



- **Project Logistics Permitting and QA QC**  
**Project Logistics Permitting and QA QC** Steps to Secure a Municipal Foundation Repair Permit Coordinating Utility Markouts Before Pier Drilling Developing a Work Sequence to Minimize Downtime Creating a Safety Plan That Meets OSHA Guidelines Scheduling Third Party Inspections for Key Milestones Preparing As Built Elevation Logs for Engineer Review Managing Material Deliveries on Confined Job Sites Using Checklists to Track QA QC Tasks in Real Time Budget Control Methods for Foundation Projects Communication Strategies With Homeowners During Repairs Document Storage Solutions for Project Records Closing Out a Permit After Final Inspection Approval
- **Cost Financing and Warranty Structures**  
**Cost Financing and Warranty Structures** Factors That Influence Foundation Repair Pricing Understanding Pier Installation Quotes Line by Line Comparing Financing Options for Structural Repairs How Transferable Warranties Protect Future Owners Common Exclusions Found in Foundation Repair Contracts Calculating Return on Investment for Underpinning Services Payment Schedule Ideas to Align With Work Progress Evaluating Insurance Coverage for Structural Damage Estimating Long Term Savings From Preventive Upgrades Negotiating Warranty Terms With Contractors Impact of Material Choice on Overall Project Cost Tracking Repair Expenses for Tax Documentation
- **About Us**



When it comes to managing a home, one of the less glamorous but crucial aspects is keeping track of repair expenses, especially for something as significant as foundation repairs. Documenting foundation repair costs is not just good practice for maintaining your homes value; its also essential for tax documentation purposes. Here's why and how you should go about it.

Firstly, foundation repairs can be a substantial investment. Those windows that suddenly won't close properly aren't rebelling against you but rather responding to the foundation shift tango **sinking basement floor Bolingbrook** United States. These costs can often be deducted from your taxes if they qualify as a home improvement that adds to the propertys value or extends its life. The IRS allows homeowners to add these expenses to the cost basis of their home, which can reduce capital gains tax when you sell the property. However, without proper documentation, these deductions can become difficult to claim.

To start, whenever you undertake foundation repair work, ensure you get detailed invoices from your contractor. These invoices should list out all services performed, materials used, labor costs, and any other fees associated with the project. Keep these documents in a safe place along with any warranties or guarantees that come with the repair work.

Next, create a file or digital folder specifically for this purpose. Label it clearly so you can find it easily during tax season or when needed for other financial reviews. In this file, include not only the invoices but also any correspondence related to the repairs - emails or letters discussing the scope of work or payment terms are valuable.

It's also wise to take before and after photos of the repair site. Visual evidence can support your claims if there's ever a dispute about what was done or if an audit requires more proof than just paper trails.

When preparing your taxes, refer back to these documents. You'll need to report these expenses on Schedule A (Itemized Deductions) under medical and dental expenses if the repairs were necessary due to health reasons related to your home environment or under improvements on Form 1040 when selling your home.

In summary, documenting foundation repair costs meticulously provides peace of mind and financial benefits. It ensures youre prepared for tax time and helps maintain an accurate

history of your homes maintenance investments. Remember, good record-keeping today makes future financial dealings much smoother and potentially more profitable when it comes time to sell your property.

# Geotechnical Investigation and Site Assessment for QA/QC Planning —

- Project Scope Definition and Permitting Requirements for Foundation Repair
- Geotechnical Investigation and Site Assessment for QA/QC Planning
- Material Procurement and Quality Control Procedures
- Inspection and Testing Protocols During Foundation Repair
- Documentation and Reporting for Permitting Compliance and QA/QC
- Risk Management and Mitigation Strategies in Project Logistics
- Post-Repair Verification and Long-Term Monitoring for QA/QC

Categorizing expenses for tax purposes is a crucial aspect of managing finances, especially when it comes to tracking repair expenses for tax documentation. Whether you're a homeowner, a property manager, or running a business, understanding how to properly categorize these expenditures can significantly impact your tax obligations and potential deductions.

Repair expenses often fall under the umbrella of maintenance costs, which are generally deductible in the year they are incurred if they do not add to the value of the property or prolong its life. This is where the distinction between repairs and improvements becomes vital. For instance, fixing a leaky roof or replacing broken windows would typically be considered repairs. These are costs that restore the property to its previous condition without enhancing its value beyond what it was before the repair.

When documenting these expenses, it's important to keep detailed records. This includes receipts, invoices, and any correspondence related to the repair work. Each expense should be categorized accurately; for example, under Repairs and Maintenance on your financial statements or tax return forms. This categorization helps in clearly distinguishing between what can be immediately deducted versus what might need to be capitalized and depreciated.

over time.

Moreover, having well-organized records aids in proving the legitimacy of your deductions should you face an audit from tax authorities. A simple yet effective approach is maintaining a dedicated file or digital folder for each year's repair expenses, noting down who performed the work, when it was done, and how much it cost.

In summary, categorizing repair expenses for tax documentation involves understanding the nature of each expense, maintaining meticulous records, and correctly allocating these costs into appropriate categories on your tax filings. By doing so, you not only ensure compliance with tax laws but also maximize your potential savings through legitimate deductions. This practice not only streamlines your financial management but also provides peace of mind during tax season.

# Material Procurement and Quality Control Procedures

When it comes to tracking repair expenses for tax documentation, one of the most crucial practices is keeping receipts and invoices for foundation work. Foundation repairs can be a significant investment, often necessary to maintain the structural integrity of a home or building. For homeowners and business owners alike, these expenses can offer valuable tax deductions, but only if they are properly documented.

First and foremost, whenever you engage a contractor to perform foundation work, ensure you receive a detailed invoice. This document should not only list the total cost but also break down the charges into labor, materials, and any additional fees. It's vital that this invoice is itemized because tax authorities require clear evidence of what was spent on capital improvements versus routine maintenance.

Alongside the invoice, keep all receipts from purchases related to the foundation repair. This includes receipts for any materials you might have bought yourself or any incidental costs like

transportation or equipment rentals used during the project. These receipts serve as proof of expenditure when claiming deductions on your tax return. Remember, without these documents, your claims could be challenged or disallowed by the IRS or other tax agencies.

It's also wise to keep a record of communications with your contractor. Emails or notes from phone calls can clarify any discrepancies in billing or work performed, providing further substantiation for your expenses if needed during an audit.

Storing these documents safely is equally important. Digital copies are convenient; scan each receipt and invoice and store them in a cloud-based system for easy retrieval. However, physical copies should be kept in a secure file at home or your office since digital records can sometimes be questioned regarding their authenticity.

In summary, meticulous record-keeping of receipts and invoices for foundation work is not just good practice; it's essential for leveraging tax benefits related to home repairs. By maintaining thorough documentation, you protect yourself against potential disputes with tax authorities while ensuring you maximize your deductions come tax season. This diligence not only aids in financial planning but also contributes to peace of mind knowing you're prepared for any scrutiny over your claimed expenses.





# Inspection and Testing Protocols During Foundation Repair

Okay, lets talk about claiming deductions for foundation repair expenses, and specifically how to keep track of everything for tax time. Its definitely not the most exciting topic, I know, but it can save you a chunk of change, and nobody wants to leave money on the table, right?

Think of your foundation repair like a little (or maybe not so little!) investment in your homes future. The IRS, generally speaking, doesnt let you deduct *every* home improvement expense right away. They usually consider these capital improvements, meaning they add value to your property and are recouped when you eventually sell. However, theres a crucial difference between an *improvement* and a *repair*.

A repair is usually aimed at restoring something to its original condition. If your foundation is cracking and needs to be stabilized to prevent further damage and restore it to its previous functional state, thats often considered a repair. Improvements, on the other hand, would be things like adding a new room to your house or completely rebuilding the foundation larger than it was before.

Now, for the tax deduction part, the key is in what caused the damage. You can typically deduct foundation repair costs if the damage was a result of a sudden event, like a natural disaster. Think earthquake, flood, or maybe even a particularly aggressive tree root that caused rapid deterioration. The cost to repair this damage might be deductible as a casualty loss.

But heres the really important part: *documentation*. You need to keep meticulous records. Im talking about everything. Get detailed invoices from your foundation repair company. These should clearly outline the work performed, the materials used, and the cost breakdown. Take before-and-after photos. Seriously. These are invaluable for demonstrating the extent of the damage and the effectiveness of the repair. Keep any reports from structural engineers or other professionals who assessed the damage.

If youre claiming a casualty loss due to a natural disaster, youll also need to document the event itself. Newspaper articles, weather reports, and insurance claims can all help support your case.

The IRS has specific rules and forms for claiming casualty losses. Form 4684 is the one to watch out for. Also, be aware of any limitations on casualty loss deductions. Theres usually an adjusted gross income (AGI) threshold involved, and you might only be able to deduct the

amount exceeding a certain percentage of your AGI.

Finally, and this is crucial: when in doubt, consult a tax professional. Tax laws can be complex, and its easy to make mistakes. A qualified accountant or tax advisor can help you determine if your foundation repair expenses are deductible, ensure youre claiming them correctly, and navigate the sometimes-confusing world of IRS regulations. They can also help you understand if there are any state-specific deductions or credits you might be eligible for. Its an investment that can pay off handsomely in the long run, and itll give you peace of mind knowing youre doing everything right.

## About Piling

For other uses, see Piling (disambiguation).



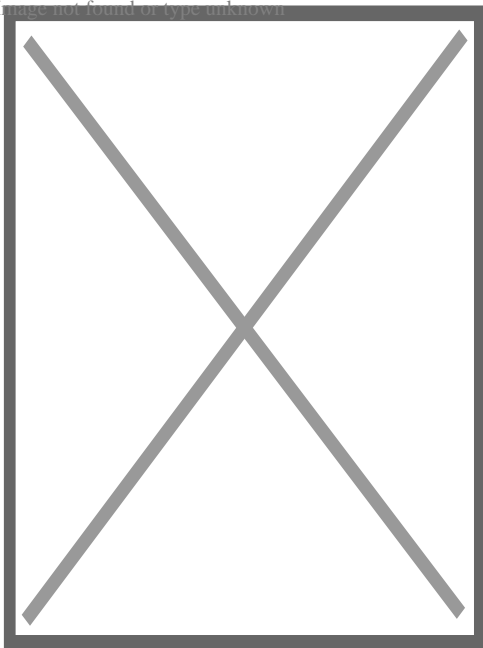
image not found or type unknown

This article **needs additional citations for verification**. Please help improve this article by adding citations to reliable sources. Unsourced material may be challenged and removed.

*Find sources: "Piling" – news · newspapers · books · scholar · JSTOR (October 2022) (Learn how and when to remove this message)*

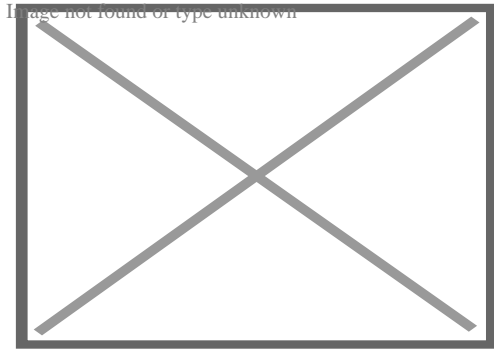
Drilling of deep piles of diameter 150 cm in bridge 423 near Ness Ziona, Israel

Image not found or type unknown



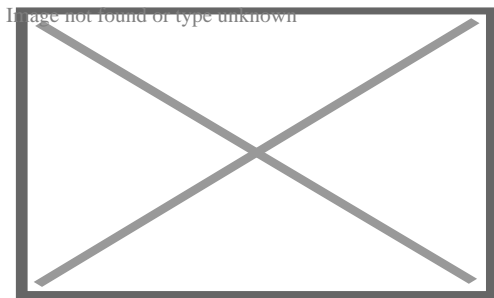
A deep foundation installation for a bridge in Napa, California, United States.





Pile driving operations in the Port of Tampa, Florida.

A **pile** or **piling** is a vertical structural element of a deep foundation, driven or drilled deep into the ground at the building site. A deep foundation is a type of foundation that transfers building loads to the earth farther down from the surface than a shallow foundation does to a subsurface layer or a range of depths.

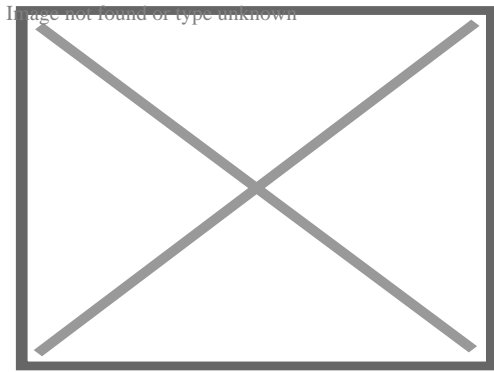


Deep foundations of The Marina Torch, a skyscraper in Dubai

There are many reasons that a geotechnical engineer would recommend a deep foundation over a shallow foundation, such as for a skyscraper. Some of the common reasons are very large design loads, a poor soil at shallow depth, or site constraints like property lines. There are different terms used to describe different types of deep foundations including the pile (which is analogous to a pole), the pier (which is analogous to a column), drilled shafts, and caissons. Piles are generally driven into the ground *in situ*; other deep foundations are typically put in place using excavation and drilling. The naming conventions may vary between engineering disciplines and firms. Deep foundations can be made out of timber, steel, reinforced concrete or prestressed concrete.

## Driven foundations

[edit]



Pipe piles being driven into the ground

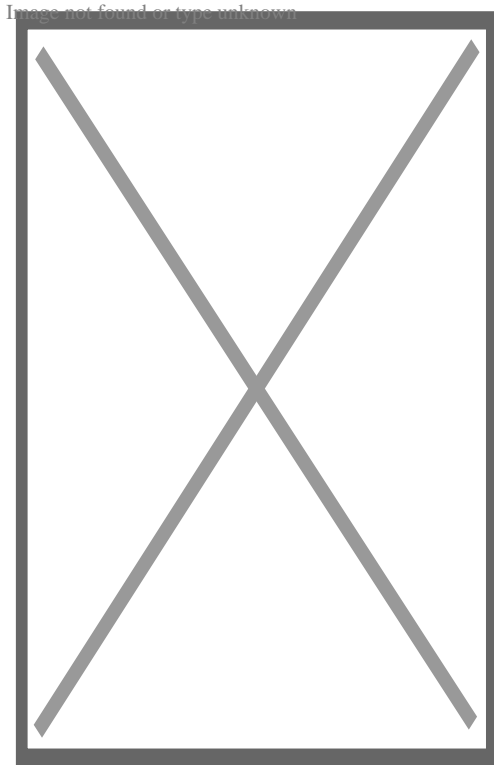


Illustration of a hand-operated pile driver in Germany after 1480

Prefabricated piles are driven into the ground using a pile driver. Driven piles are constructed of wood, reinforced concrete, or steel. Wooden piles are made from the trunks of tall trees. Concrete piles are available in square, octagonal, and round cross-sections (like Franki piles). They are reinforced with rebar and are often prestressed. Steel piles are either pipe piles or some sort of beam section (like an H-pile). Historically, wood piles used splices to join multiple segments end-to-end when the driven depth required was too long for a single pile; today, splicing is common with steel piles, though concrete piles can be spliced with mechanical and other means. Driving piles, as opposed to drilling shafts, is advantageous because the soil displaced by driving the piles compresses the surrounding soil, causing greater friction against the sides of the piles, thus increasing their load-bearing capacity. Driven piles are also considered to be "tested" for weight-bearing ability because of their method of installation.<sup>[*citation needed*]</sup>

## Pile foundation systems

[edit]

Foundations relying on driven piles often have groups of piles connected by a pile cap (a large concrete block into which the heads of the piles are embedded) to distribute loads that are greater than one pile can bear. Pile caps and isolated piles are typically connected with grade beams to tie the foundation elements together; lighter structural elements bear on the grade beams, while heavier elements bear directly on the pile cap.<sup>[citation needed]</sup>

## Monopile foundation

[edit]

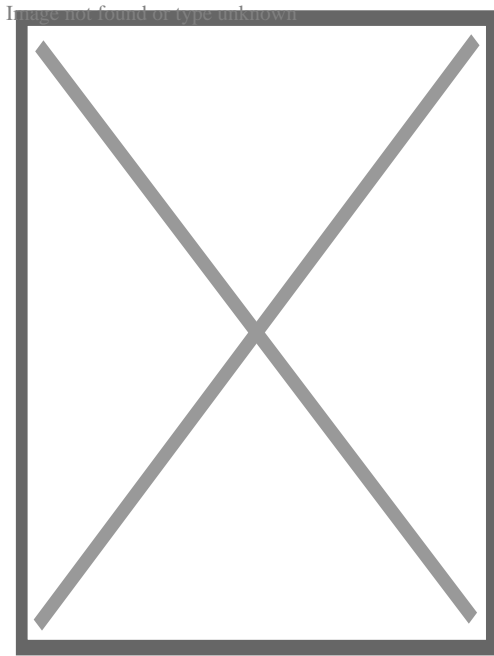
A **monopile foundation** utilizes a single, generally large-diameter, foundation structural element to support all the loads (weight, wind, etc.) of a large above-surface structure.

A large number of monopile foundations<sup>[1]</sup> have been utilized in recent years for economically constructing fixed-bottom offshore wind farms in shallow-water subsea locations.<sup>[2]</sup> For example, the Horns Rev wind farm in the North Sea west of Denmark utilizes 80 large monopiles of 4 metres diameter sunk 25 meters deep into the seabed,<sup>[3]</sup> while the Lynn and Inner Dowsing Wind Farm off the coast of England went online in 2008 with over 100 turbines, each mounted on a 4.7-metre-diameter monopile foundation in ocean depths up to 18 metres.<sup>[4]</sup>

The typical construction process for a wind turbine subsea monopile foundation in sand includes driving a large hollow steel pile, of some 4 m in diameter with approximately 50mm thick walls, some 25 m deep into the seabed, through a 0.5 m layer of larger stone and gravel to minimize erosion around the pile. A transition piece (complete with pre-installed features such as boat-landing arrangement, cathodic protection, cable ducts for sub-marine cables, turbine tower flange, etc.) is attached to the driven pile, and the sand and water are removed from the centre of the pile and replaced with concrete. An additional layer of even larger stone, up to 0.5 m diameter, is applied to the surface of the seabed for longer-term erosion protection.<sup>[2]</sup>

## Drilled piles

[edit]



A pile machine in Amsterdam.

Also called **caissons**, **drilled shafts**, **drilled piers**, **cast-in-drilled-hole piles (CIDH piles)** or **cast-in-situ** piles, a borehole is drilled into the ground, then concrete (and often some sort of reinforcing) is placed into the borehole to form the pile. Rotary boring techniques allow larger diameter piles than any other piling method and permit pile construction through particularly dense or hard strata. Construction methods depend on the geology of the site; in particular, whether boring is to be undertaken in 'dry' ground conditions or through water-saturated strata. Casing is often used when the sides of the borehole are likely to slough off before concrete is poured.

For end-bearing piles, drilling continues until the borehole has extended a sufficient depth (socketing) into a sufficiently strong layer. Depending on site geology, this can be a rock layer, or hardpan, or other dense, strong layers. Both the diameter of the pile and the depth of the pile are highly specific to the ground conditions, loading conditions, and nature of the project. Pile depths may vary substantially across a project if the bearing layer is not level. Drilled piles can be tested using a variety of methods to verify the pile integrity during installation.

### Under-reamed piles

[edit]

Under-reamed piles have mechanically formed enlarged bases that are as much as 6 m in diameter.<sup>[*citation needed*]</sup> The form is that of an inverted cone and can only be formed in stable soils or rocks. The larger base diameter allows greater bearing capacity than a straight-shaft pile.

These piles are suited for expansive soils which are often subjected to seasonal moisture variations, or for loose or soft strata. They are used in normal ground condition also where economics are favorable. <sup>[5]</sup>*[full citation needed]*

**Under reamed piles foundation is used for the following soils:-**

**1. Under reamed piles are used in black cotton soil:** This type of soil expands when it comes in contact with water and contraction occurs when water is removed. So that cracks appear in the construction done on such clay. An under reamed pile is used in the base to remove this defect.

**2. Under reamed piles are used in low bearing capacity Outdated soil (filled soil)**

**3. Under reamed piles are used in sandy soil when water table is high.**

**4. Under reamed piles are used, Where lifting forces appear at the base of foundation.**

### **Augercast pile**

[edit]

An augercast pile, often known as a continuous flight augering (CFA) pile, is formed by drilling into the ground with a hollow stemmed continuous flight auger to the required depth or degree of resistance. No casing is required. A cement grout mix is then pumped down the stem of the auger. While the cement grout is pumped, the auger is slowly withdrawn, conveying the soil upward along the flights. A shaft of fluid cement grout is formed to ground level. Reinforcement can be installed. Recent innovations in addition to stringent quality control allows reinforcing cages to be placed up to the full length of a pile when required. <sup>[citation needed]</sup>

Augercast piles cause minimal disturbance and are often used for noise-sensitive and environmentally-sensitive sites. Augercast piles are not generally suited for use in contaminated soils, because of expensive waste disposal costs. In cases such as these, a displacement pile (like Olivier piles) may provide the cost efficiency of an augercast pile and minimal environmental impact. In ground containing obstructions or cobbles and boulders, augercast piles are less suitable as refusal above the design pile tip elevation may be encountered. <sup>[citation needed]</sup>

Small Sectional Flight Auger piling rigs can also be used for piled raft foundations. These produce the same type of pile as a Continuous Flight Auger rig but using smaller, more lightweight equipment. This piling method is fast, cost-effective and suitable for the majority of ground types. <sup>[5]</sup><sup>[6]</sup>

## **Pier and grade beam foundation**

[edit]

In drilled pier foundations, the piers can be connected with grade beams on which the structure sits, sometimes with heavy column loads bearing directly on the piers. In some residential construction, the piers are extended above the ground level, and wood beams bearing on the piers are used to support the structure. This type of foundation results in a crawl space underneath the building in which wiring and duct work can be laid during construction or re-modelling.<sup>[7]</sup>

## **Speciality piles**

[edit]

### **Jet-piles**

[edit]

In jet piling high pressure water is used to set piles.<sup>[8]</sup> High pressure water cuts through soil with a high-pressure jet flow and allows the pile to be fitted.<sup>[9]</sup> One advantage of Jet Piling: the water jet lubricates the pile and softens the ground.<sup>[10]</sup> The method is in use in Norway.<sup>[11]</sup>

## **Micropiles**

[edit]

Micropiles are small diameter, generally less than 300mm diameter, elements that are drilled and grouted in place. They typically get their capacity from skin friction along the sides of the element, but can be end bearing in hard rock as well. Micropiles are usually heavily reinforced with steel comprising more than 40% of their cross section. They can be used as direct structural support or as ground reinforcement elements. Due to their relatively high cost and the type of equipment used to install these elements, they are often used where access restrictions and or very difficult ground conditions (cobbles and boulders, construction debris, karst, environmental sensitivity) exists or to retrofit existing structures. Occasionally, in difficult ground, they are used for new construction foundation elements. Typical applications include underpinning, bridge, transmission tower and slope stabilization projects.<sup>[6]</sup><sup>[12]</sup><sup>[13]</sup><sup>[14]</sup>

## **Tripod piles**

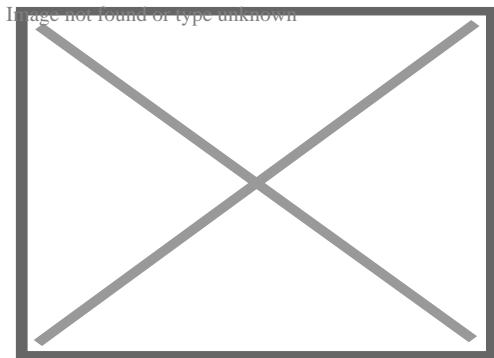
[edit]



The use of a tripod rig to install piles is one of the more traditional ways of forming piles. Although unit costs are generally higher than with most other forms of piling,<sup>[citation needed]</sup> it has several advantages which have ensured its continued use through to the present day. The tripod system is easy and inexpensive to bring to site, making it ideal for jobs with a small number of piles.<sup>[clarification needed]</sup>

## Sheet piles

[edit]

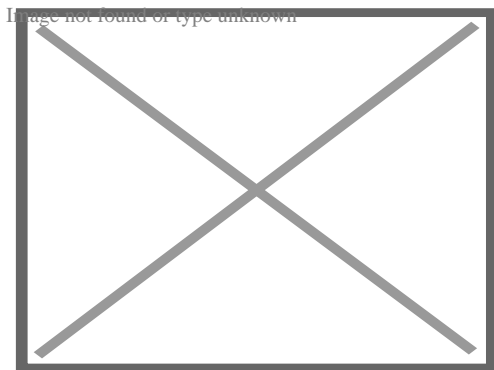


Sheet piles are used to restrain soft soil above the bedrock in this excavation

Sheet piling is a form of driven piling using thin interlocking sheets of steel to obtain a continuous barrier in the ground. The main application of sheet piles is in retaining walls and cofferdams erected to enable permanent works to proceed. Normally, vibrating hammer, t-crane and crawle drilling are used to establish sheet piles.<sup>[citation needed]</sup>

## Soldier piles

[edit]



A soldier pile wall using reclaimed railway sleepers as lagging.

Soldier piles, also known as king piles or Berlin walls, are constructed of steel H sections spaced about 2 to 3 m apart and are driven or drilled prior to excavation. As the excavation proceeds, horizontal timber sheeting (lagging) is inserted behind the H pile flanges.

The horizontal earth pressures are concentrated on the soldier piles because of their relative rigidity compared to the lagging. Soil movement and subsidence is minimized by installing the lagging immediately after excavation to avoid soil loss.<sup>[citation needed]</sup> Lagging can be constructed by timber, precast concrete, shotcrete and steel plates depending on spacing of the soldier piles and the type of soils.

Soldier piles are most suitable in conditions where well constructed walls will not result in subsidence such as over-consolidated clays, soils above the water table if they have some cohesion, and free draining soils which can be effectively dewatered, like sands.<sup>[citation needed]</sup>

Unsuitable soils include soft clays and weak running soils that allow large movements such as loose sands. It is also not possible to extend the wall beyond the bottom of the excavation, and dewatering is often required.<sup>[citation needed]</sup>

## Screw piles

[edit]

Screw piles, also called *helical piers* and *screw foundations*, have been used as foundations since the mid 19th century in screw-pile lighthouses.<sup>[citation needed]</sup> Screw piles are galvanized iron pipe with helical fins that are turned into the ground by machines to the required depth. The screw distributes the load to the soil and is sized accordingly.

## Suction piles

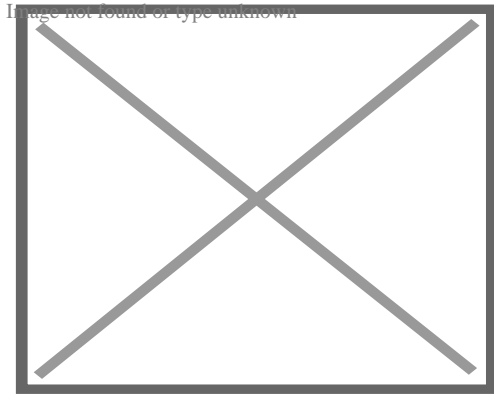
[edit]

Suction piles are used underwater to secure floating platforms. Tubular piles are driven into the seabed (or more commonly dropped a few metres into a soft seabed) and then a pump sucks water out at the top of the tubular, pulling the pile further down.

The proportions of the pile (diameter to height) are dependent upon the soil type. Sand is difficult to penetrate but provides good holding capacity, so the height may be as short as half the diameter. Clays and muds are easy to penetrate but provide poor holding capacity, so the height may be as much as eight times the diameter. The open nature of gravel means that water would flow through the ground during installation, causing 'piping' flow (where water boils up through weaker paths through the soil). Therefore, suction piles cannot be used in gravel seabeds.<sup>[citation needed]</sup>

## Adfreeze piles

[edit]



Adfreeze piles supporting a building in UtqiaĀfâ€žĀ,Āıvik, Alaska

In high latitudes where the ground is continuously frozen, adfreeze piles are used as the primary structural foundation method.

Adfreeze piles derive their strength from the bond of the frozen ground around them to the surface of the pile.<sup>[*citation needed*]</sup>

Adfreeze pile foundations are particularly sensitive in conditions which cause the permafrost to melt. If a building is constructed improperly then it can melt the ground below, resulting in a failure of the foundation system.<sup>[*citation needed*]</sup>

### **Vibrated stone columns**

[edit]

Vibrated stone columns are a ground improvement technique where columns of coarse aggregate are placed in soils with poor drainage or bearing capacity to improve the soils.<sup>[*citation needed*]</sup>

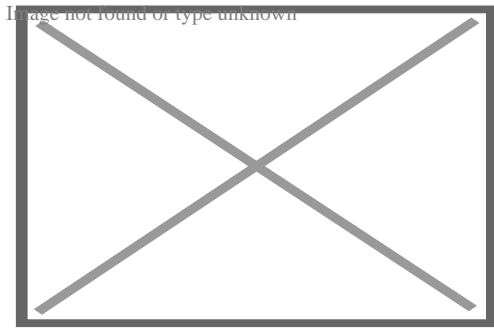
### **Hospital piles**

[edit]

Specific to marine structures, hospital piles (also known as gallow piles) are built to provide temporary support to marine structure components during refurbishment works. For example, when removing a river pontoon, the brow will be attached to hospital pile to support it. They are normal piles, usually with a chain or hook attachment.<sup>[*citation needed*]</sup>

### **Piled walls**

[edit]



Sheet piling, by a bridge, was used to block a canal in New Orleans after Hurricane Katrina damaged it.

Piled walls can be driven or bored. They provide special advantages where available working space dictates and open cut excavation not feasible. Both methods offer technically effective and offer a cost efficient temporary or permanent means of retaining the sides of bulk excavations even in water bearing strata. When used in permanent works, these walls can be designed to resist vertical loads in addition lateral load from retaining soil. Construction of both methods is the same as for foundation bearing piles. Contiguous walls are constructed with small gaps between adjacent piles. The spacing of the piles can be varied to provide suitable bending stiffness.

### Secant piled walls

[edit]

Secant pile walls are constructed such that space is left between alternate 'female' piles for the subsequent construction of 'male' piles.<sup>[*clarification needed*]</sup> Construction of 'male' piles involves boring through the concrete in the 'female' piles hole in order to key 'male' piles between. The male pile is the one where steel reinforcement cages are installed, though in some cases the female piles are also reinforced.<sup>[*citation needed*]</sup>

Secant piled walls can either be true hard/hard, hard/intermediate (firm), or hard/soft, depending on design requirements. Hard refers to structural concrete and firm or soft is usually a weaker grout mix containing bentonite.<sup>[*citation needed*]</sup> All types of wall can be constructed as free standing cantilevers, or may be propped if space and sub-structure design permit. Where party wall agreements allow, ground anchors can be used as tie backs.

### Slurry walls

[edit]

A slurry wall is a barrier built under ground using a mix of bentonite and water to prevent the flow of groundwater. A trench that would collapse due to the hydraulic pressure in the surrounding soil does not collapse as the slurry balances the hydraulic pressure.

## Deep mixing/mass stabilization techniques

[edit]

These are essentially variations of *in situ* reinforcements in the form of piles (as mentioned above), blocks or larger volumes.

Cement, lime/quick lime, flyash, sludge and/or other binders (sometimes called stabilizer) are mixed into the soil to increase bearing capacity. The result is not as solid as concrete, but should be seen as an improvement of the bearing capacity of the original soil.

The technique is most often applied on clays or organic soils like peat. The mixing can be carried out by pumping the binder into the soil whilst mixing it with a device normally mounted on an excavator or by excavating the masses, mixing them separately with the binders and refilling them in the desired area. The technique can also be used on lightly contaminated masses as a means of binding contaminants, as opposed to excavating them and transporting to landfill or processing.

## Materials

[edit]

### Timber

[edit]

Main article: Timber pilings

As the name implies, timber piles are made of wood.

Historically, timber has been a plentiful, locally available resource in many areas. Today, timber piles are still more affordable than concrete or steel. Compared to other types of piles (steel or concrete), and depending on the source/type of timber, timber piles may not be suitable for heavier loads.

A main consideration regarding timber piles is that they should be protected from rotting above groundwater level. Timber will last for a long time below the groundwater level. For timber to rot, two elements are needed: water and oxygen. Below the groundwater level, dissolved oxygen is lacking even though there is ample water. Hence, timber tends to last for a long time below the groundwater level. An example is Venice, which has had timber pilings since its beginning; even most of the oldest piles are still in use. In 1648, the Royal Palace of Amsterdam was constructed on 13,659 timber piles that still survive today since they were below groundwater level. Timber that is to be used above the water table can be protected from decay and insects by numerous forms of wood preservation using pressure treatment (alkaline copper quaternary (ACQ), chromated copper arsenate (CCA), creosote, etc.).

Splicing timber piles is still quite common and is the easiest of all the piling materials to splice. The normal method for splicing is by driving the leader pile first, driving a steel tube (normally 60–100 cm long, with an internal diameter no smaller than the minimum toe diameter) half its length onto the end of the leader pile. The follower pile is then simply slotted into the other end of the tube and driving continues. The steel tube is simply there to ensure that the two pieces follow each other during driving. If uplift capacity is required, the splice can incorporate bolts, coach screws, spikes or the like to give it the necessary capacity.

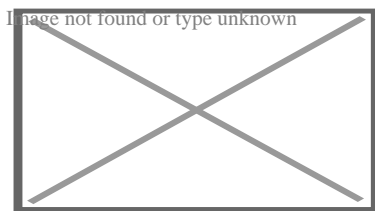
## Iron

[edit]

Cast iron may be used for piling. These may be ductile.<sup>[*citation needed*]</sup>

## Steel

[edit]



Cutaway illustration. Deep inclined (battered) pipe piles support a precast segmented skyway where upper soil layers are weak muds.

Pipe piles are a type of steel driven pile foundation and are a good candidate for inclined (battered) piles.

Pipe piles can be driven either open end or closed end. When driven open end, soil is allowed to enter the bottom of the pipe or tube. If an empty pipe is required, a jet of water or an auger can be used to remove the soil inside following driving. Closed end pipe piles are constructed by covering the bottom of the pile with a steel plate or cast steel shoe.

In some cases, pipe piles are filled with concrete to provide additional moment capacity or corrosion resistance. In the United Kingdom, this is generally not done in order to reduce the cost.<sup>[*citation needed*]</sup> In these cases corrosion protection is provided by allowing for a sacrificial thickness of steel or by adopting a higher grade of steel. If a concrete filled pipe pile is corroded, most of the load carrying capacity of the pile will remain intact due to the concrete, while it will be lost in an empty pipe pile. The structural capacity of pipe piles is primarily calculated based on steel strength and concrete strength (if filled). An allowance is made for corrosion depending on the site conditions and local building codes. Steel pipe piles can either be new steel manufactured specifically for the piling industry or reclaimed steel tubular casing previously used for other purposes such as oil and gas exploration.



H-Piles are structural beams that are driven in the ground for deep foundation application. They can be easily cut off or joined by welding or mechanical drive-fit splicers. If the pile is driven into a soil with low pH value, then there is a risk of corrosion, coal-tar epoxy or cathodic protection can be applied to slow or eliminate the corrosion process. It is common to allow for an amount of corrosion in design by simply over dimensioning the cross-sectional area of the steel pile. In this way, the corrosion process can be prolonged up to 50 years.<sup>[*citation needed*]</sup>

## **Prestressed concrete piles**

[edit]

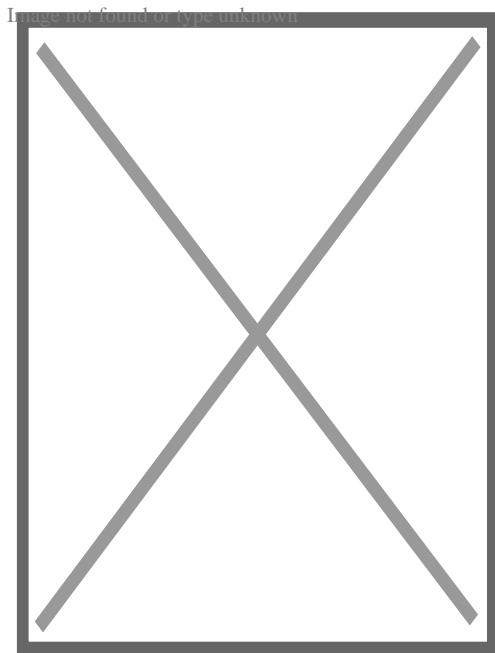
Concrete piles are typically made with steel reinforcing and prestressing tendons to obtain the tensile strength required, to survive handling and driving, and to provide sufficient bending resistance.

Long piles can be difficult to handle and transport. Pile joints can be used to join two or more short piles to form one long pile. Pile joints can be used with both precast and prestressed concrete piles.

## **Composite piles**

[edit]

A "composite pile" is a pile made of steel and concrete members that are fastened together, end to end, to form a single pile. It is a combination of different materials or different shaped materials such as pipe and H-beams or steel and concrete.



'Pile jackets' encasing old concrete piles in a saltwater environment to prevent corrosion and consequential weakening of the piles when cracks allow saltwater to contact the internal steel reinforcement rods

## **Construction machinery for driving piles into the ground**

[edit]

Construction machinery used to drive piles into the ground:[<sup>15</sup>]

- Pile driver is a device for placing piles in their designed position.
- Diesel pile hammer is a device for hammering piles into the ground.
- Hydraulic hammer is removable working equipment of hydraulic excavators, hydroficated machines (stationary rock breakers, loaders, manipulators, pile driving hammers) used for processing strong materials (rock, soil, metal) or pile driving elements by impact of falling parts dispersed by high-pressure fluid.
- Vibratory pile driver is a machine for driving piles into sandy and clay soils.
- Press-in pile driver is a machine for sinking piles into the ground by means of static force transmission.[<sup>16</sup>]
- Universal drilling machine.

## **Construction machinery for replacement piles**

[edit]

Construction machinery used to construct replacement piles:[<sup>15</sup>]

- Sectional Flight Auger or Continuous Flight Auger
- Reverse circulation drilling
- Ring bit concentric drilling

## **See also**

[edit]

- Eurocode EN 1997
- International Society for Micropiles
- Post in ground construction also called earthfast or posthole construction; a historic method of building wooden structures.
- Stilt house, also known as a lake house; an ancient, historic house type built on pilings.
- Shallow foundations
- Pile bridge
- Larssen sheet piling

## **Notes**

[edit]

1. ^ Offshore Wind Turbine Foundations, 2009-09-09, accessed 2010-04-12.

2. ^ **a b** Constructing a turbine foundation Archived 21 May 2011 at the Wayback Machine Horns Rev project, Elsam monopile foundation construction process, accessed 2010-04-12]
3. ^ Horns Revolution Archived 14 July 2011 at the Wayback Machine, Modern Power Systems, 2002-10-05, accessed 2010-04-14.
4. ^ "Lynn and Inner Dowsing description". Archived from the original on 26 July 2011. Retrieved 23 July 2010.
5. ^ **a b** Handbook on Under-reamed and bored compaction pile foundation, Central building research institute Roorkee, Prepared by Devendra Sharma, M. P. Jain, Chandra Prakash
6. ^ **a b** Siel, Barry D.; Anderson, Scott A. "Implementation of Micropiles by the Federal Highway Administration" (PDF). *Federal Highway Administration (US)*. cite journal: Cite journal requires |journal= (help)
7. ^ Marshall, Brain (April 2000). "How House Construction Works". *How Stuff Works*. HowStuffWorks, Inc. Retrieved 4 April 2013.
8. ^ "jet-pile". Merriam-Webster. Retrieved 2 August 2020.
9. ^ Guan, Chengli; Yang, Yuyou (21 February 2019). "Field Study on the Waterstop of the Rodin Jet Pile". *Applied Sciences*. doi:10.3390/app9081709. Retrieved 2 August 2020.
10. ^ "Press-in with Water Jetting". Giken.com. Giken Ltd. Retrieved 2 August 2020.
11. ^ "City Lade, Trondheim". Jetgrunn.no. Jetgrunn AS. Retrieved 2 August 2020.
12. ^ Omer, Joshua R. (2010). "A Numerical Model for Load Transfer and Settlement of Bored Cast In-Situ Piles". *Proceedings of the 35th Annual Conference on Deep Foundations*. Archived from the original on 14 April 2021. Retrieved 20 July 2011.
13. ^ "International Society for Micropiles". Retrieved 2 February 2007.
14. ^ "GeoTechTools". Geo-Institute. Retrieved 15 April 2022.
15. ^ **a b** McNeil, Ian (1990). *An Encyclopaedia of the history of technology*. Routledge. ISBN 9780415147927. Retrieved 20 July 2022 – via Internet Archive.
16. ^ "General description of the press-in pile driving unit". *Concrete Pumping Melbourne*. 13 October 2021. Archived from the original on 25 December 2022. Retrieved 20 July 2022.

## References

[edit]

- Italiantrivelle Foundation Industry Archived 25 June 2014 at the Wayback Machine The Deep Foundation web portal Italiantrivelle is the number one source of information regarding the Foundation Industry. (Link needs to be removed or updated, links to inappropriate content)
- Fleming, W. G. K. et al., 1985, *Piling Engineering*, Surrey University Press; Hunt, R. E., *Geotechnical Engineering Analysis and Evaluation*, 1986, McGraw-Hill.
- Coduto, Donald P. *Foundation Design: Principles and Practices* 2nd ed., Prentice-Hall Inc., 2001.
- NAVFAC DM 7.02 Foundations and Earth Structures U.S. Naval Facilities Engineering Command, 1986.
- Rajapakse, Ruwan., *Pile Design and Construction Guide*, 2003

- Tomlinson, P.J., *Pile Design and Construction Practice*, 1984
- Stabilization of Organic Soils Archived 22 February 2012 at the Wayback Machine
- Sheet piling handbook, 2010

## External links

[[edit](#)]

 image not found or type unknown

Wikimedia Commons has media related to ***Deep foundations***.

- Deep Foundations Institute

- **v**

- **t**

- **e**


Geotechnical engineering

Offshore geotechnical engineering

## Investigation and instrumentation

Field (*in situ*)

Laboratory  
testing

-  Core drill
-  Cone penetration test
-  Geo-electrical sounding
-  Permeability test
-  Load test
  - Static
  - Dynamic
  - Statnamic
-  Pore pressure measurement
  - Piezometer
  - Well
-  Ram sounding
-  Rock control drilling
-  Rotary-pressure sounding
-  Rotary weight sounding
-  Sample series
-  Screw plate test
- Deformation monitoring
  -  Inclinator
  -  Settlement recordings
-  Shear vane test
-  Simple sounding
-  Standard penetration test
-  Total sounding
-  Trial pit
-  Visible bedrock
- Nuclear densometer test
- Exploration geophysics
- Crosshole sonic logging
- Pile integrity test
- Wave equation analysis
- Soil classification
- Atterberg limits
- California bearing ratio
- Direct shear test
- Hydrometer
- Proctor compaction test
- R-value
- Sieve analysis
- Triaxial shear test
- Oedometer test
- Hydraulic conductivity tests
- Water content tests

## **Soil**

### Types

- Clay
- Silt
- Sand
- Gravel
- Peat
- Loam
- Loess
- Hydraulic conductivity
- Water content
- Void ratio
- Bulk density
- Thixotropy

### Properties

- Reynolds' dilatancy
- Angle of repose
- Friction angle
- Cohesion
- Porosity
- Permeability
- Specific storage
- Shear strength
- Sensitivity



**Structures  
(Interaction)**

Natural features

- Topography
- Vegetation
- Terrain
- Topsoil
- Water table
- Bedrock
- Subgrade
- Subsoil
- Shoring structures
  - Retaining walls
  - Gabion
  - Ground freezing
  - Mechanically stabilized earth
  - Pressure grouting
  - Slurry wall
  - Soil nailing
  - Tieback

Earthworks

- Land development
- Landfill
- Excavation
- Trench
- Embankment
- Cut
- Causeway
- Terracing
- Cut-and-cover
- Cut and fill
- Fill dirt
- Grading
- Land reclamation
- Track bed
- Erosion control
- Earth structure
- Expanded clay aggregate
- Crushed stone
- Geosynthetics
  - Geotextile
  - Geomembrane
  - Geosynthetic clay liner
  - Cellular confinement

Foundations

- Infiltration
- Shallow
- Deep

<b>Mechanics</b>	Forces	<ul style="list-style-type: none"> <li>○ Effective stress</li> <li>○ Pore water pressure</li> <li>○ Lateral earth pressure</li> <li>○ Overburden pressure</li> <li>○ Preconsolidation pressure</li> <li>○ Permafrost</li> <li>○ Frost heaving</li> <li>○ Consolidation</li> <li>○ Compaction</li> <li>○ Earthquake <ul style="list-style-type: none"> <li>○ Response spectrum</li> <li>○ Seismic hazard</li> <li>○ Shear wave</li> </ul> </li> </ul>
	Phenomena/ problems	<ul style="list-style-type: none"> <li>○ Landslide analysis <ul style="list-style-type: none"> <li>○ Stability analysis</li> <li>○ Mitigation</li> <li>○ Classification</li> <li>○ Sliding criterion</li> <li>○ Slab stabilisation</li> </ul> </li> <li>○ Bearing capacity * Stress distribution in soil</li> </ul>
<b>Numerical analysis software</b>		<ul style="list-style-type: none"> <li>○ SEEP2D</li> <li>○ STABL</li> <li>○ SVFlux</li> <li>○ SVSlope</li> <li>○ UTEXAS</li> <li>○ Plaxis</li> <li>○ Geology</li> <li>○ Geochemistry</li> <li>○ Petrology</li> <li>○ Earthquake engineering</li> <li>○ Geomorphology</li> </ul>
<b>Related fields</b>		<ul style="list-style-type: none"> <li>○ Soil science</li> <li>○ Hydrology</li> <li>○ Hydrogeology</li> <li>○ Biogeography</li> <li>○ Earth materials</li> <li>○ Archaeology</li> <li>○ Agricultural science <ul style="list-style-type: none"> <li>○ Agrology</li> </ul> </li> </ul>

Authority control databases: National

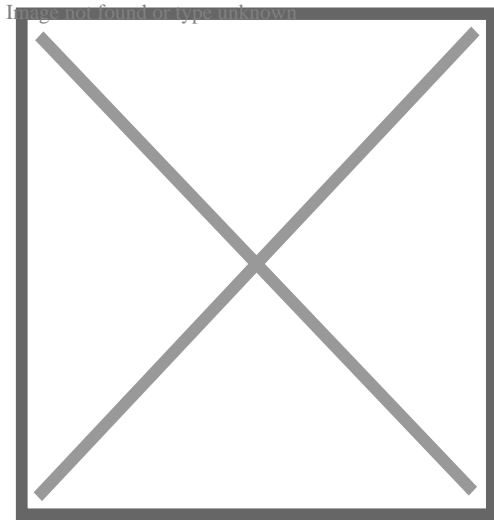
- Germany
- France
- Edit this at Wikidata
- BNF data
- Czech Republic

## About Pump

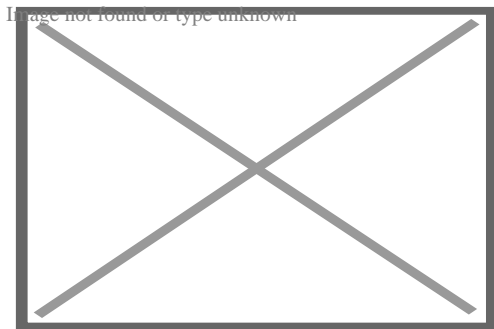


**The accessibility of this article is in question.** The specific issue is: **animation fails MOS, see talk**. Relevant discussion may be found on the talk page. *(April 2025)*

"Water Pump" redirects here. For the community in Pakistan, see Water Pump, Karachi. For other uses of "pump" or "pumps", see Pump (disambiguation).



A small, electrically powered pump



A large, electrically driven pump for waterworks near the Hengsteysee, Germany

A **pump** is a device that moves fluids (liquids or gases), or sometimes slurries,<sup>[1]</sup> by mechanical action, typically converted from electrical energy into hydraulic or pneumatic energy.

Mechanical pumps serve in a wide range of applications such as pumping water from wells, aquarium filtering, pond filtering and aeration, in the car industry for water-cooling and fuel injection, in the energy industry for pumping oil and natural gas or for operating cooling towers and other components of heating, ventilation and air conditioning systems. In the medical industry, pumps are used for biochemical processes in developing and manufacturing medicine, and as artificial replacements for body parts, in particular the artificial heart and penile prosthesis.

When a pump contains two or more pump mechanisms with fluid being directed to flow through them in series, it is called a *multi-stage pump*. Terms such as *two-stage* or *double-stage* may be used to specifically describe the number of stages. A pump that does not fit this description is simply a *single-stage pump* in contrast.

In biology, many different types of chemical and biomechanical pumps have evolved; biomimicry is sometimes used in developing new types of mechanical pumps.

## Types

[edit]

Mechanical pumps may be **submerged** in the fluid they are pumping or be placed **external** to the fluid.

Pumps can be classified by their method of displacement into electromagnetic pumps, positive-displacement pumps, impulse pumps, velocity pumps, gravity pumps, steam pumps and valveless pumps. There are three basic types of pumps: positive-displacement, centrifugal and axial-flow pumps. In centrifugal pumps the direction of flow of the fluid changes by ninety degrees as it flows over an impeller, while in axial flow pumps the direction of flow is unchanged.<sup>[2]</sup><sup>[3]</sup>

See also: Vacuum pump

## Electromagnetic pump

[edit]

This section is an excerpt from Electromagnetic pump.[edit]

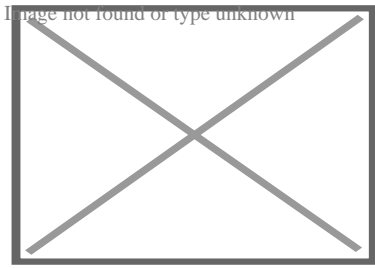
An electromagnetic pump is a pump that moves liquid metal, molten salt, brine, or other electrically conductive liquid using electromagnetism.

A magnetic field is set at right angles to the direction the liquid moves in, and a current is passed through it. This causes an electromagnetic force that moves the liquid.

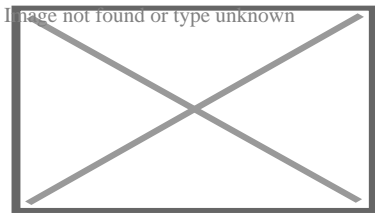
Applications include pumping molten solder in many wave soldering machines, pumping liquid-metal coolant, and magnetohydrodynamic drive.

## Positive-displacement pumps

[edit]



Lobe pump internals



Lobe pump internals

A positive-displacement pump makes a fluid move by trapping a fixed amount and forcing (displacing) that trapped volume into the discharge pipe.

Some positive-displacement pumps use an expanding cavity on the suction side and a decreasing cavity on the discharge side. Liquid flows into the pump as the cavity on the suction side expands and the liquid flows out of the discharge as the cavity collapses. The volume is constant through each cycle of operation.

## Positive-displacement pump behavior and safety

[edit]

Positive-displacement pumps, unlike centrifugal, can theoretically produce the same flow at a given rotational speed no matter what the discharge pressure. Thus, positive-displacement pumps are *constant flow machines*. However, a slight increase in internal leakage as the pressure increases prevents a truly constant flow rate.

A positive-displacement pump must not operate against a closed valve on the discharge side of the pump, because it has no shutoff head like centrifugal pumps. A positive-displacement pump operating against a closed discharge valve continues to produce flow and the pressure in the discharge line increases until the line bursts, the pump is severely damaged, or both.

A relief or safety valve on the discharge side of the positive-displacement pump is therefore necessary. The relief valve can be internal or external. The pump manufacturer normally has the option to supply internal relief or safety valves. The internal valve is usually used only as a safety precaution. An external relief valve in the discharge line, with a return line back to the suction line or supply tank, provides increased safety.

## Positive-displacement types

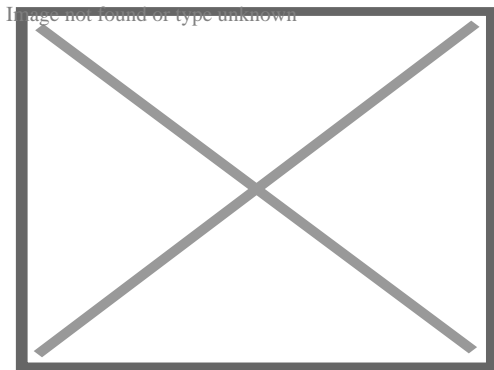
[edit]

A positive-displacement pump can be further classified according to the mechanism used to move the fluid:

- *Rotary-type* positive displacement: internal and external gear pump, screw pump, lobe pump, shuttle block, flexible vane and sliding vane, circumferential piston, flexible impeller, helical twisted roots (e.g. the Wendelkolben pump) and liquid-ring pumps
- *Reciprocating-type* positive displacement: piston pumps, plunger pumps and diaphragm pumps
- *Linear-type* positive displacement: rope pumps and chain pumps

## Rotary positive-displacement pumps

[edit]



Rotary vane pump

These pumps move fluid using a rotating mechanism that creates a vacuum that captures and draws in the liquid.<sup>[4]</sup>

*Advantages:* Rotary pumps are very efficient<sup>[5]</sup> because they can handle highly viscous fluids with higher flow rates as viscosity increases.<sup>[6]</sup>

*Drawbacks:* The nature of the pump requires very close clearances between the rotating pump and the outer edge, making it rotate at a slow, steady speed. If rotary pumps are operated at high speeds, the fluids cause erosion, which eventually causes enlarged

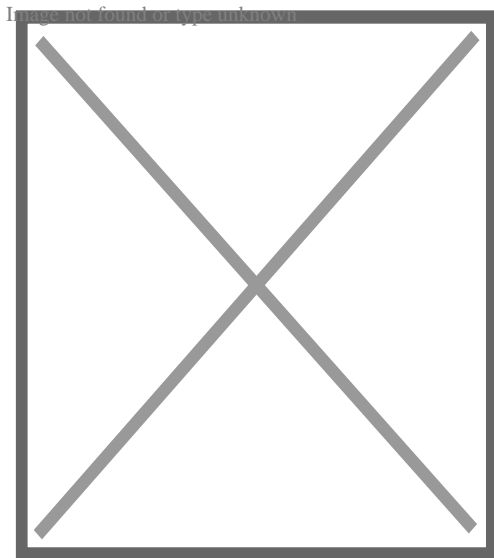
clearances that liquid can pass through, which reduces efficiency.

Rotary positive-displacement pumps fall into five main types:

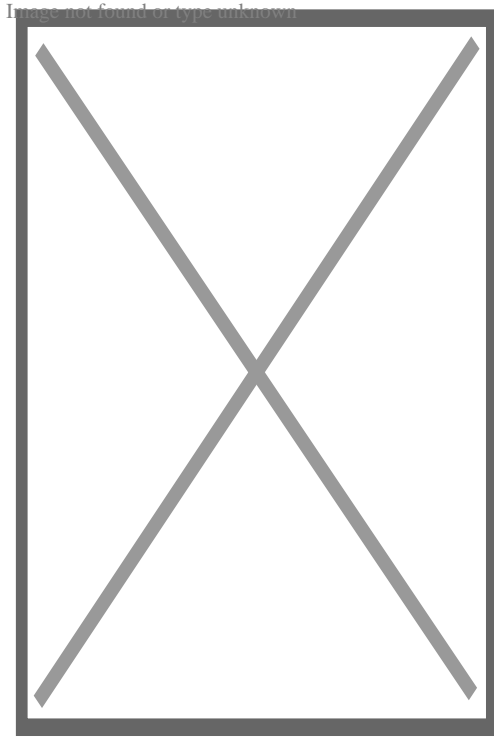
- Gear pumps – a simple type of rotary pump where the liquid is pushed around a pair of gears.
- Screw pumps – the shape of the internals of this pump is usually two screws turning against each other to pump the liquid
- Rotary vane pumps
- Hollow disc pumps (also known as eccentric disc pumps or hollow rotary disc pumps), similar to scroll compressors, these have an eccentric cylindrical rotor encased in a circular housing. As the rotor orbits, it traps fluid between the rotor and the casing, drawing the fluid through the pump. It is used for highly viscous fluids like petroleum-derived products, and it can also support high pressures of up to 290 psi.<sup>[7][8][9][10][11][12][13]</sup>
- Peristaltic pumps have rollers which pinch a section of flexible tubing, forcing the liquid ahead as the rollers advance. Because they are very easy to keep clean, these are popular for dispensing food, medicine, and concrete.

## Reciprocating positive-displacement pumps

[edit]



Simple hand pump



Antique "pitcher" pump (c. 1924) at the Colored School in Alapaha, Georgia, US

See also: Reciprocating pump

Reciprocating pumps move the fluid using one or more oscillating pistons, plungers, or membranes (diaphragms), while valves restrict fluid motion to the desired direction. In order for suction to take place, the pump must first pull the plunger in an outward motion to decrease pressure in the chamber. Once the plunger pushes back, it will increase the chamber pressure and the inward pressure of the plunger will then open the discharge valve and release the fluid into the delivery pipe at constant flow rate and increased pressure.

Pumps in this category range from *simplex*, with one cylinder, to in some cases *quad* (four) cylinders, or more. Many reciprocating-type pumps are *duplex* (two) or *triplex* (three) cylinder. They can be either *single-acting* with suction during one direction of piston motion and discharge on the other, or *double-acting* with suction and discharge in both directions. The pumps can be powered manually, by air or steam, or by a belt driven by an engine. This type of pump was used extensively in the 19th century—in the early days of steam propulsion—as boiler feed water pumps. Now reciprocating pumps typically pump highly viscous fluids like concrete and heavy oils, and serve in special applications that demand low flow rates against high resistance. Reciprocating hand pumps were widely used to pump water from wells. Common bicycle pumps and foot pumps for inflation use reciprocating action.

These positive-displacement pumps have an expanding cavity on the suction side and a decreasing cavity on the discharge side. Liquid flows into the pumps as the cavity on the suction side expands and the liquid flows out of the discharge as the cavity collapses. The



volume is constant given each cycle of operation and the pump's volumetric efficiency can be achieved through routine maintenance and inspection of its valves.[<sup>14</sup>]

Typical reciprocating pumps are:

- *Plunger pump* – a reciprocating plunger pushes the fluid through one or two open valves, closed by suction on the way back.
- *Diaphragm pump* – similar to plunger pumps, where the plunger pressurizes hydraulic oil which is used to flex a diaphragm in the pumping cylinder. Diaphragm valves are used to pump hazardous and toxic fluids.
- *Piston pump displacement pumps* – *usually simple devices for pumping small amounts of liquid or gel manually. The common hand soap dispenser is such a pump.*
- *Radial piston pump* – a form of hydraulic pump where pistons extend in a radial direction.
- Vibratory pump or vibration pump – a particularly low-cost form of plunger pump, popular in low-cost espresso machines.[<sup>15</sup>][<sup>16</sup>] The only moving part is a spring-loaded piston, the armature of a solenoid. Driven by half-wave rectified alternating current, the piston is forced forward while energized, and is retracted by the spring during the other half cycle. Due to their inefficiency, vibratory pumps typically cannot be operated for more than one minute without overheating, so are limited to intermittent duty.

## Various positive-displacement pumps

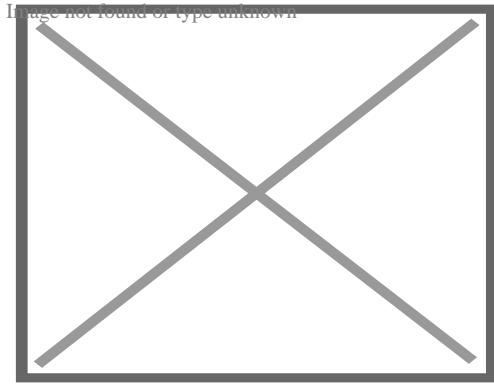
[edit]

The positive-displacement principle applies in these pumps:

- Rotary lobe pump
- Progressing cavity pump
- Rotary gear pump
- Piston pump
- Diaphragm pump
- Screw pump
- Gear pump
- Hydraulic pump
- Rotary vane pump
- Peristaltic pump
- Rope pump
- Flexible impeller pump

## Gear pump

[edit]



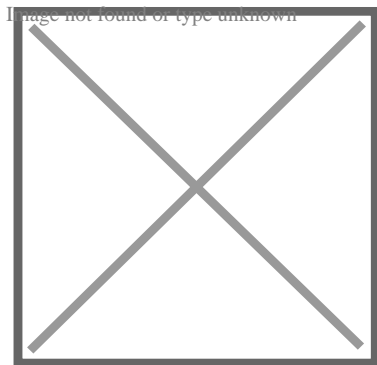
Gear pump

Main article: Gear pump

This is the simplest form of rotary positive-displacement pumps. It consists of two meshed gears that rotate in a closely fitted casing. The tooth spaces trap fluid and force it around the outer periphery. The fluid does not travel back on the meshed part, because the teeth mesh closely in the center. Gear pumps see wide use in car engine oil pumps and in various hydraulic power packs.

## Screw pump

[edit]



Screw pump

Main article: Screw pump

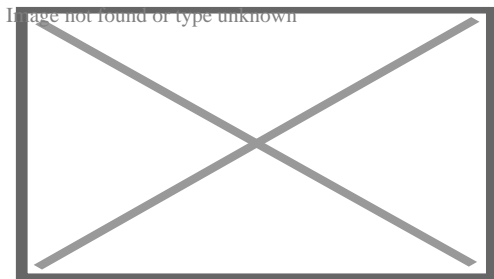
A screw pump is a more complicated type of rotary pump that uses two or three screws with opposing thread — e.g., one screw turns clockwise and the other counterclockwise. The screws are mounted on parallel shafts that often have gears that mesh so the shafts turn

together and everything stays in place. In some cases the driven screw drives the secondary screw, without gears, often using the fluid to limit abrasion. The screws turn on the shafts and drive fluid through the pump. As with other forms of rotary pumps, the clearance between moving parts and the pump's casing is minimal.

## Progressing cavity pump

[edit]

Main article: Progressing cavity pump

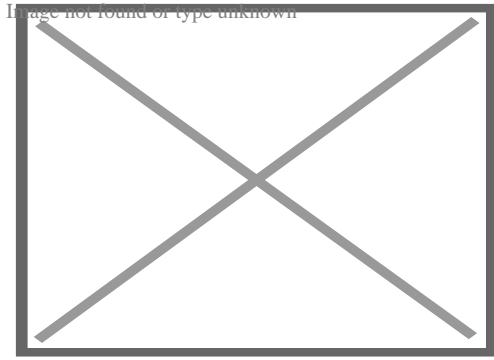


Progressing cavity pump

Widely used for pumping difficult materials, such as sewage sludge contaminated with large particles, a progressing cavity pump consists of a helical rotor, about ten times as long as its width, and a stator, mainly made out of rubber. This can be visualized as a central core of diameter  $x$  with, typically, a curved spiral wound around of thickness half  $x$ , though in reality it is manufactured in a single lobe. This shaft fits inside a heavy-duty rubber sleeve or stator, of wall thickness also typically  $x$ . As the shaft rotates inside the stator, the rotor gradually forces fluid up the rubber cavity. Such pumps can develop very high pressure at low volumes at a rate of 90 PSI per stage on water for standard configurations.

## Roots-type pump

[edit]



A Roots lobe pump

Main article: Roots-type supercharger

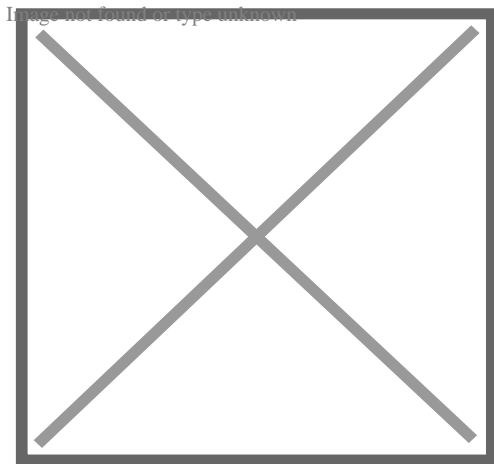
Named after the Roots brothers who invented it, this lobe pump displaces the fluid trapped between two long helical rotors, each fitted into the other when perpendicular at 90°, rotating inside a triangular shaped sealing line configuration, both at the point of suction and at the point of discharge. This design produces a continuous flow with equal volume and no vortex. It can work at low pulsation rates, and offers gentle performance that some applications require.

Applications include:

- High capacity industrial air compressors.
- Roots superchargers on internal combustion engines.
- A brand of civil defense siren, the Federal Signal Corporation's Thunderbolt.

## Peristaltic pump

[edit]



360° peristaltic pump

Main article: Peristaltic pump

A *peristaltic pump* is a type of positive-displacement pump. It contains fluid within a flexible tube fitted inside a circular pump casing (though linear peristaltic pumps have been made). A number of *rollers*, *shoes*, or *wipers* attached to a rotor compress the flexible tube. As the rotor turns, the part of the tube under compression closes (or *occludes*), forcing the fluid through the tube. Additionally, when the tube opens to its natural state after the passing of the cam it draws (*restitution*) fluid into the pump. This process is called *peristalsis* and is used in many biological systems such as the gastrointestinal tract.

## Plunger pumps

[edit]

Main article: Plunger pump

*Plunger pumps* are reciprocating positive-displacement pumps.

These consist of a cylinder with a reciprocating plunger. The suction and discharge valves are mounted in the head of the cylinder. In the suction stroke, the plunger retracts and the suction valves open causing suction of fluid into the cylinder. In the forward stroke, the plunger pushes the liquid out of the discharge valve. Efficiency and common problems: With only one cylinder in plunger pumps, the fluid flow varies between maximum flow when the plunger moves through the middle positions, and zero flow when the plunger is at the end positions. A lot of energy is wasted when the fluid is accelerated in the piping system. Vibration and *water hammer* may be a serious problem. In general, the problems are compensated for by using two or more cylinders not working in phase with each other. Centrifugal pumps are also susceptible to water hammer. Surge analysis, a specialized study, helps evaluate this risk in such systems.

## Triplex-style plunger pump

[edit]

Triplex plunger pumps use three plungers, which reduces the pulsation relative to single reciprocating plunger pumps. Adding a pulsation dampener on the pump outlet can further smooth the *pump ripple*, or ripple graph of a pump transducer. The dynamic relationship of the high-pressure fluid and plunger generally requires high-quality plunger seals. Plunger pumps with a larger number of plungers have the benefit of increased flow, or smoother flow without a pulsation damper. The increase in moving parts and crankshaft load is one

drawback.

Car washes often use these triplex-style plunger pumps (perhaps without pulsation dampers). In 1968, William Bruggeman reduced the size of the triplex pump and increased the lifespan so that car washes could use equipment with smaller footprints. Durable high-pressure seals, low-pressure seals and oil seals, hardened crankshafts, hardened connecting rods, thick ceramic plungers and heavier duty ball and roller bearings improve reliability in triplex pumps. Triplex pumps now are in a myriad of markets across the world.

Triplex pumps with shorter lifetimes are commonplace to the home user. A person who uses a home pressure washer for 10 hours a year may be satisfied with a pump that lasts 100 hours between rebuilds. Industrial-grade or continuous duty triplex pumps on the other end of the quality spectrum may run for as much as 2,080 hours a year.<sup>[17]</sup>

The oil and gas drilling industry uses massive semi-trailer-transported triplex pumps called mud pumps to pump drilling mud, which cools the drill bit and carries the cuttings back to the surface.<sup>[18]</sup> Drillers use triplex or even quintuplex pumps to inject water and solvents deep into shale in the extraction process called *fracking*.<sup>[19]</sup>

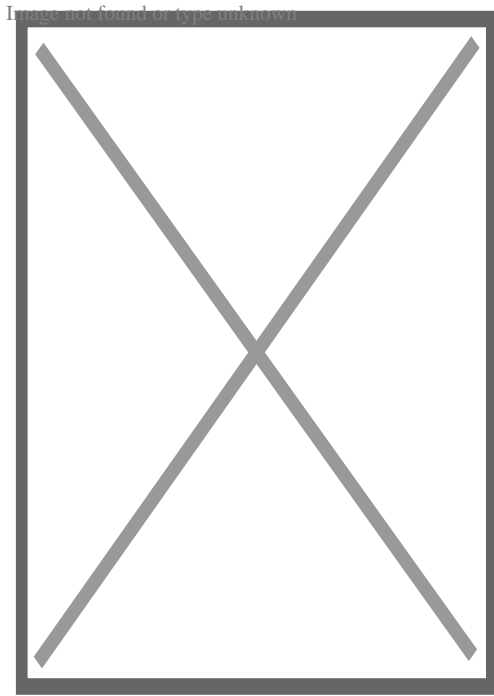
## Diaphragm pump

[edit]

Typically run on electricity compressed air, diaphragm pumps are relatively inexpensive and can perform a wide variety of duties, from pumping air into an aquarium, to liquids through a filter press. Double-diaphragm pumps can handle viscous fluids and abrasive materials with a gentle pumping process ideal for transporting shear-sensitive media.<sup>[20]</sup>

## Rope pump

[edit]



Rope pump schematic

Main article: Rope pump

Devised in China as chain pumps over 1000 years ago, these pumps can be made from very simple materials: A rope, a wheel and a pipe are sufficient to make a simple rope pump. Rope pump efficiency has been studied by grassroots organizations and the techniques for making and running them have been continuously improved.<sup>[21]</sup>

## Impulse pump

[edit]

Impulse pumps use pressure created by gas (usually air). In some impulse pumps the gas trapped in the liquid (usually water), is released and accumulated somewhere in the pump, creating a pressure that can push part of the liquid upwards.

Conventional impulse pumps include:

- *Hydraulic ram pumps* – kinetic energy of a low-head water supply is stored temporarily in an air-bubble hydraulic accumulator, then used to drive water to a higher head.
- *Pulser pumps* – run with natural resources, by kinetic energy only.
- *Airlift pumps* – run on air inserted into pipe, which pushes the water up when bubbles move upward

Instead of a gas accumulation and releasing cycle, the pressure can be created by burning of hydrocarbons. Such combustion driven pumps directly transmit the impulse from a combustion event through the actuation membrane to the pump fluid. In order to allow this direct transmission, the pump needs to be almost entirely made of an elastomer (e.g. silicone rubber). Hence, the combustion causes the membrane to expand and thereby pumps the fluid out of the adjacent pumping chamber. The first combustion-driven soft pump was developed by ETH Zurich.<sup>[22]</sup>

## Hydraulic ram pump

[edit]

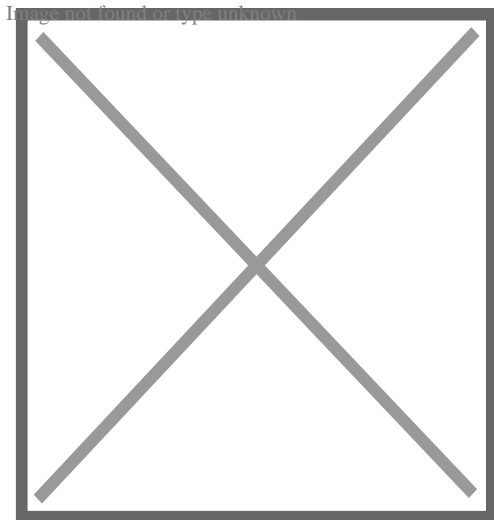
A hydraulic ram is a water pump powered by hydropower.<sup>[23]</sup>

It takes in water at relatively low pressure and high flow-rate and outputs water at a higher hydraulic-head and lower flow-rate. The device uses the water hammer effect to develop pressure that lifts a portion of the input water that powers the pump to a point higher than where the water started.

The hydraulic ram is sometimes used in remote areas, where there is both a source of low-head hydropower, and a need for pumping water to a destination higher in elevation than the source. In this situation, the ram is often useful, since it requires no outside source of power other than the kinetic energy of flowing water.

## Velocity pumps

[edit]



A centrifugal pump uses an impeller with backward-swept arms



Rotodynamic pumps (or dynamic pumps) are a type of velocity pump in which kinetic energy is added to the fluid by increasing the flow velocity. This increase in energy is converted to a gain in potential energy (pressure) when the velocity is reduced prior to or as the flow exits the pump into the discharge pipe. This conversion of kinetic energy to pressure is explained by the *First law of thermodynamics*, or more specifically by *Bernoulli's principle*.

Dynamic pumps can be further subdivided according to the means in which the velocity gain is achieved.<sup>[24]</sup>

These types of pumps have a number of characteristics:

1. Continuous energy
2. Conversion of added energy to increase in kinetic energy (increase in velocity)
3. Conversion of increased velocity (kinetic energy) to an increase in pressure head

A practical difference between dynamic and positive-displacement pumps is how they operate under closed valve conditions. Positive-displacement pumps physically displace fluid, so closing a valve downstream of a positive-displacement pump produces a continual pressure build up that can cause mechanical failure of pipeline or pump. Dynamic pumps differ in that they can be safely operated under closed valve conditions (for short periods of time).

## Radial-flow pump

[edit]

Such a pump is also referred to as a *centrifugal pump*. The fluid enters along the axis or center, is accelerated by the impeller and exits at right angles to the shaft (radially); an example is the centrifugal fan, which is commonly used to implement a vacuum cleaner. Another type of radial-flow pump is a vortex pump. The liquid in them moves in tangential direction around the working wheel. The conversion from the mechanical energy of motor into the potential energy of flow comes by means of multiple whirls, which are excited by the impeller in the working channel of the pump. Generally, a radial-flow pump operates at higher pressures and lower flow rates than an axial- or a mixed-flow pump.

## Axial-flow pump

[edit]

Main article: Axial-flow pump

These are also referred to as *all-fluid pumps*. The fluid is pushed outward or inward to move fluid axially. They operate at much lower pressures and higher flow rates than radial-flow (centrifugal) pumps. Axial-flow pumps cannot be run up to speed without special

precaution. If at a low flow rate, the total head rise and high torque associated with this pipe would mean that the starting torque would have to become a function of acceleration for the whole mass of liquid in the pipe system.[<sup>25</sup>]

Mixed-flow pumps function as a compromise between radial and axial-flow pumps. The fluid experiences both radial acceleration and lift and exits the impeller somewhere between 0 and 90 degrees from the axial direction. As a consequence mixed-flow pumps operate at higher pressures than axial-flow pumps while delivering higher discharges than radial-flow pumps. The exit angle of the flow dictates the pressure head-discharge characteristic in relation to radial and mixed-flow.

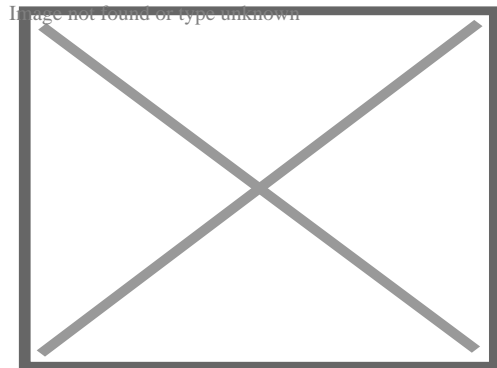
## Regenerative turbine pump

[edit]

Regenerative turbine pump animation

Image not found or type unknown

Regenerative turbine pump animation



Close-up of a Regenerative Turbine Pump Impeller

Also known as **drag**, **friction**, **liquid-ring pump**, **peripheral**, **traction**, **turbulence**, or **vortex** pumps, regenerative turbine pumps are a class of rotodynamic pump that operates at high head pressures, typically 4–20 bars (400–2,000 kPa; 58–290 psi).[<sup>26</sup>]

The pump has an impeller with a number of vanes or paddles which spins in a cavity. The suction port and pressure ports are located at the perimeter of the cavity and are isolated by a barrier called a **stripper**, which allows only the **tip channel** (fluid between the blades)

to recirculate, and forces any fluid in the **side channel** (fluid in the cavity outside of the blades) through the pressure port. In a regenerative turbine pump, as fluid spirals repeatedly from a vane into the side channel and back to the next vane, kinetic energy is imparted to the periphery,<sup>[26]</sup> thus pressure builds with each spiral, in a manner similar to a regenerative blower.<sup>[27][28][29]</sup>

As regenerative turbine pumps cannot become vapor locked, they are commonly applied to volatile, hot, or cryogenic fluid transport. However, as tolerances are typically tight, they are vulnerable to solids or particles causing jamming or rapid wear. Efficiency is typically low, and pressure and power consumption typically decrease with flow. Additionally, pumping direction can be reversed by reversing direction of spin.<sup>[29][27][30]</sup>

## Side-channel pump

[edit]

A **side-channel** pump has a suction disk, an impeller, and a discharge disk.<sup>[31]</sup>

## Eductor-jet pump

[edit]

Main article: Eductor-jet pump

This uses a jet, often of steam, to create a low pressure. This low pressure sucks in fluid and propels it into a higher-pressure region.

## Gravity pumps

[edit]

Gravity pumps include the *syphon* and *Heron's fountain*. The *hydraulic ram* is also sometimes called a gravity pump. In a gravity pump the fluid is lifted by gravitational force.

## Steam pump

[edit]

Steam pumps have been for a long time mainly of historical interest. They include any type of pump powered by a steam engine and also pistonless pumps such as Thomas Savery's or the Pulsometer steam pump.

Recently there has been a resurgence of interest in low-power solar steam pumps for use in smallholder irrigation in developing countries. Previously small steam engines have not

been viable because of escalating inefficiencies as vapour engines decrease in size. However the use of modern engineering materials coupled with alternative engine configurations has meant that these types of system are now a cost-effective opportunity.

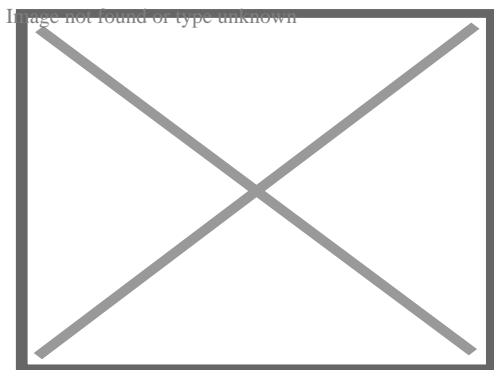
## Valveless pumps

[edit]

Valveless pumping assists in fluid transport in various biomedical and engineering systems. In a valveless pumping system, no valves (or physical occlusions) are present to regulate the flow direction. The fluid pumping efficiency of a valveless system, however, is not necessarily lower than that having valves. In fact, many fluid-dynamical systems in nature and engineering more or less rely upon valveless pumping to transport the working fluids therein. For instance, blood circulation in the cardiovascular system is maintained to some extent even when the heart's valves fail. Meanwhile, the embryonic vertebrate heart begins pumping blood long before the development of discernible chambers and valves. Similar to blood circulation in one direction, bird respiratory systems pump air in one direction in rigid lungs, but without any physiological valve. In microfluidics, valveless impedance pumps have been fabricated, and are expected to be particularly suitable for handling sensitive biofluids. Ink jet printers operating on the piezoelectric transducer principle also use valveless pumping. The pump chamber is emptied through the printing jet due to reduced flow impedance in that direction and refilled by capillary action.

## Pump repairs

[edit]



Derelict windmill connected to water pump with water storage tank in the foreground

Examining pump repair records and mean time between failures (MTBF) is of great importance to responsible and conscientious pump users. In view of that fact, the preface to the 2006 Pump User's Handbook alludes to "pump failure" statistics. For the sake of convenience, these failure statistics often are translated into MTBF (in this case, installed life before failure).[<sup>32</sup>

In early 2005, Gordon Buck, John Crane Inc.'s chief engineer for field operations in Baton Rouge, Louisiana, examined the repair records for a number of refinery and chemical plants to obtain meaningful reliability data for centrifugal pumps. A total of 15 operating plants having nearly 15,000 pumps were included in the survey. The smallest of these plants had about 100 pumps; several plants had over 2000. All facilities were located in the United States. In addition, considered as "new", others as "renewed" and still others as "established". Many of these plants—but not all—had an alliance arrangement with John Crane. In some cases, the alliance contract included having a John Crane Inc. technician or engineer on-site to coordinate various aspects of the program.

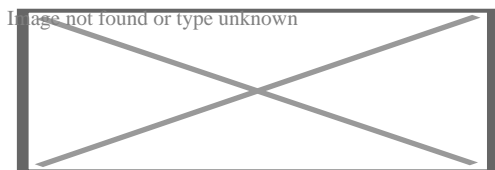
Not all plants are refineries, however, and different results occur elsewhere. In chemical plants, pumps have historically been "throw-away" items as chemical attack limits life. Things have improved in recent years, but the somewhat restricted space available in "old" DIN and ASME-standardized stuffing boxes places limits on the type of seal that fits. Unless the pump user upgrades the seal chamber, the pump only accommodates more compact and simple versions. Without this upgrading, lifetimes in chemical installations are generally around 50 to 60 percent of the refinery values.

Unscheduled maintenance is often one of the most significant costs of ownership, and failures of mechanical seals and bearings are among the major causes. Keep in mind the potential value of selecting pumps that cost more initially, but last much longer between repairs. The MTBF of a better pump may be one to four years longer than that of its non-upgraded counterpart. Consider that published average values of avoided pump failures range from US\$2600 to US\$12,000. This does not include lost opportunity costs. One pump fire occurs per 1000 failures. Having fewer pump failures means having fewer destructive pump fires.

As has been noted, a typical pump failure, based on actual year 2002 reports, costs US\$5,000 on average. This includes costs for material, parts, labor and overhead. Extending a pump's MTBF from 12 to 18 months would save US\$1,667 per year — which might be greater than the cost to upgrade the centrifugal pump's reliability.<sup>[32][1][33]</sup>

## Applications

[edit]



Metering pump for gasoline and additives

Pumps are used throughout society for a variety of purposes. Early applications includes the use of the windmill or watermill to pump water. Today, the pump is used for irrigation, water supply, gasoline supply, air conditioning systems, refrigeration (usually called a

compressor), chemical movement, sewage movement, flood control, marine services, etc.

Because of the wide variety of applications, pumps have a plethora of shapes and sizes: from very large to very small, from handling gas to handling liquid, from high pressure to low pressure, and from high volume to low volume.

## Priming a pump

[edit]

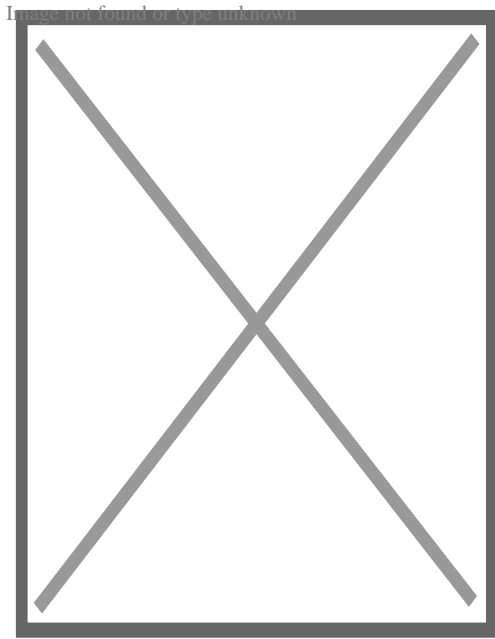
Typically, a liquid pump cannot simply draw air. The feed line of the pump and the internal body surrounding the pumping mechanism must first be filled with the liquid that requires pumping: An operator must introduce liquid into the system to initiate the pumping, known as *priming* the pump. Loss of prime is usually due to ingestion of air into the pump, or evaporation of the working fluid if the pump is used infrequently. Clearances and displacement ratios in pumps for liquids are insufficient for pumping compressible gas, so air or other gasses in the pump can not be evacuated by the pump's action alone. This is the case with most velocity (rotodynamic) pumps — for example, centrifugal pumps. For such pumps, the position of the pump and intake tubing should be lower than the suction point so it is primed by gravity; otherwise the pump should be manually filled with liquid or a secondary pump should be used until all air is removed from the suction line and the pump casing. Liquid ring pumps have a dedicated intake for the priming liquid separate from the intake of the fluid being pumped, as the fluid being pumped may be a gas or mix of gas, liquid, and solids. For these pumps the priming liquid intake must be supplied continuously (either by gravity or pressure), however the intake for the fluid being pumped is capable of drawing a vacuum equivalent to the boiling point of the priming liquid.<sup>[34]</sup>

Positive-displacement pumps, however, tend to have sufficiently tight sealing between the moving parts and the casing or housing of the pump that they can be described as *self-priming*. Such pumps can also serve as *priming pumps*, so-called when they are used to fulfill that need for other pumps in lieu of action taken by a human operator.

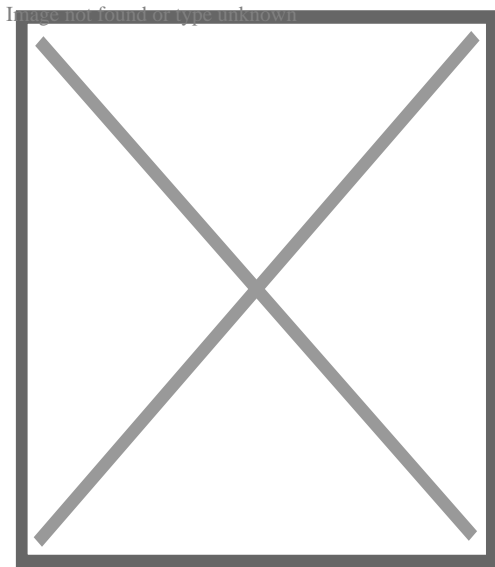
## Pumps as public water supplies

[edit]

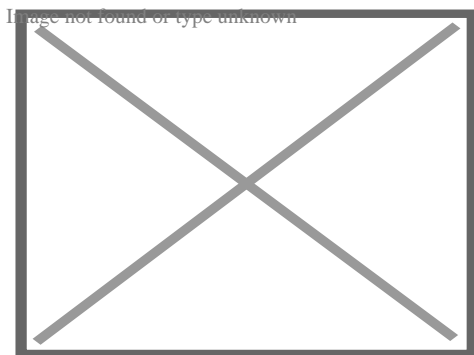
Main article: Hand pump



Arabic depiction of a piston pump, by Al-Jazari, c. 1206<sup>[35]</sup><sup>[36]</sup>



First European depiction of a piston pump, by Taccola, c. 1450<sup>[37]</sup>



Irrigation is underway by pump-enabled extraction directly from the Gumti, seen in the background, in Comilla, Bangladesh.

One sort of pump once common worldwide was a hand-powered water pump, or 'pitcher pump'. It was commonly installed over community water wells in the days before piped water supplies.

In parts of the British Isles, it was often called *the parish pump*. Though such community pumps are no longer common, people still used the expression *parish pump* to describe a place or forum where matters of local interest are discussed.<sup>[38]</sup>

Because water from pitcher pumps is drawn directly from the soil, it is more prone to contamination. If such water is not filtered and purified, consumption of it might lead to gastrointestinal or other water-borne diseases. A notorious case is the 1854 Broad Street cholera outbreak. At the time it was not known how cholera was transmitted, but physician John Snow suspected contaminated water and had the handle of the public pump he suspected removed; the outbreak then subsided.

Modern hand-operated community pumps are considered the most sustainable low-cost option for safe water supply in resource-poor settings, often in rural areas in developing countries. A hand pump opens access to deeper groundwater that is often not polluted and also improves the safety of a well by protecting the water source from contaminated buckets. Pumps such as the Afridev pump are designed to be cheap to build and install, and easy to maintain with simple parts. However, scarcity of spare parts for these type of pumps in some regions of Africa has diminished their utility for these areas.

## **Sealing multiphase pumping applications**

[edit]

Multiphase pumping applications, also referred to as tri-phase, have grown due to increased oil drilling activity. In addition, the economics of multiphase production is attractive to upstream operations as it leads to simpler, smaller in-field installations, reduced equipment costs and improved production rates. In essence, the multiphase pump can accommodate all fluid stream properties with one piece of equipment, which has a smaller footprint. Often, two smaller multiphase pumps are installed in series rather than having just one massive pump.

## **Types and features of multiphase pumps**

[edit]

### **Helico-axial (centrifugal)**

[edit]



A rotodynamic pump with one single shaft that requires two mechanical seals, this pump uses an open-type axial impeller. It is often called a *Poseidon pump*, and can be described as a cross between an axial compressor and a centrifugal pump.

### **Twin-screw (positive-displacement)**

[edit]

The twin-screw pump is constructed of two inter-meshing screws that move the pumped fluid. Twin screw pumps are often used when pumping conditions contain high gas volume fractions and fluctuating inlet conditions. Four mechanical seals are required to seal the two shafts.

### **Progressive cavity (positive-displacement)**

[edit]

Progressive Cavity Pumps are well suited to pump sludge, slurries, viscous, and shear sensitive fluids. [39] Progressive cavity pumps are single-screw types use in surface and downhole oil production.[40] They serve a vast arrange of industries and applications ranging from Wastewater Treatment,[41] Pulp and Paper, oil and gas, mining, and oil and gas.

### **Electric submersible (centrifugal)**

[edit]

These pumps are basically multistage centrifugal pumps and are widely used in oil well applications as a method for artificial lift. These pumps are usually specified when the pumped fluid is mainly liquid.

*Buffer tank* A buffer tank is often installed upstream of the pump suction nozzle in case of a slug flow. The buffer tank breaks the energy of the liquid slug, smooths any fluctuations in the incoming flow and acts as a sand trap.

As the name indicates, multiphase pumps and their mechanical seals can encounter a large variation in service conditions such as changing process fluid composition, temperature variations, high and low operating pressures and exposure to abrasive/erosive media. The challenge is selecting the appropriate mechanical seal arrangement and support system to ensure maximized seal life and its overall effectiveness.[42][43][44]

## Specifications

[edit]

Pumps are commonly rated by horsepower, volumetric flow rate, outlet pressure in metres (or feet) of head, inlet suction in suction feet (or metres) of head. The head can be simplified as the number of feet or metres the pump can raise or lower a column of water at atmospheric pressure.

From an initial design point of view, engineers often use a quantity termed the specific speed to identify the most suitable pump type for a particular combination of flow rate and head. Net Positive Suction Head (NPSH) is crucial for pump performance. It has two key aspects: 1) NPSHr (Required): The Head required for the pump to operate without cavitation issues. 2) NPSHa (Available): The actual pressure provided by the system (e.g., from an overhead tank). For optimal pump operation, NPSHa must always exceed NPSHr. This ensures the pump has enough pressure to prevent cavitation, a damaging condition.

## Pumping power

[edit]

Main article: Bernoulli's equation

The power imparted into a fluid increases the energy of the fluid per unit volume. Thus the power relationship is between the conversion of the mechanical energy of the pump mechanism and the fluid elements within the pump. In general, this is governed by a series of simultaneous differential equations, known as the Navier–Stokes equations. However a more simple equation relating only the different energies in the fluid, known as Bernoulli's equation can be used. Hence the power, *P*, required by the pump:

$$P=\frac{\Delta pQ}{\eta}$$

Image not found or type unknown

where  $\Delta p$  is the change in total pressure between the inlet and outlet (in Pa), and *Q*, the volume flow-rate of the fluid is given in m<sup>3</sup>/s. The total pressure may have gravitational, static pressure and kinetic energy components; i.e. energy is distributed between change in the fluid's gravitational potential energy (going up or down hill), change in velocity, or change in static pressure.  $\eta$  is the pump efficiency, and may be given by the manufacturer's information, such as in the form of a pump curve, and is typically derived from either fluid dynamics simulation (i.e. solutions to the Navier–Stokes for the particular pump geometry), or by testing. The efficiency of the pump depends upon the pump's configuration and operating conditions (such as rotational speed, fluid density and viscosity etc.)

$$\Delta p=\rho \left( \frac{v_2^2-v_1^2}{2}+\Delta z+\Delta p_{\mathrm{static}} \right)$$

Image not found or type unknown

For a typical "pumping" configuration, the work is imparted on the fluid, and is thus positive. For the fluid imparting the work on the pump (i.e. a turbine), the work is negative. Power required to drive the pump is determined by dividing the output power by the pump efficiency. Furthermore, this definition encompasses pumps with no moving parts, such as a siphon.

## Efficiency

[edit]

Pump efficiency is defined as the ratio of the power imparted on the fluid by the pump in relation to the power supplied to drive the pump. Its value is not fixed for a given pump, efficiency is a function of the discharge and therefore also operating head. For centrifugal pumps, the efficiency tends to increase with flow rate up to a point midway through the operating range (peak efficiency or Best Efficiency Point (BEP) ) and then declines as flow rates rise further. Pump performance data such as this is usually supplied by the manufacturer before pump selection. Pump efficiencies tend to decline over time due to wear (e.g. increasing clearances as impellers reduce in size).

When a system includes a centrifugal pump, an important design issue is matching the *head loss-flow characteristic* with the pump so that it operates at or close to the point of its maximum efficiency.

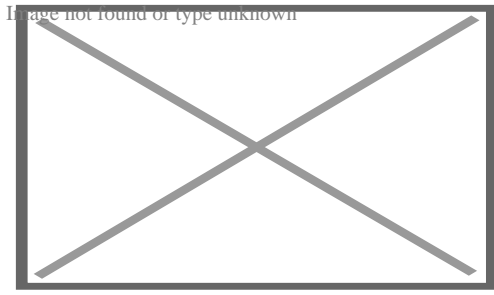
Pump efficiency is an important aspect and pumps should be regularly tested. Thermodynamic pump testing is one method.

## Minimum flow protection

[edit]

Most large pumps have a minimum flow requirement below which the pump may be damaged by overheating, impeller wear, vibration, seal failure, drive shaft damage or poor performance.<sup>[45]</sup> A minimum flow protection system ensures that the pump is not operated below the minimum flow rate. The system protects the pump even if it is shut-in or dead-headed, that is, if the discharge line is completely closed.<sup>[46]</sup>

The simplest minimum flow system is a pipe running from the pump discharge line back to the suction line. This line is fitted with an orifice plate sized to allow the pump minimum flow to pass.<sup>[47]</sup> The arrangement ensures that the minimum flow is maintained, although it is wasteful as it recycles fluid even when the flow through the pump exceeds the minimum flow.



Part of a process flow diagram of pump minimum flow protection arrangement

A more sophisticated, but more costly, system (see diagram) comprises a flow measuring device (FE) in the pump discharge which provides a signal into a flow controller (FIC) which actuates a flow control valve (FCV) in the recycle line. If the measured flow exceeds the minimum flow then the FCV is closed. If the measured flow falls below the minimum flow the FCV opens to maintain the minimum flowrate.<sup>[45]</sup>

As the fluids are recycled the kinetic energy of the pump increases the temperature of the fluid. For many pumps this added heat energy is dissipated through the pipework. However, for large industrial pumps, such as oil pipeline pumps, a recycle cooler is provided in the recycle line to cool the fluids to the normal suction temperature.<sup>[48]</sup> Alternatively the recycled fluids may be returned to upstream of the export cooler in an oil refinery, oil terminal, or offshore installation.

## References

[edit]

1. ^ **a b** Submersible slurry pumps in high demand. Engineeringnews.co.za. Retrieved on 2011-05-25.
2. ^ TAXONOMY OF PUMPS AND WATER LIFTS. Fao.org. Retrieved on 2011-05-25.
3. ^ *Engineering Sciences Data Unit (2007). "Radial, mixed and axial flow pumps. Introduction" (PDF). Archived from the original (PDF) on 2014-03-08. Retrieved 2017-08-18.*
4. ^ *"Understanding positive displacement pumps | PumpScout". Archived from the original on 2018-01-04. Retrieved 2018-01-03.*
5. ^ *"The Volumetric Efficiency of Rotary Positive Displacement Pumps". www.pumpsandsystems.com. 2015-05-21. Retrieved 2019-03-27.*
6. ^ *inc., elyk innovation. "Positive Displacement Pumps - LobePro Rotary Pumps". www.lobepro.com. Archived from the original on 2018-01-04. Retrieved 2018-01-03.*  
cite web: |last= has generic name (help)
7. ^ *"Eccentric Disc Pumps". PSG.*
8. ^ *"Hollow Disc Rotary Pumps". APEX Equipment. Archived from the original on 2020-08-06. Retrieved 2019-12-20.*
9. ^ *"M Pompe | Hollow Oscillating Disk Pumps | self priming pumps | reversible pumps | low-speed pumps". www.mpompe.com. Archived from the original on 2020-02-06. Retrieved 2019-12-20.*
10. ^ *"Hollow disc pumps". Pump Supplier Bedu.*

11. ^ "3P PRINZ - Hollow rotary disk pumps - Pompe 3P - Made in Italy". [www.3pprinz.com](http://www.3pprinz.com). Archived from the original on 2020-08-06. Retrieved 2019-12-20.
12. ^ "Hollow Disc Pump". [magnatexpumps.com](http://magnatexpumps.com). Archived from the original on 2020-08-06. Retrieved 2019-12-20.
13. ^ "Hollow Rotary Disc Pumps". November 4, 2014.
14. ^ Inc., Triangle Pump Components. "What Is Volumetric Efficiency?". Retrieved 2018-01-03. cite news: |last= has generic name (help)
15. ^ "FAQs and Favorites – Espresso Machines". [www.home-barista.com](http://www.home-barista.com). 21 November 2014.
16. ^ "The Pump: The Heart of Your Espresso Machine". Clive Coffee.
17. ^ "Definitive Guide: Pumps Used in Pressure Washers". *The Pressure Washr Review*. 13 August 2015. Retrieved May 14, 2016.
18. ^ "Drilling Pumps". Gardner Denver.
19. ^ "Stimulation and Fracturing pumps: Reciprocating, Quintuplex Stimulation and Fracturing Pump" Archived 2014-02-22 at the Wayback Machine. Gardner Denver.
20. ^ "Advantages of an Air Operated Double Diaphragm Pump". Retrieved 2018-01-03.
21. ^ Tanzania water Archived 2012-03-31 at the Wayback Machine blog – example of grassroots researcher telling about his study and work with the rope pump in Africa.
22. ^ C.M. Schumacher, M. Loepfe, R. Fuhrer, R.N. Grass, and W.J. Stark, "3D printed lost-wax casted soft silicone monoblocks enable heart-inspired pumping by internal combustion," *RSC Advances*, Vol. 4, pp. 16039–16042, 2014.
23. ^ Demirbas, Ayhan (2008-11-14). *Biofuels: Securing the Planet's Future Energy Needs*. Springer Science & Business Media. ISBN 9781848820111.
24. ^ Welcome to the Hydraulic Institute Archived 2011-07-27 at the Wayback Machine. Pumps.org. Retrieved on 2011-05-25.
25. ^ "Radial, mixed and axial flow pumps" (PDF). *Institution of Diploma Marine Engineers, Bangladesh*. June 2003. Archived from the original (PDF) on 2014-03-08. Retrieved 2017-08-18.
26. ^ **a b** Quail F, Scanlon T, Stickland M (2011-01-11). "Design optimisation of a regenerative pump using numerical and experimental techniques" (PDF). *International Journal of Numerical Methods for Heat & Fluid Flow*. **21**: 95–111. doi:10.1108/09615531111095094. Retrieved 2021-07-21.
27. ^ **a b** "Regenerative Turbine Pump". [rothpump.com](http://rothpump.com). Retrieved 30 April 2021.
28. ^ Rajmane, M. Satish; Kallurkar, S.P. (May 2015). "CFD Analysis of Domestic Centrifugal Pump for Performance Enhancement". *International Research Journal of Engineering and Technology*. 02 / #02. Retrieved 30 April 2021.
29. ^ **a b** "Regenerative turbine pumps: product brochure" (PDF). PSG Dover: Ebsra. pp. 3-4-7. Retrieved 30 April 2021.
30. ^ "Regenerative Turbine Pump vs Centrifugal Pump". *Dyna Flow Engineering*. Archived from the original on 30 April 2021. Retrieved 30 April 2021.
31. ^ "What is a Side Channel Pump?". *Michael Smith Engineers*. Retrieved December 24, 2022.
32. ^ **a b** Pump Statistics Should Shape Strategies Archived 2016-03-04 at the Wayback Machine. Mt-online.com 1 October 2008. Retrieved 24 September 2014.
33. ^ Wasser, Goodenberger, Jim and Bob (November 1993). "Extended Life, Zero Emissions Seal for Process Pumps". *John Crane Technical Report*. Routledge. TRP

28017.

34. ^ Nash (2017-01-20). *NASH Liquid Ring Vacuum Pump - How It Works*. Retrieved 2024-11-07 – via YouTube.
35. ^ Donald Routledge Hill, "Mechanical Engineering in the Medieval Near East", *Scientific American*, May 1991, pp. 64-9 (cf. Donald Hill, Mechanical Engineering Archived 25 December 2007 at the Wayback Machine)
36. ^ Ahmad Y. al-Hassan. *"The Origin of the Suction Pump: al-Jazari 1206 A.D."* Archived from the original on 26 February 2008. Retrieved 16 July 2008.
37. ^ Hill, Donald Routledge (1996). *A History of Engineering in Classical and Medieval Times*. London: Routledge. p. 143. ISBN 0-415-15291-7.
38. ^ "Online Dictionary – Parish Pump". Retrieved 2010-11-22.
39. ^ Daniel, Alvarado. "Production Engineer". *sulzer*. Retrieved 6 March 2025.
40. ^ Alvarado, Daniel. "Production Engineer". *slb*. Retrieved 6 March 2025.
41. ^ Daniel, Alvarado (25 February 2025). "Production Engineer". *ACCA Pumps*. Retrieved 6 March 2025.
42. ^ Sealing Multiphase Pumping Applications | Seals Archived 2009-09-03 at the Wayback Machine. Pump-zone.com. Retrieved on 2011-05-25.
43. ^ John Crane Seal Sentinel – John Crane Increases Production Capabilities with Machine that Streamlines Four Machining Functions into One Archived 2010-11-27 at the Wayback Machine. Sealsentinel.com. Retrieved on 2011-05-25.
44. ^ Vacuum pump new on SA market. Engineeringnews.co.za. Retrieved on 2011-05-25.
45. ^ **a b** Crane Engineering. *"minimum flow bypass line"*. Crane Engineering. Retrieved 25 January 2021.
46. ^ Gas Processors Suppliers Association (2004). *GPSA Engineering Data Book* (12 ed.). Tulsa: GPSA. pp. Chapter 7 Pumps and hydraulic turbines.
47. ^ Pump Industry (30 September 2020). *"Four methods for maintaining minimum flow conditions"*. Pump Industry. Retrieved 25 January 2021.
48. ^ Shell, *Shearwater P&IDs* dated 1997

## Further reading

[edit]

- Australian Pump Manufacturers' Association. *Australian Pump Technical Handbook*, 3rd edition. Canberra: Australian Pump Manufacturers' Association, 1987. ISBN 0-7316-7043-4.
- Hicks, Tyler G. and Theodore W. Edwards. *Pump Application Engineering*. McGraw-Hill Book Company.1971. ISBN 0-07-028741-4
- Karassik, Igor, ed. (2007). *Pump Handbook* (4 ed.). McGraw Hill. ISBN 9780071460446.
- Robbins, L. B. "Homemade Water Pressure Systems". *Popular Science*, February 1919, pages 83–84. Article about how a homeowner can easily build a pressurized home water system that does not use electricity.



Wikimedia Commons has media related to **Pumps**.

- v
- t
- e

## Machines

### Classical simple machines

### Clocks

### Compressors and pumps

### External combustion engines

### Internal combustion engines

### Linkages

### Turbine

### Aerofoil

- Inclined plane
- Lever
- Pulley
- Screw
- Wedge
- Wheel and axle
- Atomic clock
- Chronometer
- Pendulum clock
- Quartz clock
- Archimedes' screw
- Eductor-jet pump
- Hydraulic ram
- Pump
- Trompe
- Vacuum pump
- Steam engine
- Stirling engine
- Gas turbine
- Reciprocating engine
- Rotary engine
- Nutating disc engine
- Pantograph
- Peaucellier-Lipkin
- Gas turbine
- Jet engine
- Steam turbine
- Water turbine
- Wind generator
- Windmill
- Sail
- Wing
- Rudder
- Flap
- Propeller

- Vacuum tube
- Transistor
- Diode
- Resistor
- Capacitor
- Inductor

- Automobile
- Mecha
- Robot

- Agricultural
- Seed-counting machine
- Vending machine
- Wind tunnel
- Check weighing machines
- Riveting machines
- Spring (device)

- Spring (device)

- Germany
- United States
- France

- Japan
- Czech Republic
- Israel

Drainage is the natural or artificial removal of a surface's water and sub-surface water from a location with excess water. The inner drain of a lot of agricultural soils can prevent severe waterlogging (anaerobic problems that hurt origin growth), however several dirt requires artificial drain to boost manufacturing or to handle water supplies.

## Driving Directions in Cook County



Driving Directions From 42.088525008778, -88.079435634324 to

Driving Directions From 42.021124436568, -88.109125186152 to

Driving Directions From 42.017845685371, -88.11591807218 to

Driving Directions From 42.084324223519, -88.137710099374 to

Driving Directions From 42.10843482977, -88.114090738222 to

Driving Directions From 42.086153671225, -88.19640031169 to

Driving Directions From 42.051159627372, -88.202951526236 to

Driving Directions From 42.008657936699, -88.152725208607 to

Driving Directions From 42.007242948498, -88.153060682778 to

Driving Directions From 42.073881347839, -88.179224443136 to

<https://www.google.com/maps/place/@42.050000207566,-88.075050390596,25.2z/data=!4m6!3m5!1sNone!8m2!3d42.0637725!4d-88.1396465!16s%2F>

<https://www.google.com/maps/place/@42.087798734568,-88.063295005626,25.2z/data=!4m6!3m5!1sNone!8m2!3d42.0637725!4d-88.1396465!16s%2F>

<https://www.google.com/maps/place/@42.10843482977,-88.114090738222,25.2z/data=!4m6!3m5!1sNone!8m2!3d42.0637725!4d-88.1396465!16s%2F>

<https://www.google.com/maps/place/@42.050966333631,-88.065085692084,25.2z/data=!4m6!3m5!1sNone!8m2!3d42.0637725!4d-88.1396465!16s%2F>

<https://www.google.com/maps/place/@42.03783000352,-88.074000387298,25.2z/data=!4m6!3m5!1sNone!8m2!3d42.0637725!4d-88.1396465!16s%2F>

<https://www.google.com/maps/place/@42.047694157891,-88.091046817967,25.2z/data=!4m6!3m5!1sNone!8m2!3d42.0637725!4d-88.1396465!16s%2F>

<https://www.google.com/maps/place/@42.010753136556,-88.109359678334,25.2z/data=!4m6!3m5!1sNone!8m2!3d42.0637725!4d-88.1396465!16s%2F>

<https://www.google.com/maps/place/@42.056354483873,-88.088327608895,25.2z/data=!4m6!3m5!1sNone!8m2!3d42.0637725!4d-88.1396465!16s%2F>

<https://www.google.com/maps/place/@42.102108978802,-88.091450952786,25.2z/data=!4m6!3m5!1sNone!8m2!3d42.0637725!4d-88.1396465!16s%2F>

<https://www.google.com/maps/place/@42.042207985309,-88.186095527361,25.2z/data=!4m6!3m5!1sNone!8m2!3d42.0637725!4d-88.1396465!16s%2F>

<https://www.google.com/maps/dir/?api=1&origin=42.042207985309,-88.186095527361&destination=%2C+2124+Stonington+Ave%2C+Hoffman+Estates%2C+IL&travelmode=driving&query=foundation+settlement+signs>

<https://www.google.com/maps/dir/?api=1&origin=42.011697190191,-88.159742980637&destination=%2C+2124+Stonington+Ave%2C+Hoffman+Estates%2C+wSxDtinD4gRiv4kY3RRh9U&travelmode=transit&query=structural+engineer+consultant>

<https://www.google.com/maps/dir/?api=1&origin=42.068719913035,-88.076011775936&destination=%2C+2124+Stonington+Ave%2C+Hoffman+Estates%2C+wSxDtinD4gRiv4kY3RRh9U&travelmode=transit&query=foundation+stability+check+C>

<https://www.google.com/maps/dir/?api=1&origin=42.040913746131,-88.212085693635&destination=%2C+2124+Stonington+Ave%2C+Hoffman+Estates%2C+wSxDtinD4gRiv4kY3RRh9U&travelmode=transit&query=helical+pier+installation+Scha>

<https://www.google.com/maps/dir/?api=1&origin=42.002740342082,-88.143950765717&destination=%2C+2124+Stonington+Ave%2C+Hoffman+Estates%2C+wSxDtinD4gRiv4kY3RRh9U&travelmode=transit&query=sprayed+urethane+foam+lifting>

<https://www.google.com/maps/dir/?api=1&origin=42.10843482977,-88.114090738222&destination=%2C+2124+Stonington+Ave%2C+Hoffman+Estates%2C+wSxDtinD4gRiv4kY3RRh9U&travelmode=transit&query=house+leveling+service+Des->

<https://www.google.com/maps/dir/?api=1&origin=42.089226014242,-88.21676191398&destination=%2C+2124+Stonington+Ave%2C+Hoffman+Estates%2C+wSxDtinD4gRiv4kY3RRh9U&travelmode=driving&query=crawl+space+underpinning+H>

<https://www.google.com/maps/dir/?api=1&origin=42.076323560785,-88.219373904701&destination=%2C+2124+Stonington+Ave%2C+Hoffman+Estates%2C+wSxDtinD4gRiv4kY3RRh9U&travelmode=transit&query=slab+foundation+lifting+Hoffm>

<https://www.google.com/maps/dir/?api=1&origin=42.097395420237,-88.146014933305&destination=%2C+2124+Stonington+Ave%2C+Hoffman+Estates%2C+wSxDtinD4gRiv4kY3RRh9U&travelmode=transit&query=sinking+basement+floor+Boli>

<https://www.google.com/maps/dir/?api=1&origin=42.027868101227,-88.201484266296&destination=%2C+2124+Stonington+Ave%2C+Hoffman+Estates%2C+wSxDtinD4gRiv4kY3RRh9U&travelmode=driving&query=water+intrusion+prevention+>

Check our other pages :

- [Communication Strategies With Homeowners During Repairs](#)
- [Developing a Work Sequence to Minimize Downtime](#)
- [Comparing Financing Options for Structural Repairs](#)
- [Scheduling Third Party Inspections for Key Milestones](#)

United Structural Systems of Illinois, Inc

Phone : +18473822882

City : Hoffman Estates

State : IL

Zip : 60169

Address : 2124 Stonington Ave

### **Google Business Profile**

Company Website : <https://www.unitedstructuralsystems.com/>

### **USEFUL LINKS**

[\*\*foundation crack repair Chicago\*\*](#)

[\*\*residential foundation inspection\*\*](#)

[\*\*home foundation leveling\*\*](#)

[\*\*basement foundation repair\*\*](#)

[\*\*Sitemap\*\*](#)

[\*\*Privacy Policy\*\*](#)

[\*\*About Us\*\*](#)

Follow us