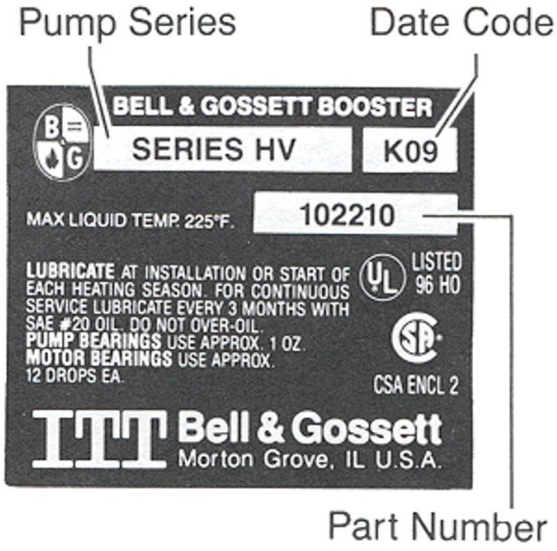
HRP Training Aid: Pumps

DESCRIPTION	ECCN
Pumps, high pressure	**0A998.b.3**
Pumps, liquid propellant	**9A106.d**
Pumps, mercury or lithium amalgam	**1B233.b.2**
Pumps, multiple-seal	**2B350.i**
Pumps, potassium amide in liquid ammonia	**1B230**
Pumps, seal-less	**2B350.i**
Pumps designed for industrial service	**2B999.j**
Pumps designed to move molten metals by electromagnetic force	**2A993**
Vacuum pumps	**2B231, 2B350.i**
Vacuum pumps, bellows-sealed scroll-type	**2B233**
Pumps—especially designed or prepared (EDP)	**10 CFR Part 110**

KEY NOTES/HELPFUL TIPS

- Pumps are used in almost every industrial process and will be routinely encountered.
- There are many different kinds of pumps, but two major types are controlled:
  - Pumps for moving liquid—multiple-seal or seal-less
  - Pumps for creating a vacuum
- Not all pumps are controlled. Only those meeting certain specifications related to materials of construction, capacity, pressure capabilities, and physical size are subject to controls.



Information provided on manufacturer's nameplate is helpful and often includes the pump type, capacity, etc. Contact the manufacturer for additional details.

Weapons of Mass Destruction Pump Applications

Nuclear

- Reactor primary coolant system
- Ammonia–hydrogen exchange process for producing heavy water
- Uranium enrichment processes (e.g., gas centrifuge, gaseous diffusion, electromagnetic isotope separation, atomic vapor laser isotope separation, molecular laser isotope separation, plasma separation process)

Chemical

- Throughout the chemical weapons production cycle

Missile uses

- Liquid-fueled rocket engines
- Production of liquid fuels

Civilian Applications

Pumps are used in almost every industrial process:

- Production of chemicals, petroleum products, and pharmaceuticals
- Water treatment and supply, water desalination
- Manufacture of pulp and paper
- Metallurgical processes
- Semiconductor fabrication
- E-beam welding
- Mass spectrometers
- Desalination plants

Major Pump Manufacturers (Hundreds Worldwide)

United States

- ABS Pumps
- Ace Pump Corp.
- Bauer Industrial
- CAT Pumps
- Enmet Corp.
- General Pump
- Haliburton Co.
- Peerless Pump Co.

- Gorman-Rupp Co.
- Warren Rupp Inc.
- Watson-Marlow Bredel
- Wilden Pump & Engineering Co.
- Zoeller Pump Co.

Asia

- Alfa Pumps and Systems (India)
- Centrifugal Casting Company (India)
- Chiyoda Kohan Co. (Japan)
- Chugoku IEC Co. (Japan)
- Fuzhou D&J Power Co. (China)
- Hokushin Pump Co. (Japan)
- Iwaki Co (Japan)
- Niihama Pump Works Co. (Japan)

Europe

- Alfa Laval Pumps (UK)
- Allweiler AG (Germany)
- Biehler SA (France)
- Bijur Products (France)
- Johnson Pump Oy (Finland)
- Seepex Inc. (Germany)
- Sterling Fluid Systems (Germany)
- Sulzer Pumps (Switzerland)

Pumps, High Pressure

ECCN 0A998.b.3

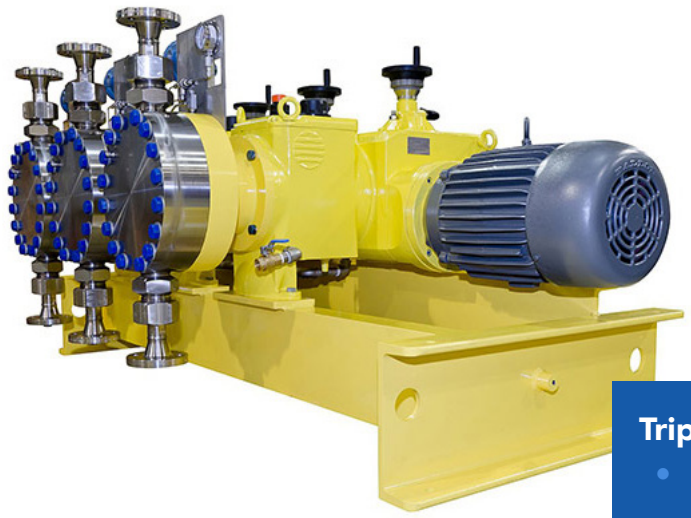
This ECCN controls exports for foreign policy reasons. This category includes certain oil and gas exploration equipment, software, and data (including Item b.3 below):

- b.3 High pressure pumps

Note: Russian Industry Sector Sanctions apply to all items under this ECCN.

Tip: Look for any references to hydraulic fracturing or fracking on available paperwork.

Definition: Hydraulic fracturing, commonly known as fracking, is the process of injecting water, sand, chemicals, or a combination thereof into a well to break up underground bedrock to free up oil or gas reserves.



Triplex pump for hydraulic fracturing

- Reciprocating, positive displacement pump using three pistons (plungers)
- Able to handle a wide range of corrosive/abrasive fluids and slurries containing large particulates
- Horsepower: 2,500 – 3,000
- Typical weight: ~20,000 lb
- Pressures: Up to 15,000 psi

Pumps, Liquid Propellant

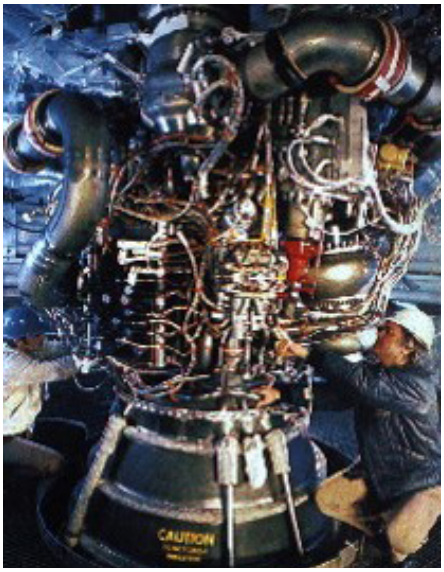
ECCN 9A106.d

This ECCN controls pumps capable of pumping propellant in a liquid rocket propulsion system with both of the following characteristics:

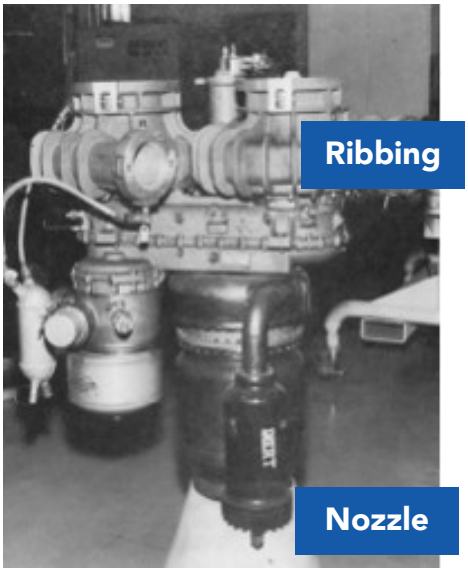
- Shaft speeds ≥8,000 RPM or with discharge pressures ≥7,000 kPa (1,000 psi)
- Designed or modified to operate in vibration environments greater than 10 Grms between 20 Hz and 2 kHz

Key Points and Appearance—Turbo Pumps

- Turbo pumps are basically a centrifugal pump driven by a turbine rather than an electric motor.
- Housings for the turbine and impeller look like centrifugal pump heads.
- Housings may have ribbing for structural strength and additional surface area for cooling.
- Pumps may be packaged separately from the engine nozzle.



Large turbo pump assembly.



Multishaft turbo pump assembly.

Pumps, Mercury or Lithium Amalgam ECCN 1B233.b.2

This ECCN controls exports of equipment for the separation of lithium isotopes (including item b.2 below):

- b.2. Mercury and/or lithium amalgam pumps

Key Points and Appearance—Progressive Cavity Pumps

- A corkscrew shaft within a barrel creates series of cavities.
- Fluid moves forward or "progresses" as the corkscrew rotates.
- An electric motor is needed to drive the pump head.
- The pump head may be packaged separately from the drive motor.
- The lining can be nonmetallic (e.g., plastic-like corrosion-resistant material).

Pumps, Multiple-Seal and Seal-Less ECCN 2B350.i

This ECCN controls chemical manufacturing facilities and equipment, including pumps under Item i with the following characteristics:

- Multiple-seal and seal-less pumps with manufacturer's specified maximum flow rate >0.6 m3/h (600 L/h), or
- Vacuum pumps with manufacturer's specified maximum flow rate >5 m3/h (5,000 L/h) under standard temperature (273 K [0 °C]) and pressure (101.3 kPa) conditions
- Casings (pump bodies), preformed casing liners, impellers, rotors or jet pump nozzles designed for such pumps, in which all surfaces that come into direct contact with the chemical(s) being processed are made from any of the following corrosion-resistant materials:
  - Alloys with >25% nickel and 20% chromium by weight
  - Nickel or alloys with >40% nickel by weight

- Fluoropolymers (polymeric or elastomeric materials with >35% fluorine by weight)
- Glass (including vitrified or enameled coatings or glass lining)
- Tantalum or tantalum alloys
- Titanium or titanium alloys
- Zirconium or zirconium alloys
- Niobium (columbium) or niobium alloys
- Graphite or carbon–graphite
- Ceramics
- Ferrosilicon (high silicon and iron alloys)

Note: This ECCN does not control equipment that is both (1) "specially designed" for use in civil applications (e.g., food processing, pulp and paper processing, or water purification) and (2) inappropriate, by the nature of its design, for use in storing, processing, producing or conducting, and controlling the flow of export-controlled chemical weapons precursors.

Pump Types and Terminology Associated with ECCN 2B350.i

Look for the following terms:

- Multiple-seal pump
- Seal-less pump—magnetic coupling, magnetic drive, canned motor, canned drive
- Bellows or diaphragm pump
- Gear pump
- Centrifugal pump
- Vacuum pump

Centrifugal Pumps

ECCN 2B350.i

Key Features and Appearance

- Pump head (chamber) contains an internal impeller (like a fan).
- An electric motor is required to drive the pump head.
- Inlet and outlet fluid flow connections
- May have multiple seals or be seal-less (e.g., canned motor pumps or magnetic drive pumps)
  - Canned motor pumps—Also called a hermetic pump. The pump and hermetically sealed electric motor are mounted on a single shaft, eliminating the requirement of mechanical shaft seals.
  - Magnetic drive pumps—The pump is connected to the motor via a magnetic field, and there is no physical connection or mechanical shaft seals (i.e., no leakage).
- Centrifugal pumps are made of special corrosion-resistant materials.

Typical centrifugal pump

- Shaft of the electric motor connects to the drive pump head, requiring seals
- **Not controlled**

Magnetically coupled centrifugal pump

- A magnetic field connects the motor to the pump, which does not require seals
- Note, the white lining material in the inlet and outlet ports is corrosion-resistant fluoropolymer (e.g., Teflon)

Canned motor pump

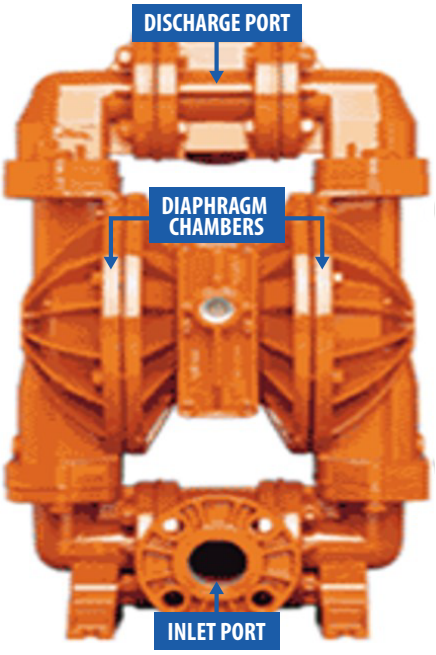
- Pump and motor are integrated, and the fluid being handled is sealed inside
- Completely leak-free, which is useful for transporting liquids that are explosive, flammable, or toxic and chemicals like strong acids or strong alkalis
- Excellent durability in high-temperature and high-pressure applications

Diaphragm Pumps

ECCN 2B350.i

Key features and appearance

- Visibly distinct from other types of pumps
- No visible motor; no electrical or heat-generating components; fluid driven (e.g., air, oil)
- Single or multiple pumping chambers (cases) in parallel
- Inlet and outlet on opposite sides
- Handles a wider range of fluids than any other type of pump (e.g., corrosive and abrasive liquids, slurries, volatile fluids)
- Used routinely in the chemical industry and in the production of heavy water



Triple diaphragm pump used in heavy water production

Gear Pumps

ECCN 2B350.i

Key features and appearance

- Usually used in systems with highly viscous fluids, such as oil (i.e., petrochemical industry)
- Can be used in systems for chemical weapons production when made of the proper corrosion-resistant materials
- Belt or shaft driven
- A common shaft turns multiple gears in a casing
- Gears provide a motive force for the fluid, pushing the fluid through the pump

Gear pump attached to drive motor

Gear pump assembly

Vacuum Pumps

ECCN 2B350.i

- Vacuum pumps evacuate gasses from sealed systems to achieve pressures far below atmospheric pressure.
- Two vacuum pumps are often used together for
  - the initial pumping down (roughing) of a system to pressures low enough that high-vacuum pumps can function (i.e., roughing pumps or low vacuum pumps) and
  - once the system is at low enough pressure, a high-vacuum pump brings the system down to even lower pressure.

Types of vacuum pumps

Look for references to the following:

- High-vacuum pumps
  - Diffusion
  - Turbomolecular
  - Molecular (aka molecular drag)
  - Cryogenic
  - Ion
- Positive displacement pumps
  - Rotary vane
  - Scroll pump
  - Oil-sealed rotary piston
  - Reciprocating piston
  - Diaphragm pump
  - Rotary screw
  - Lobed rotor (roots type)

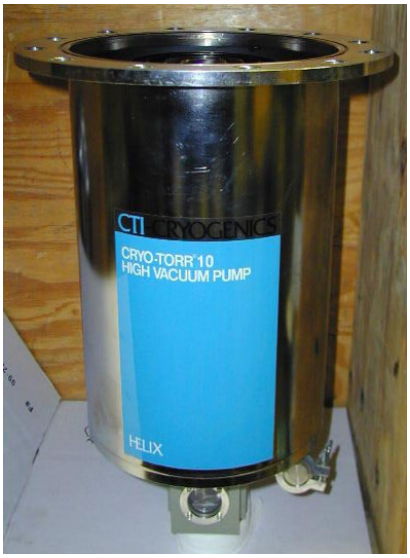
High-vacuum pumps

Diffusion pumps have a distinctive appearance

- Large gas inlet and small gas outlet
- Ribbed body (external cooling coils)
- Elbow connecting the outlet to the rest of the pump

High-vacuum turbomolecular pump

- Operation is similar to a turbine
- Energy is transferred to gas molecules using high speed rotating, angled blades that propel the gas at high speeds
- Rotor blades inside the housing are visible at the inlet

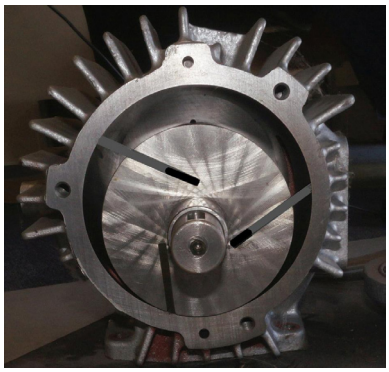


Cryogenic vacuum pump

- Ultrahigh vacuum pumps are also known as cryopumps
- Creates a vacuum by condensing gas molecules onto solid surfaces at extremely low (cryogenic) temperatures

Positive Displacement Vacuum Pumps

- Use various mechanical arrangements for evacuating equipment/processes, such as rotary vanes, scrolls, rotary screws, pistons, rotating lobes, or diaphragms.
- Quite different in appearance; however, all will have inlet and outlet ports, and most will be motorized. Diaphragm pumps may be air driven.
- Look for nameplates on pumps for information including manufacturer, pump type, model number, and pump capacities.

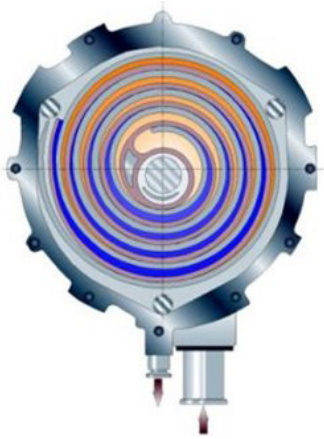


Rotary vane pump

- A circular rotor offset in a larger circular stator with a number of sliding sealing vanes extending between the rotor and the chamber wall

Scroll type vacuum pump

- *Left*, All wetted parts are coated with corrosion-resistant PTFE (fluoropolymer).
- *Right*, An internal view of the interleaving scrolls. An orbiting scroll moves within a fixed scroll.



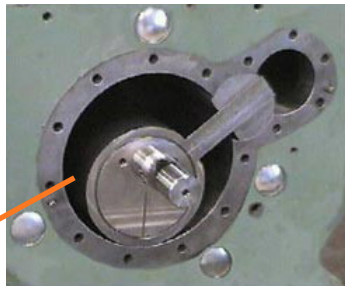
Rotary screw vacuum pump

Roots pump

- Aka a rotary lobe pump
- Note elliptical impeller housing

Oil-sealed rotary piston pumps

- Use a slide valve and rotary piston (internal feature) to mechanically create a vacuum
- Come in varying shapes and sizes, depending upon the manufacturer



Rotary piston

Oerlikon Leybold oil-sealed rotary piston pump

Kinney oil-sealed rotary piston pump

Used in electromagnetic isotope separation process for uranium enrichment

Pumps, Potassium Amide in Liquid Ammonia ECCN 1B230

This ECCN controls pumps capable of circulating solutions of concentrated or dilute potassium amide catalyst in liquid ammonia (KNH2/NH3), having all of the following characteristics:

a. Airtight (i.e., hermetically sealed)
b. A capacity >8.5 m3/h; and
c. Either of the following characteristics:
  c.1. For concentrated potassium amide solutions (≥1%), an operating pressure of 1.5–60 MPa (15–600 atm); or
  c.2. For dilute potassium amide solutions (<1%), an operating pressure of 20–60 MPa (200–600 atm).

Related controls: (1) Equipment "specially designed" or prepared for the production of heavy water is subject to the export licensing authority of the Nuclear Regulatory Commission (see 10 CFR Part 110).

Pumps Designed for Industrial Service ECCN 2B999.j

This ECCN controls specific processing equipment, n.e.s., to **North Korea** for anti-terrorism (AT) reasons, including item j below:

> j. Pumps designed for industrial service and for use with an electrical motor of 5 HP or greater

Pumps Designed to Move Molten Metals by Electromagnetic Forces ECCN 2A993

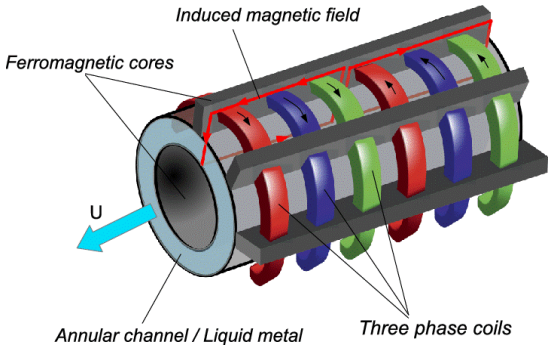
This ECCN controls pumps designed to move molten metals by electromagnetic forces to Iran and **North Korea** for anti-terrorism (AT) reasons.

Key Points

- Pumps designed to move molten metal by electromagnetic forces are also called electromagnetic pumps or EMPs.
- Typically, the liquid metal travels along an annular channel between two concentric cylinders.

Applications

- Cooling nuclear reactors
- Pouring and transporting metals in foundries at extremely high temperatures
- Pumping molten solder in wave soldering machines
- Pumping liquid-metal coolant



Schematic view of a typical electromagnetic pump.

CMI Novacast PG 450 electromagnetic pump
Application: High-capacity aluminum casting in foundries

Vacuum Pumps

ECCN 2B231

This ECCN controls vacuum pumps with all of the following characteristics:

a. Input throat size ≥380 mm (15 in.)
b. Pumping speed ≥15 m3/s (32,000 cfm) and
c. Capable of producing an ultimate vacuum <13.3 mPa

Varian Model HS-20 vacuum diffusion pump

- Used in uranium enrichment processes (e.g., electromagnetic isotope separation)
- No moving mechanical parts
- Large body wrapped with cooling coils (ribs)
- One upward extending smaller arm
- Large inlet compared to outlet
- Capable of producing pressures as low as 10-8 Pa
- (7.5 × 10-11 torr)
- **ECCN 2B231**

Vacuum pumps, bellows-sealed scroll-type ECCN 2B233

This ECCN controls bellows-sealed scroll-type compressors and bellows-sealed scroll-type vacuum pumps with all of the following characteristics:

- **a.** Capable of an inlet volume flow rate of ≥50 m3/h;
- **b.** Capable of a pressure ratio of ≥2:1; and
- **c.** Having all surfaces that come in contact with the process gas made from any of the following:
  - **c.1.** Aluminum or aluminum alloy
  - **c.2.** Aluminum oxide
  - **c.3.** Stainless steel
  - **c.4.** Nickel or nickel alloy
  - **c.5.** Phosphor bronze
  - **c.6.** Fluoropolymers

EUMECA (formerly Normetex Pompes) Model 600 bellows-sealed scroll-type vacuum pump

- Used for pumping corrosive gases including UF6, ClF3, and HF
- Volume flow rate: 600 m3/h (350 cfm)
- Ultimate vacuum: < 8 × 10-2 mbar
- Height: 9.5 ft
- Weight: 10,600 lb

Pumps Especially Designed or Prepared (EDP) 10 CFR Part 110

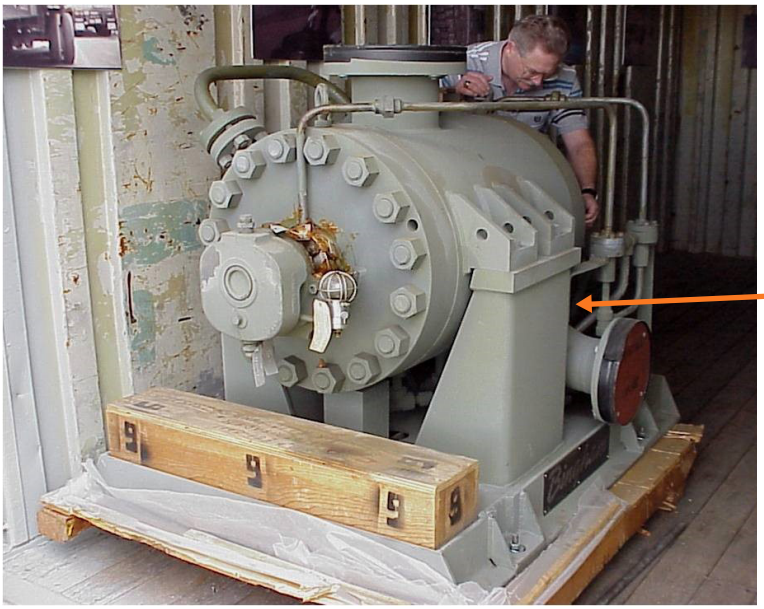
Pumps especially designed or prepared (EDP) for the processing, use, or production of special fissionable material (e.g., plutonium-239; uranium-233; uranium enriched in the isotopes 235 or 233) are subject to the export licensing authority of the U.S. Nuclear Regulatory Commission (see 10 CFR Part 110).

Examples of pumps EDP for circulating the primary coolant for nuclear reactors

Thirteen-stage centrifugal core spray pump EDP for a boiling water reactor

Primary coolant pump EDP for a pressurized water reactor.

Centrifugal vertical pump EDP for a boiling water reactor.



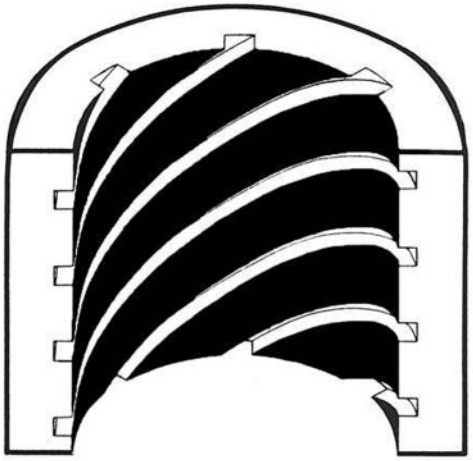
An **N** stamp on a nameplate affixed to a pump EDP for nuclear reactor service. The nameplate also lists the pump manufacturer, serial number, date of manufacture, design temperature and casing design pressure.

ASME N-type Certificates for Nuclear Components

	Old Marking	New Marking
• Nuclear vessels, pumps, valves, piping systems, storage tanks, core support structures, concrete containments, spent fuel containments and high level waste containments	N	N
• Field installation and shop assembly	NA	NA
• Fabrication, with or without design responsibility, of tubular products with filler metal, parts, appurtenances and piping subassemblies, for nuclear appurtenances and supports	NPT	NPT
• Pressure relief valves	NV	NV
• Containments for spent nuclear fuel and high level radioactive waste	N3	N3

Molecular Pumps EDP for Uranium Enrichment Using Gas Centrifuge Technology

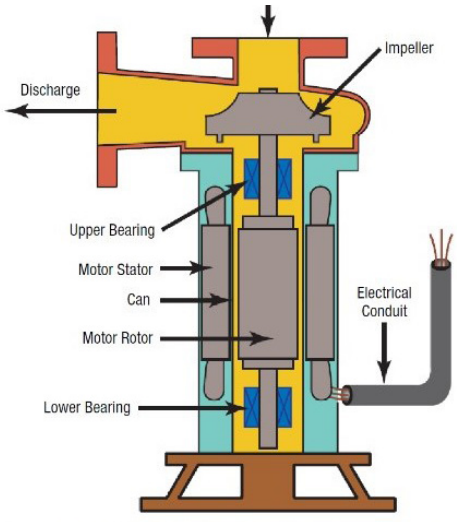
- Also called Holweck pumps
- Cylindrical tube or pipe with internally machined or extruded helical grooves
- Attaches to upper part of a gas centrifuge housing; stationary
- Typically manufactured from steel, stainless steel, or aluminum
- May have a distinct blackening in the groove area



Molecular pump. Note the helical grooves.

Stage Pumps EDP for Towers for Heavy Water Production Utilizing the Ammonia-Hydrogen Exchange Process

- Stage pumps include especially designed submersible pumps for circulation of liquid ammonia within a contacting stage internal to the stage towers.
  - Typical pump dimensions: 20 in. long × 10 in. diameter
  - Hermetically sealed by inserting a tubular "can" between the rotor and stator
  - Look for any references to "canned motor pump"



Vertical canned motor centrifugal pump.

Ammonia–hydrogen exchange tower for heavy water production. Inside the tower, especially designed submersible pumps circulate liquid ammonia from stage to stage.

Pumps: Packaging and Handling

- Shipped in one piece with caps/seals on the inlets and outlets to prevent contaminants from getting inside
- Smaller pumps packaged in cardboard boxes or wooden crates
- Larger pumps can be crated or banded onto pallets; frequently shipped as a whole unit with motor attached

Skid mounted pump.

Pump packaged in cardboard box.

Pump packaged in wooden crate.

Large pump in transit.

Pump secured on wooden pallet.