High Head Centrifugal Grinder Pumps in Low Pressure Sewer

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Presentation Overview

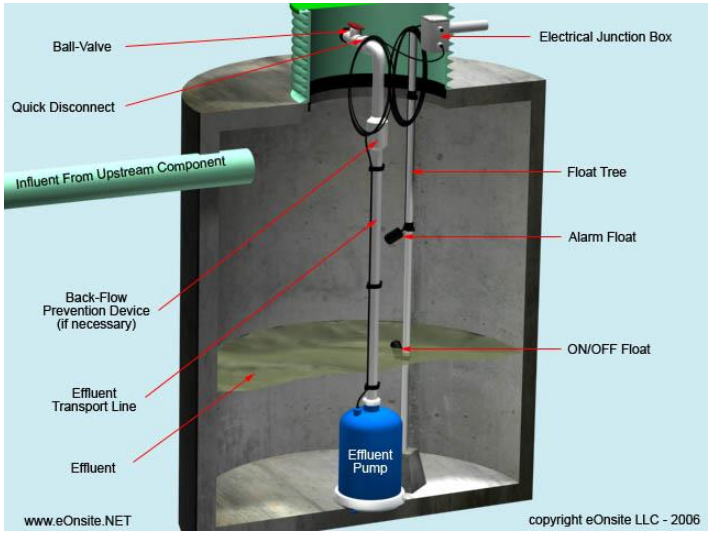
Presentation will provide practical pump knowledge for pressure sewer applications and will provide product comparison between two different pump technologies available and the application benefits of each.

Low Pressure Sewer

Low Pressure Sewer System

- Two major types of pressure sewer
  - Septic Tank Effluent Pump (STEP)
  - Grinder Pump (GP)

- In **STEP** systems:
  - Conventional septic tank is used to capture solids
  - Liquid effluent is contained in holding tank containing a pump and control devices. The effluent is pumped to treatment
  - Recommended minimum scouring pipe velocity is 1 FPS
  - Periodic pumping of septic tank is required



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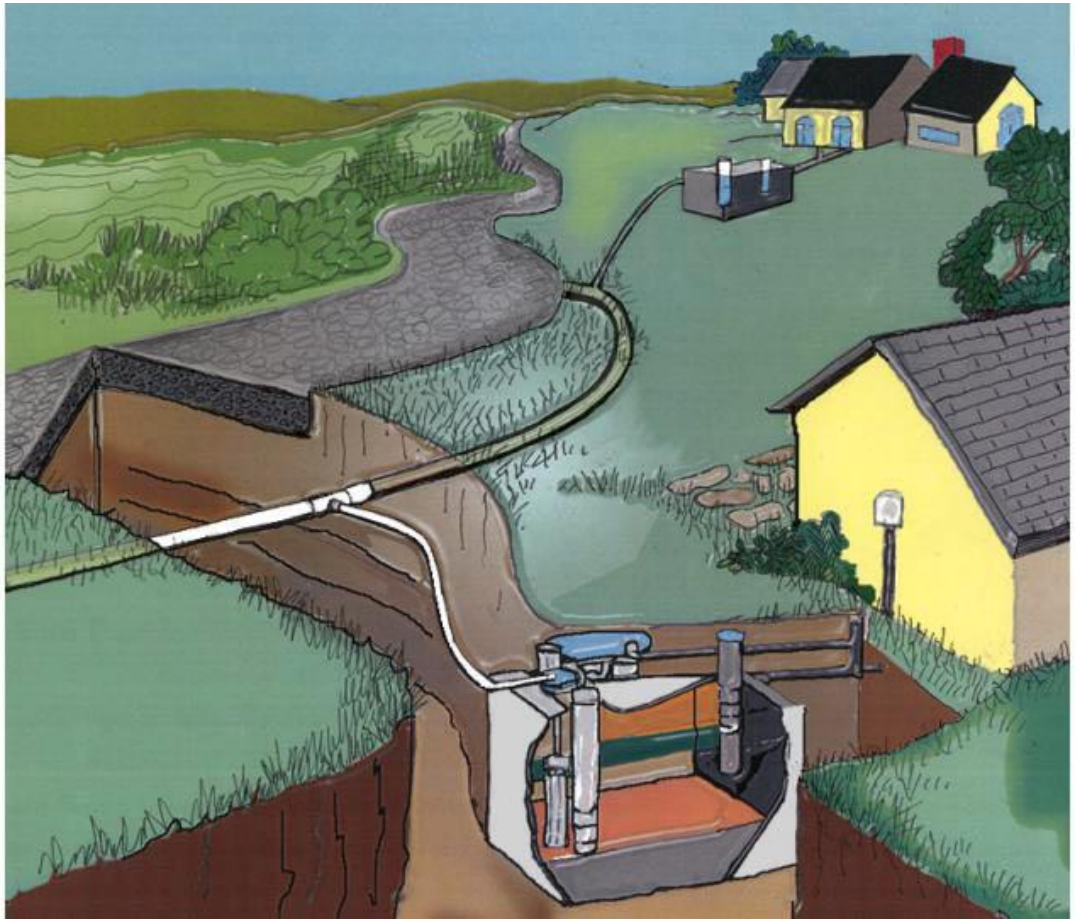
Low Pressure Sewer (STEP)



Purdue University Document ID-265

STEP System utilizing tank to collect solids and effluent is pumped via small diameter pipe

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Low Pressure Sewer

Grinder Pump Low Pressure Sewer System

- A system that utilizes individual residential grinder pumps* to pump the wastewater through a small diameter pipe network to a treatment system.
- Connection quantity can be a few to 1,000's
- Pressure sewers are compatible with other collection system techniques.
- Typical to have a blended system of grinder pumps and gravity with large submersible pumping stations
- Minimum pipe scouring velocity is 2 - 3 feet per second+

**A residential grinder pump is a submersible pump designed to reduce wastewater particulate to a slurry and provides the energy to force the slurry through the small diameter pipe network .*

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Low Pressure Sewer

- LPS is an economical solution to challenging environmental conditions where gravity sewers are impractical

- Typical pressure sewer sites include:
  - Rocky or sandy soil – Minimizes depth of excavations
  - Hilly terrain – Follows the surface profile instead of downward slope
  - High ground water tables – Minimizes or eliminates dewatering
  - Long flat terrain – Minimizes depth of excavations and eliminates lift stations to raise the water up to the next gravity line
  - Slow growth areas - Lowers upfront cost and capital investment.
  - Existing structures/roads – Reduces disruption of roads and mature landscape.
  - Environmentally sensitive areas – Reduced spill potential
  - Failing septic systems can be replaced with minimal disturbance

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Pressure Sewer Applications

- LPS has been implemented all over the world with millions of connected residences and businesses.
- Cost is a significant driver for utilization of pressure sewer in remote, rural, low density locations
- Septic System replacement utilizing pressure sewer is currently the largest applications, second to new home construction.

Prudhoe Bay, Alaska

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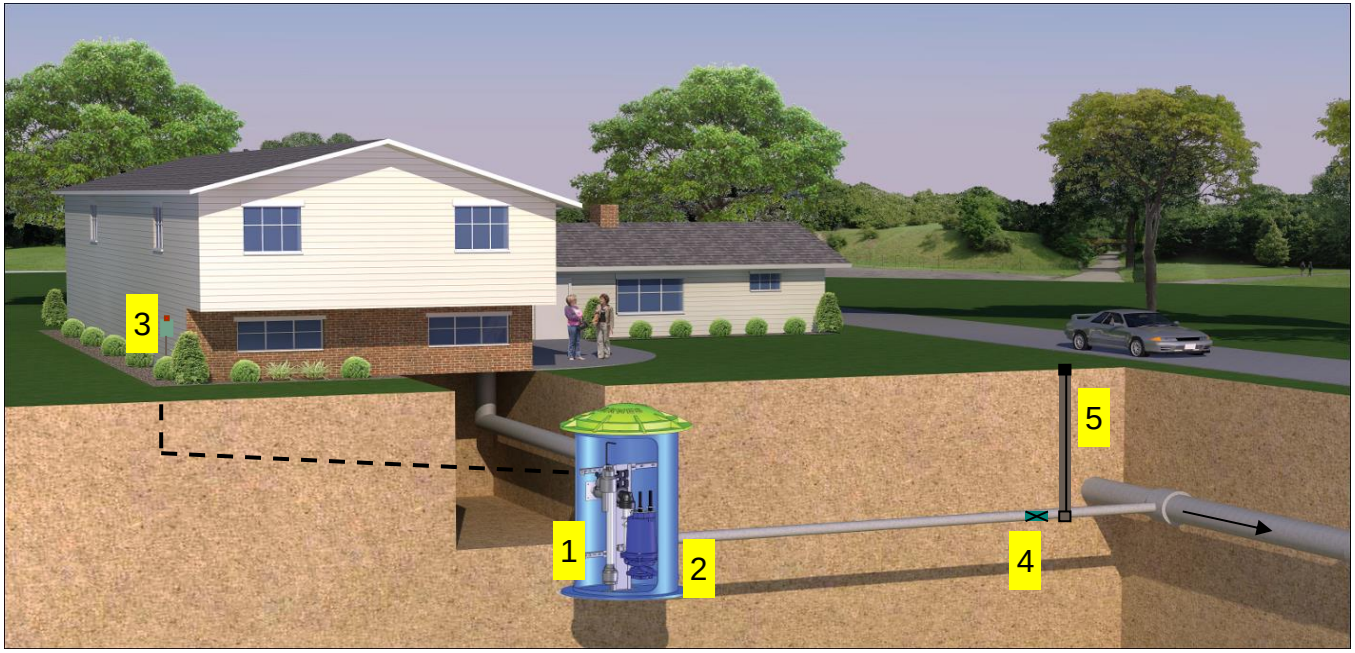
LPS Grinder Pumps

A typical Low Pressure Sewer (LPS) System includes a grinder pump and level control[1], basin[2], alarm/control panel[3], pipe, redundant check[4] valve, air release valves and shut off valves[5].

For a dependable system with minimal maintenance issues, all of the components must be sized and applied correctly.



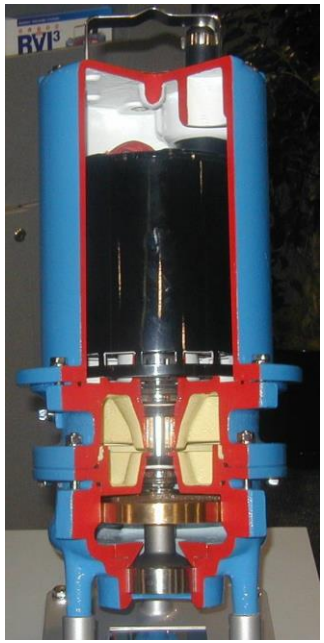
LPS Grinder Pumps

The primary component of any LPS System

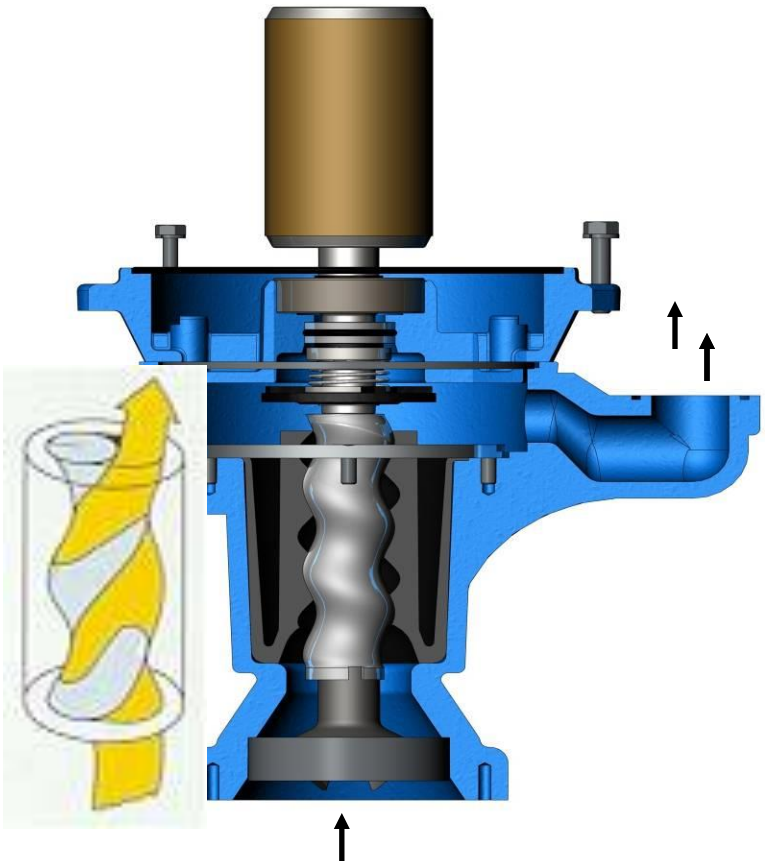
Centrifugal and **Progressing Cavity** Type Grinder Pump

Both styles have been implemented in grinder pump basins for over 30 years by a number of different manufacturers

Both pumps, 1 – 2 Hp, grind the sewage into small particles (1/8”) prior to pumping action of the respective components



PC Grinder Pumps



Progressing Cavity Type
Grinder Pump Cut Away

Progressing Cavity (PC) Grinder Pumps

- Progressing Cavity (PC) grinder pumps utilize two primary components, a metal rotor and a matching elastomeric stator. These depend on friction between each other in order to seal against the developed pressure.
- The progressive cavity pump is ideal for handling slurries, viscous, shear sensitive material or when applications require, significant suction lift capabilities or high discharge pressures.

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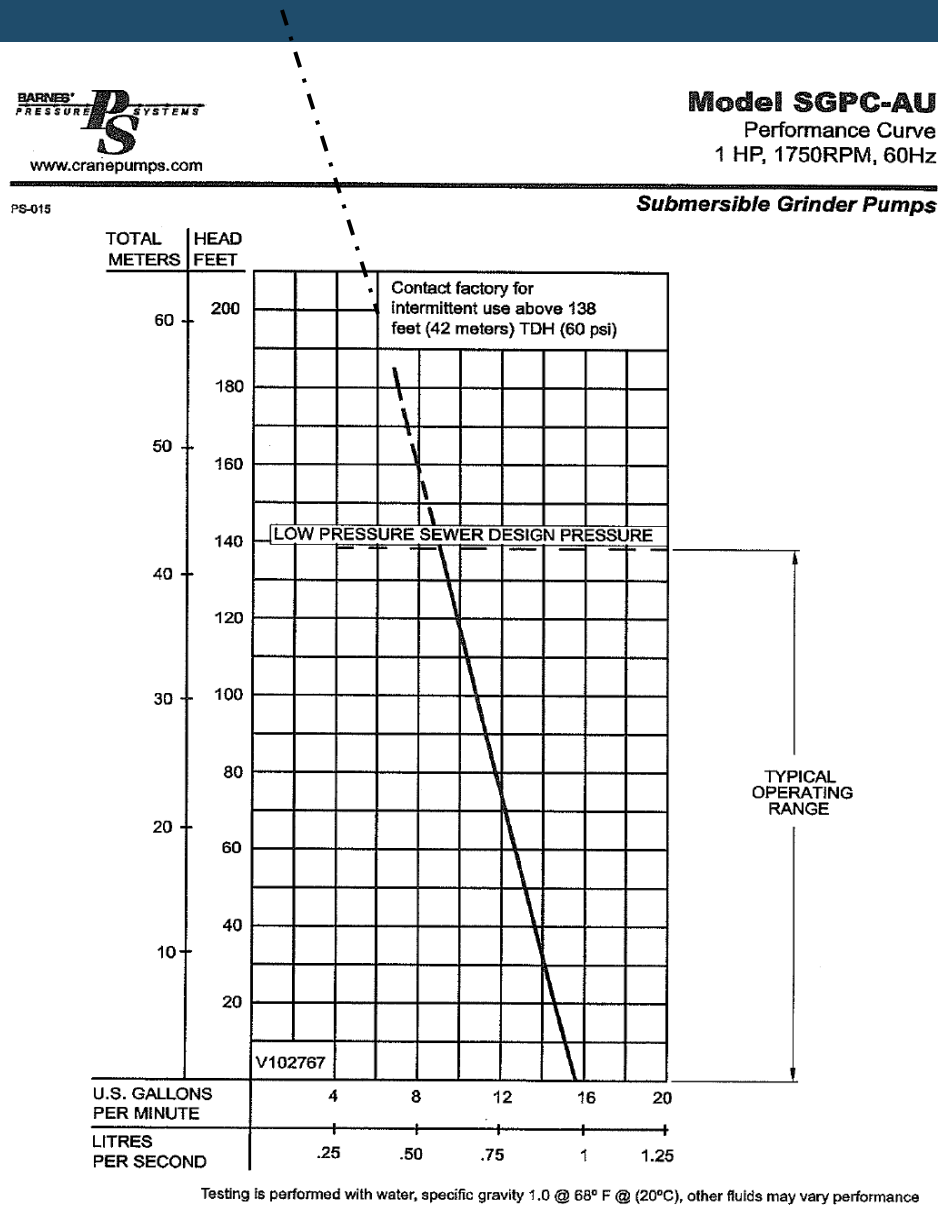
PC Grinder Pumps

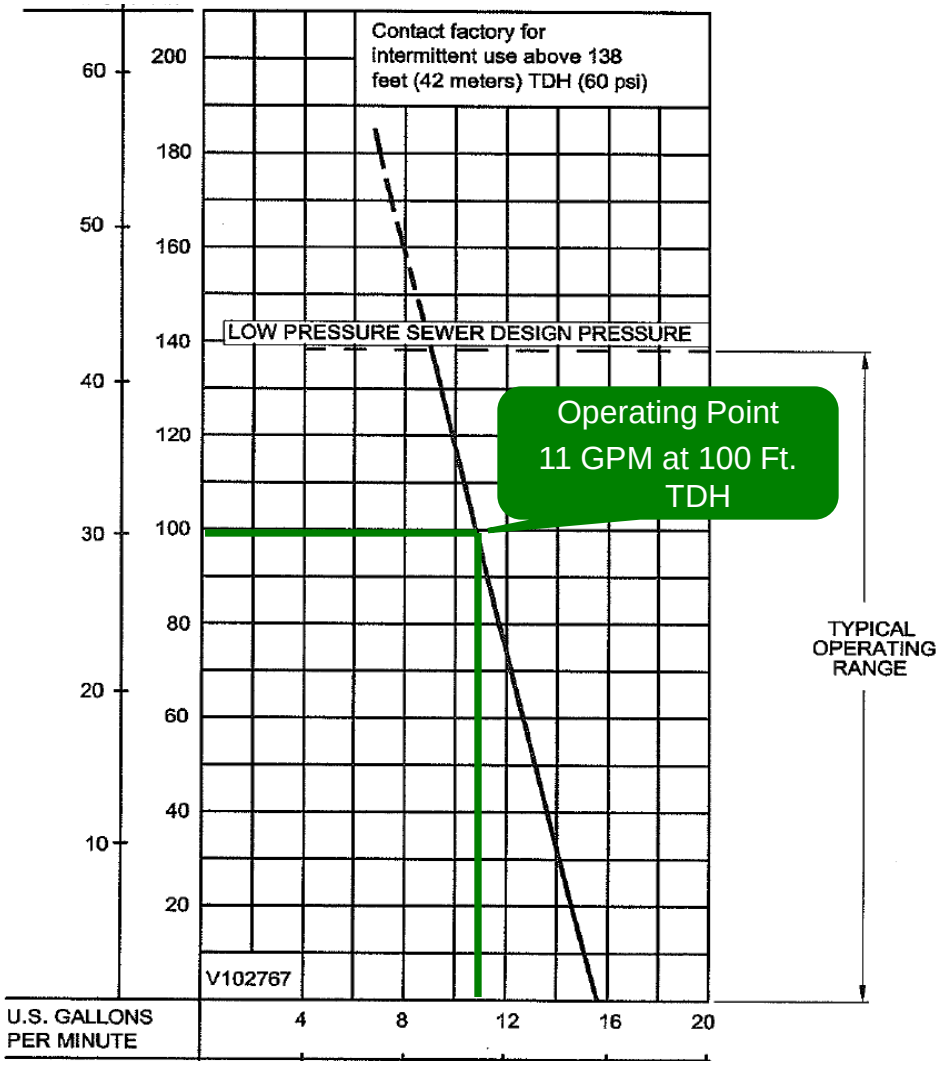
- The PC pump develops whatever pressure, up to the point of stall, is needed to overcome system pressure. If a PC pump is operated against a closed valve or blocked line, the result is pressure much higher than design limits and accelerated stator wear, potential motor failure, or pipe component failure.

- PC pump is always wearing



PC Grinder Pumps

- Typical residential PC grinder pumps have a working flow of 8 – 16 GPM
- PC pumps are utilized due to their ability to produce high discharge pressures; 120 ft. (52 psi) to 200+ ft (86 psi)



- Progressing Cavity pumps **were** the only choice to effectively handle pressures higher than 115-120 feet of head without resorting to large horsepower pumps.

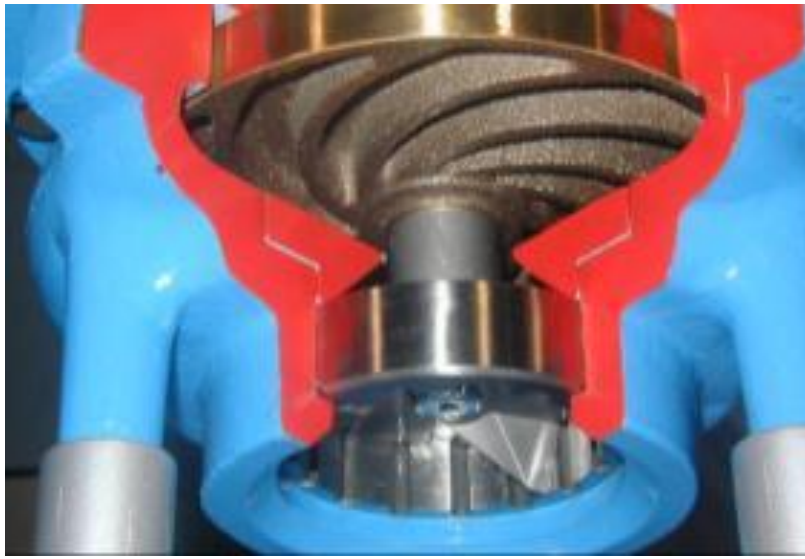
- Larger horsepower centrifugal pumps (2 Hp +) are not practical for residential applications; due to physical size, amp draw and voltage

Centrifugal Grinder Pumps

Centrifugal Grinder Pump

- Centrifugal grinder pumps have been used in residential and light commercial pressure sewer applications for 35 years.

- Discharge pressures were limited to ~120 ft. TDH until the development of the two-stage grinder pump.



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Centrifugal Grinder Pumps

- Typically fitted with recessed vortex impeller
- A “vortex” impeller is so named because the swirling action of its blades creates a vortex within the casing. This vortex captures any solid particles and moves them out of the casing discharge.
- Less than 10% of the particles come into contact with the impeller or casing, negating the abrasion and wear potential.

Energy Usage

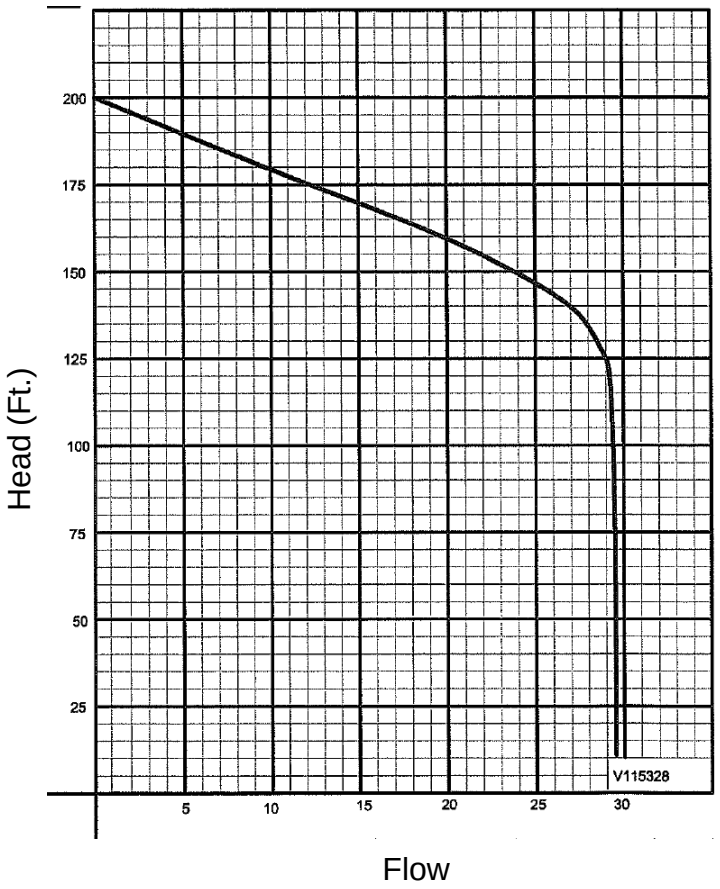
Low Electrical Energy Consumption

Typical Annual Usage

Item	Kilowatt Hours	
Air Conditioner	2000	
Clothes Dryer	1200	
Refrigerator	750	
Television	500	
Grinder Pump	**150**	**$15-25/Year est.**
Coffee Maker	100	
Vacuum Cleaner	45	
Clock	17	

Centrifugal Grinder Pumps

- Typically operate without cavitation at any point on the performance curve.
  - The grinding mechanism throttles the intake to a point were cavitation is limited to the interior of the cutting mechanism
- Typically Non-overloading at any point on the performance curve



Centrifugal Grinder Pumps

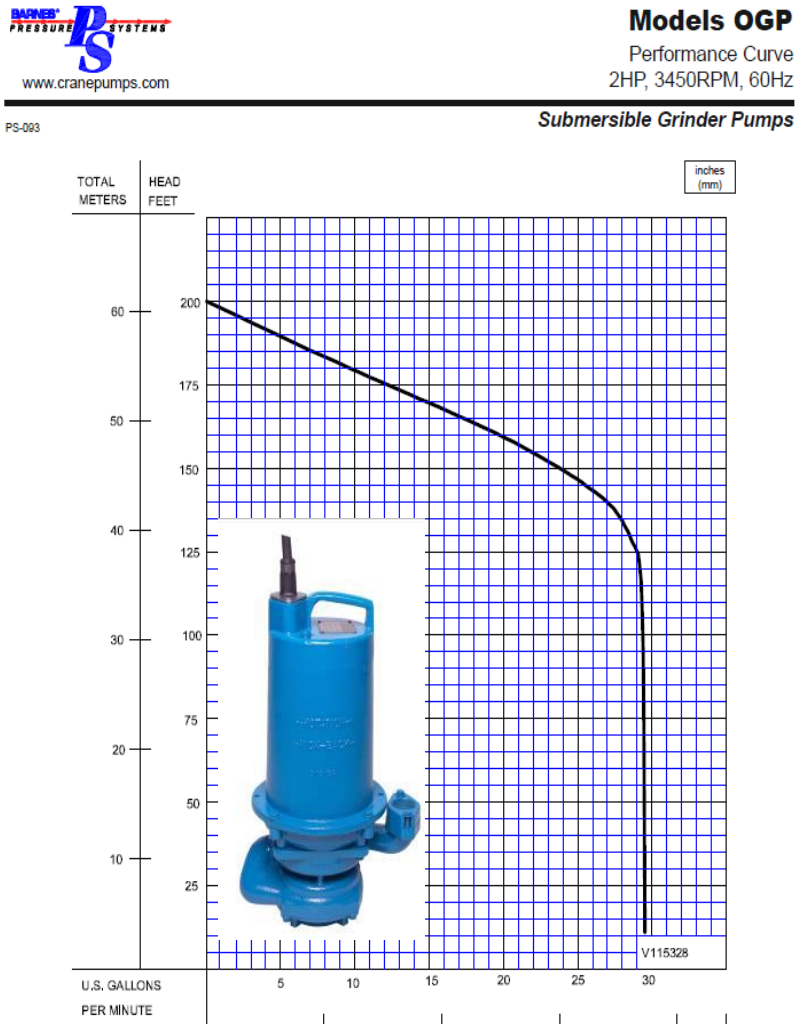
High Head Centrifugal Grinder Pump

- Numerous pump manufacturers have released multi-stage, High Head centrifugal grinder pumps within the past 6 years

- Economical 2Hp, 240V, residential grinder pumps providing for TDH over 180 feet at 8-9 GPM and shut-off head in excess of 200 feet. At head pressure below 125 feet TDH, flows are nearly 30 GPM.

- The significance of the high head grinder pump is more fully appreciated by the designer when pipes are sized, scouring velocities analyzed and retention times are being calculated.

Two Stage Centrifugal Grinder Pumps



Barnes Pump Model
OGP2022L, 2 Hp.

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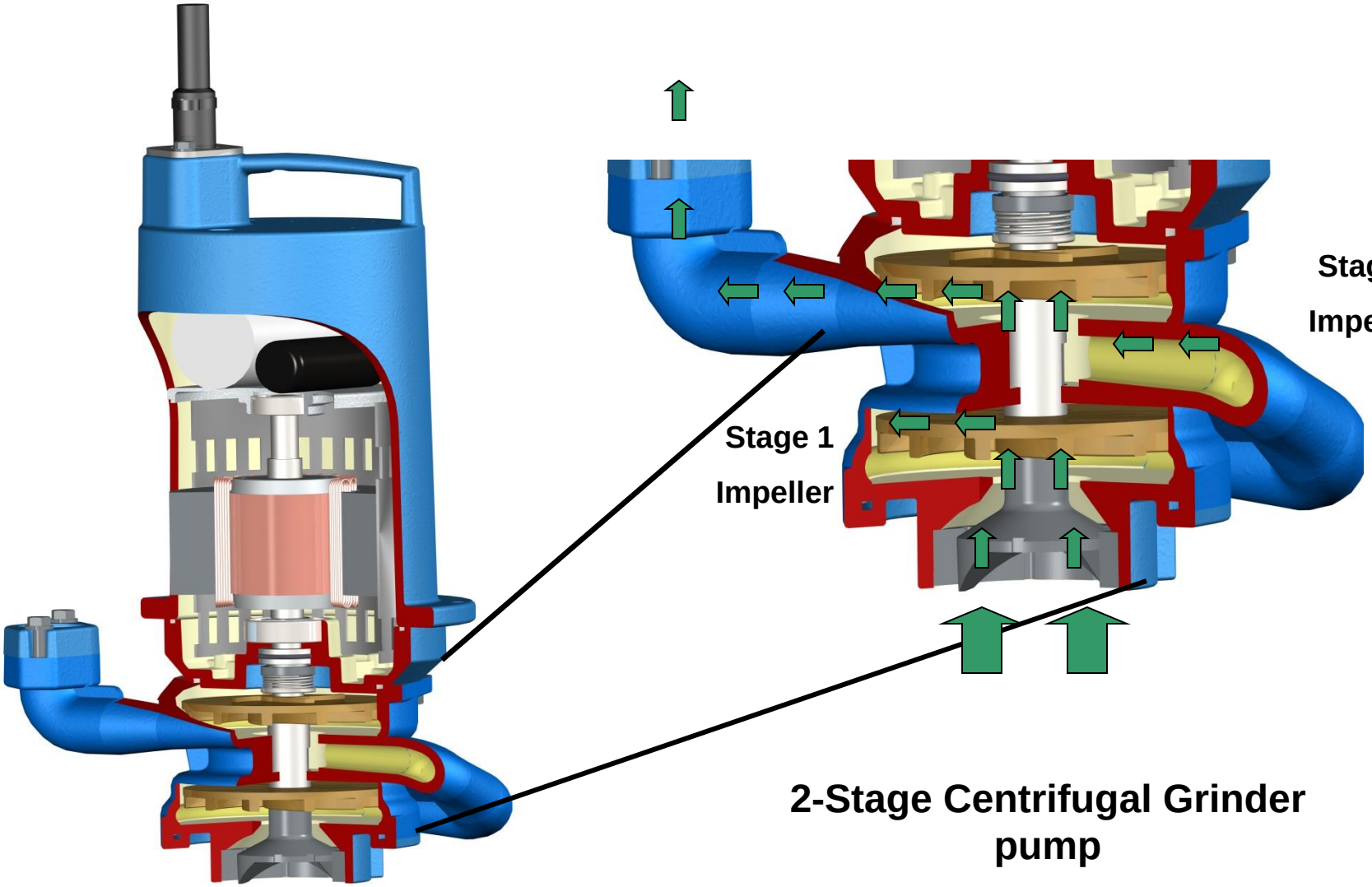
Two Stage Centrifugal Grinder Pumps



2-Stage Centrifugal Grinder pump

Hydraulic Response Flexibility

High Head Centrifugal Pump Advantage

- "Hydraulic Response Flexibility"
  - High Head / High Flow centrifugal pump provide pumping flexibility with an increased band of operation parameters
  - System designers routinely have to design within the 20 year plan….resulting in **oversized pipe**.
    - High Head / High Flow pump assists designer to get the needed velocity.
  - Seasonal or semi-seasonal usage
    - High Head / High Flow pump assists designer to get the needed velocity
  - PC pump is limited to 14-18 max GPM
    - At 100+ ft TDH, pump can not scour a 1-1/2" pipe.

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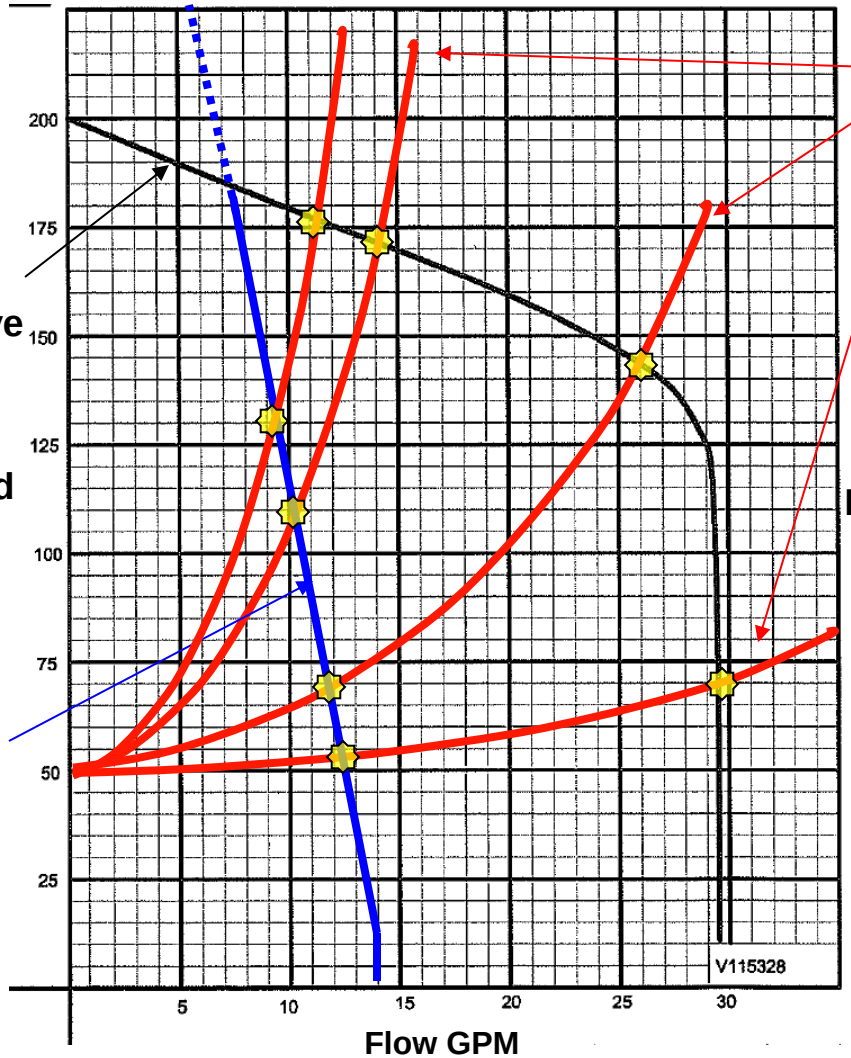
Hydraulic Response Flexibility

High Head Centrifugal Pump Advantage

- More Pumps Activated simultaneously (i.e. After loss of power event)
  - Centrifugal pump can be deadhead without pump failure
- Obstructions, closed valve or air pocket in pipe
  - Centrifugal pump can be deadhead without pump failure
- Future system expansion expectations
  - Wide operating rage provide the designed with flexibility

Pump Performance

Pump Operation Defined By System Head



Centrifugal Pump Curve

PC Pump Curve

Typical System Head Curves 15-29.5 GPM

Friction Head
Varies over time

Static Head
Fixed

The **System Head Curve** is unique to each pump and varies in response to the constantly changing system conditions

All pumps follow the system head curve. Output is the intersection of the system head curve and the pump curve.

Service Issues

The **primary reason** of pump failure with any grinder pump type is homeowner related. The introduction of non-biodegradable products or excessive grease to the collection system is the No 1 reason for service calls.

Excessive Grease

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Pipe Velocity

A critical component to any LPS system is self-cleansing pipe system with the associated minimum velocities.

- Targeted velocity is 2 – 6 FPS

Pipe Velocity

Lack of Scouring Velocity

- Laterals and mains build sediment
  - Difficult to clean 1-1/4” lateral pipe
- System head pressures increase
- Pipe blockage
- Extended retention times and H_2S issues
  - Odor complaints
  - Premature lift station equipment failure
- Increase PC pump stator wear

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Pipe Velocity

FLOW REQUIREMENTS FOR 2 FPS PIPE VELOCITY

NOMINAL PIPE SIZE (inches)	PVC SDR-21		HDPE DR-11	
	Actual Diameter (Inches)	GPM @ 2 FPS	Actual Diameter (Inches)	GPM @ 2 FPS
1.25	1.49	11	1.34	9
1.50	1.71	14	1.53	12
2.00	2.14	22	1.92	18
2.50	2.58	33	-	-
3.00	3.15	48	2.83	39
4.00	4.05	80	3.63.	65
6.00	5.95	174	5.35	140
8.00	7.56	294	6.96	237
10.00	9.67	457	8.68	369

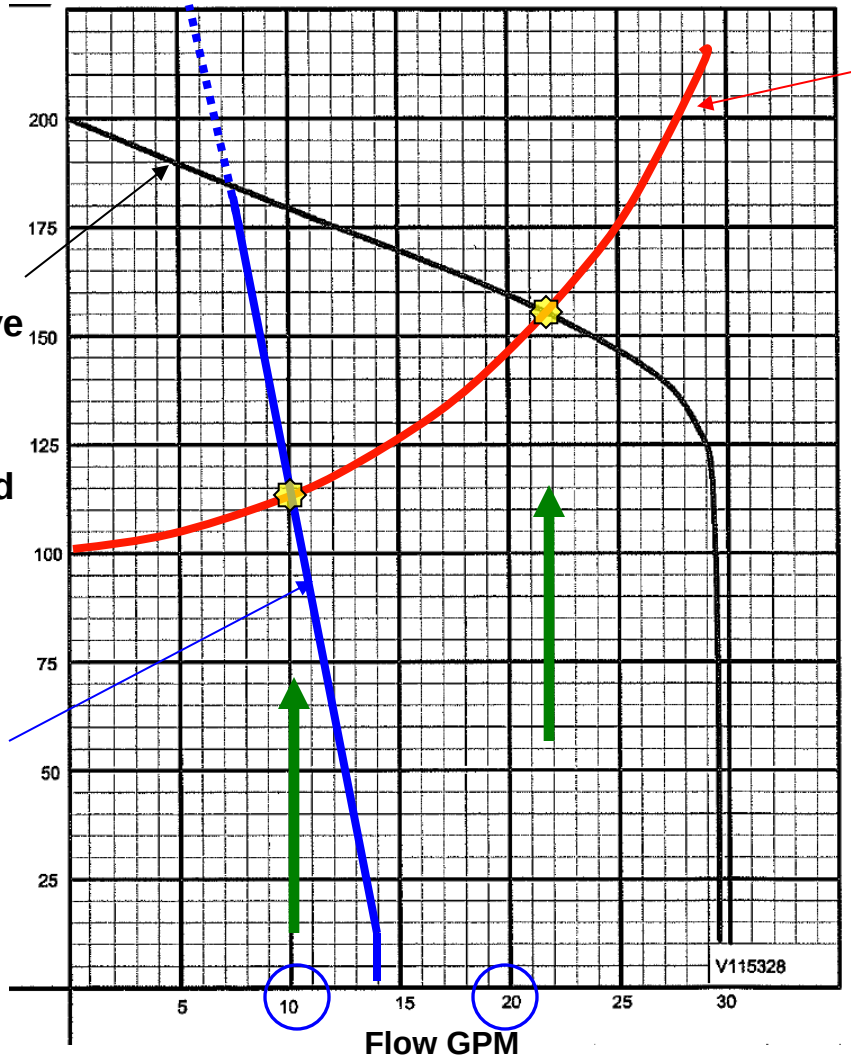
Laterals

Mains and Branch Pipes

GOAL: 2 FPS Minimum Self Cleaning Velocity

Pipe Velocity

Flows At 100 Ft. Static Head



Typical System Head Curves

Centrifugal Pump Curve

PC Pump Curve

Static Head
Fixed

Which pump will provide the necessary scouring velocity within the lateral (1-1/4” or 1-1/2” dia) and mains (2” min) ?

LPS Grinder Pumps

Potential Application limitations of a centrifugal grinder pumps

- Electrical current requirements exceeds household supply
  - Solution: Upgrade home electrical to accommodate grinder pump requirement.

- Pipe friction losses increase with velocity
  - Solution: Size pipe according to design flow

LPS Grinder Pumps

Changing System Conditions

- Connected homes less than 20 year design. Example – Rural area with open lots
- Build out rate less than forecasted. Example – New development
- GPD / EDU less than expected
- Seasonal Usage – Vacation home
- Resort area with very high usage. Example holidays
- Power outage
- Ground water infiltration

Need a system that will adjust to changing conditions

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Prince's Lake, IN

Location: 60 miles South of Indianapolis

Topography: Undulating hills (Static heads from 27 – 109 ft.)

Segmentation: 165 Combined main & branch sections

Initial Install Period: 2000 / 2001

Project Quantity: 562 Grinder pump basin packages

Initial Pumps Supplied: Progressing cavity pumps, 1Hp

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Prince's Lake, IN

Issue: Multiple/Frequent Pump Failures

Root Cause: Missing air/vacuum release valves

Solution: High Head Centrifugal Pump, Barnes Model OGP

Replacement Sequence:

2005: 2 Units furnished for preliminary evaluation

2007: 50 Units supplied for 6 month evaluation period

2008: 250 Units supplied for replacement for identified area of project with high rate of progressing cavity pump failures

2009 to Present 520+ Units installed as replacements for progressing cavity pumps on project

Results: Significant decrease with pump failures and substantial operating cost savings

LPS Grinder Pumps

Handouts

(Available Upon Request)

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Pressure Sewer Project Success Factors

Community Education and Communication
- Keep the community in the loop as to the progress and anticipated costs
- Involvement of sewer committee and staff in reviewing neighboring installations
- Once system is on-line, repetitive / periodic communication with customers reaffirms expected usage practices (Do's and Don'ts).

Engineering and Design
- Solicit Engineering firms with a track history in Pressure Sewer Design
- Proper hydraulic design consistent with modern approaches and equipment
- Allocate for special situations and applications such as extreme cold climates, heavy snow fall, slow initial build out, seasonal usage, extended retention times, system future expansion, and commercial applications.
- Involvement of a preferred grinder pump system manufacture at the beginning
- One home – One grinder pump. Avoid sharing common unit and separate power drops

Proven Reliable Equipment

CRANE PUMPS & SYSTEMS BARNES

A High Head Centrifugal Grinder Pump For Use in Residential Low Pressure Sewer Applications

Pressure Sewer Systems

Pressure Sewer Systems are an effective method to transfer residential wastewater through small diameter pipes to collection or treatment facilities where other methods are less economical or less feasible. The primary differences between conventional gravity sewer systems and pressure sewer systems are in the piping network and the reduction of solids size in the wastewater at each residence. Pressure Sewer Systems use specialized submersible grinder pumps, which are designed to reduce sewage particulate size to easily move the sewage through small diameter pipes.

Adopted from SWPA White Paper, "A Pressure Sewer Overview"

The application of grinder pumps and pressure sewer systems is a cost-effective, longer life answer to allow more home sites, both existing and new, access to a public sewer system or regional private waste water treatment system.

Pressure Sewer Systems can be used where gravity systems won't work because of uphill topography, surface rock, high water tables, waterfront locations, very flat land and other constraints on excavation. In general, these systems are installed outdoors, below grade, with a locked cover mounted just above grade. The burial depth (i.e., basin length) is set by local codes and usually depends on maximum frost depth and residence elevations. A typical system includes a pump, basin, controls, piping and valves.

Thank You