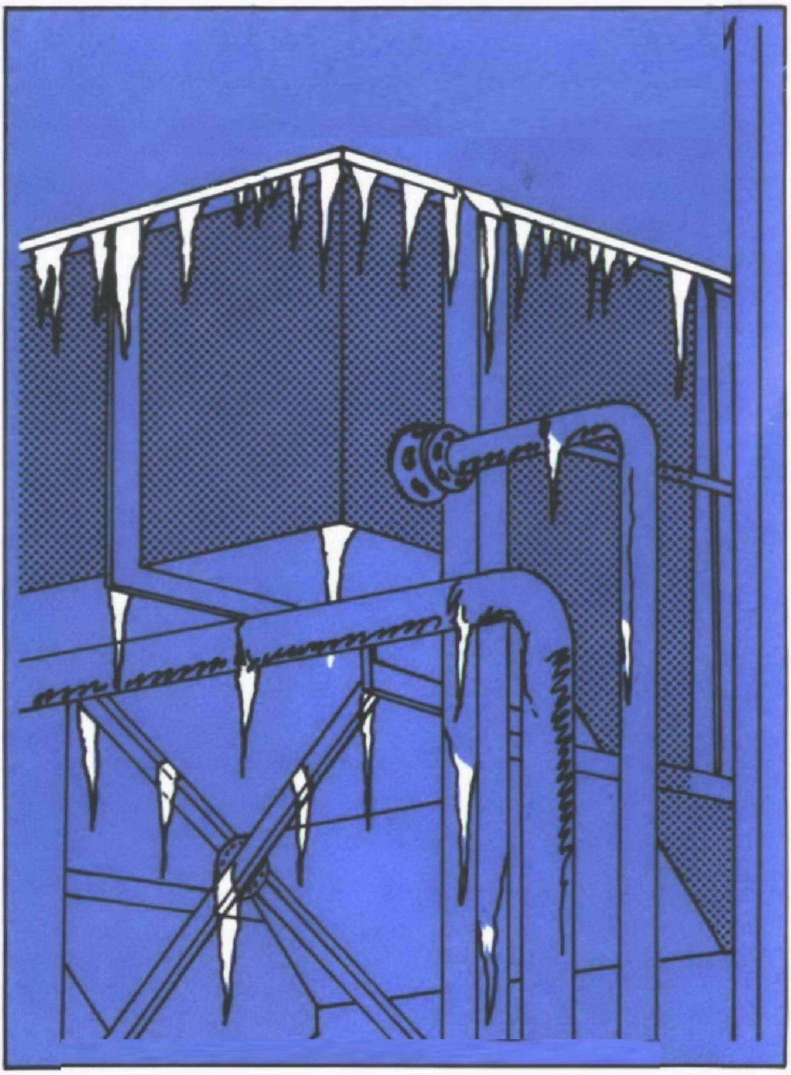
United States
Environmental Protection
Agency

September
1986

EPA

Operation of Conventional Wastewater Treatment Facilities in Cold Weather



Background

Cold weather can have significant and often severe effects on the operation and performance of a wastewater treatment facility. Because the system's components and the physical, chemical and biological treatment responses are temperature dependent, performance efficiency can suffer under low temperature conditions However, cold weather conditions can also offer beneficial opportunities for heat recovery and sludge dewatering

A national survey reported that cold weather problems were a major cause of poor performance and often resulted in higher operation and maintenance costs. In some cases, it appears that cold weather conditions were not fully considered in the original facility design. As a result, treatment plant operators have developed solutions to the problems caused by cold weather. Their solutions should be helpful to other operators and also to design engineers so that these problems might be avoided in future systems.

The Problems and Solutions

The survey identified the cold weather problems most commonly encountered among conventional treatment facilities and their solutions These solutions can be implemented by either improved design, equipment or by simple operation and maintenance procedures.

The majority of cold weather problems can be grouped into the following categories:

- Ice formation in various process components.
- Viscosity changes in the wastewater and in lubricants for mechanical equipment.
- Reaction rate changes in physical, chemical and biological reactions.

Ice formation in process components is the most troublesome, since the entire plant's operation will be disrupted if one unit has to be shut down even temporarily. A survey of facilities in northern New England indicated significant problems with preliminary treatment, clarifiers (both primary and secondary), and biological reactors. Tables 1, 2, and 3 list these problems and the solutions developed by the operators

Problem	Solution
Ice in headworks and on bar racks and grit screen	Cover inlet channel; flush rack with water, clean more frequently, duct kerosene heater into unit
Screened rags freeze	Remove very frequently
Grit conveyor freezes	Enclose the unit.
Collected grit freezes	Store containers in heated shelter before emptying
Screw pumps freeze	Install timer to "bump" screw once per hour; run warm water on unit.
Valves and hoses freeze	Drain lines, keep flow on (only if plant water system)
Automatic samplers freeze	Place inside heated shelter, build temporary winter shelter with light bulb for heat; insulate suction lines, purge lines after sampling, suction lines should be vertical for quick drainage
Flow measurement devices freeze	Use heat tape and insulation on transmitter, heat (with light bulb) and insulate chamber, use heat tape on Parshall flume linkage; add antifreeze to float box.
Bypass channel at grit removal freezes	Switch flow to bypass for 30 min/day
Ice formation in the comminutor chamber	Build temporary structure.
Access doors freeze due to condensation	Put heat tape around door perimeter

Table 1. Problems with Preliminary Treatment in Cold Weather

Grit handling seems to be one of the most difficult preliminary treatment activities in cold weather. Temporary wind screens erected during cold months will reduce heat losses and freezing problems, but in extreme climates future designs should enclose the entire grit removal operation including conveyors and dumpster storage areas

Problem	Solution
Surface icing	Cover the tank, shorten detention times; remove skimmer arms; operate 24 hrs /day; suspend rock filled plastic bucket in tank to reduce ice stresses on walls
Icing in idle units	Pump units routinely, remove ice before restart
Icing in gear units	Install heat tapes; drain water after rain and after thaw periods.
Scum trough freezing	Cover unit, hand remove ice; install automatic flushing unit, use hot water, stop scum removal in winter, decrease exposed plate area if adjustable
Ice on controls for traveling bridge	Build enclosure.
Condensation icing on electrical bus bars	Install hot air gun
Hydrants and hoses freeze	Drain, leave flow on (only if plant water system)
Snow accumulation stops monorake wheels	Shut down during storm.
Samplers freeze	Build box with light bulb for heat.
Waste activated sludge lines freeze	Place lines deeper in ground; insure drainage between uses.
Scum line freezes	Flush with hot water; use sewer pig to clean.

Table 2. Problems with Clarifiers in Cold Weather

The most serious problem with both primary and secondary clarifiers is ice build-up and scum freezing on the beach plate. This can damage the skimmer mechanism The response in many locations has been to totally remove the scum skimmer arm in the cold weather months.

Problem	Solution
Ice build-up on surface aerator	Steam ice off, bump unit on and off, turn off for 1/2 hour to allow liquid to warm unit then run at high speed
Ice build-up on support towers or aerator shroud	Use hose and hot water, shorten detention time or run unit on timers, remove shroud to avoid impact damage from ice thrown up by aerator
Cooling of liquid affects performance	Use timers on aerators, use diffused air instead of surface units, remove some aerator blades; increase MCRT; decrease F/M ratio
Icing in idle units	Fill tank and circulate water with small sump pump, remove ice prior to restart to avoid structural damage to rakes, etc. on restart
Icing on oxidation ditch brushes	House brush, use heat lamps; use floating log or screen to keep ice from brush.
Complete ice cover on tanks	Remove ice; cover tank
Icing on trickling filter walls	Stop flow from outer nozzles, cover whole unit
Poor performance for trickling filter	Cover unit, close some air vents

Table 3 Problems with Biological Units in Cold Weather

Figure 1 illustrates a system developed at Hampton, NH which flushes the solids out of the scum box after each pass of the skimmer arm The flush bar is tripped by the skimmer arm and allows tank effluent to enter the box and wash out the remaining floating solids The amount of flush water is adjusted with counterweights on the bar. The device works well, but freezing still occurs during prolonged periods of extremely cold weather.

Cold Weather

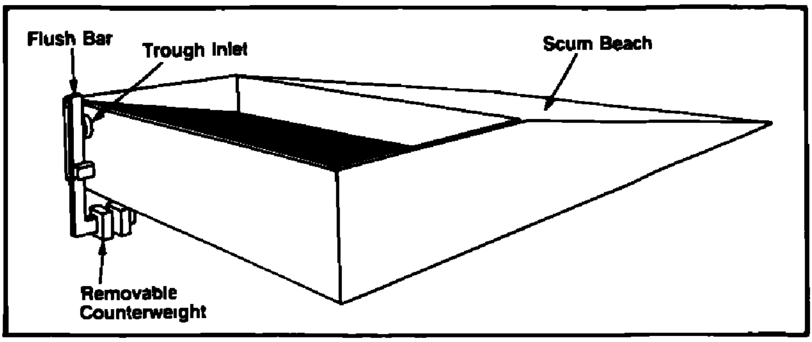


Figure 1 Self-cleaning scum trough at Hampton, New Hampshire wastewater treatment plant

Some Opportunities

Most manufacturers recommend seasonal changes of oil in gear boxes and similar equipment A number of systems have changed successfully to the use of the synthetic, multiviscosity year-round lubricants These lubricants are analyzed twice a year for metals and water content to determine excessive wear or the presence of moisture Under normal conditions the lubricant may last three years or more Since it can take 20 to 25 gallons of oil for each change, the savings for materials and labor can be significant

The wastewater entering the system represents a heat source which can be beneficially utilized in the cold months The possibilities range from simple temporary covers over tanks for passive heat conservation to active efforts using heat exchangers for direct heat recovery Heat exchangers in the system at Fort Greely, Alaska extract enough heat from the wastewater to heat the main building and the chlorination station Heat exchangers are also used at Wilton, Maine and Delafield, Wisconsin to extract heat from the wastewater

Freezing as a Benefit

Freezing temperatures can be beneficially utilized for sludge dewatering Freezing and then thawing a sludge will convert a material with a jelly-like consistency to a granular material which drains immediately A sludge at 2 to 8 percent solids placed on a sand bed and allowed to freeze can attain 25 percent solids as soon as it is thawed

The key to successful performance is to apply the sludge to the bed in layers about 8 cm deep and to allow each layer to freeze before the next is applied. It is essential for the sludge to freeze completely for the dewatering benefits to be realized. A very deep layer might never freeze to the bottom in locations where alternating freezing and thawing conditions occur. Design details can be found in references 2 and 3. A preliminary estimate of the total depth of sludge which could be frozen in sequential 8 cm layers can be determined with this equation:

$$Y_T = 1.76 (F_p) - 101$$

Where: Y_T = total depth (cm) of sludge that could be frozen during cold weather if applied in 8 cm layers.

F_P = maximum depth (cm) of frost penetration into the soil at the location of concern (From local experience or records).

Figure 2 illustrates this relationship for the United States.

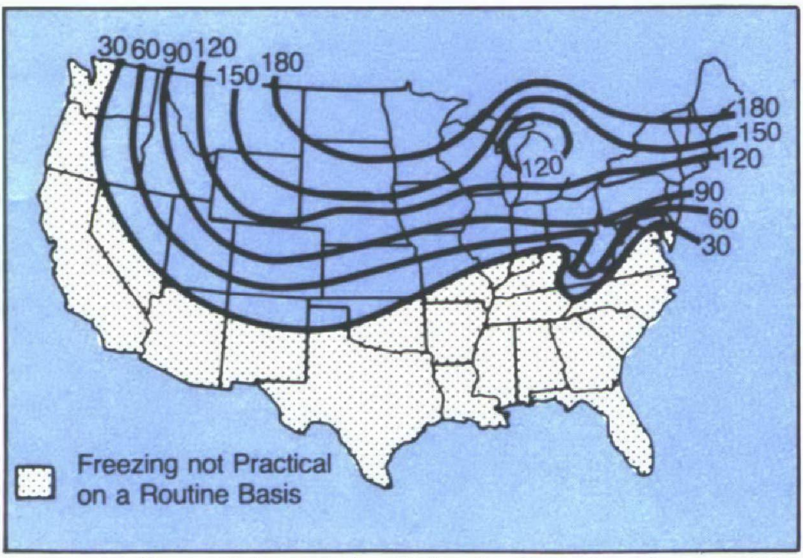


Figure 2. Potential total depth (cm) of sludge that could be frozen if applied in 8 cm. layers.

Conclusions

Cold weather can seriously affect the operation and performance of wastewater treatment facilities. Many of these problems can be eliminated or reduced to tolerable levels by carefully trained operators, and can be avoided in future systems by appropriate design modifications. Therefore, the design of a system should consider what the site conditions will be like during cold weather months when high winds, snow and ice are prevalent.

References

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