxygen

- Sensor Failure
- Fluctuating sludge Level in the digester
- Feed valve failure
- Fluctuating Temperature within the tank

Trouble shooting case: increase oxygen level in the digester





Thank You

Questions Please!