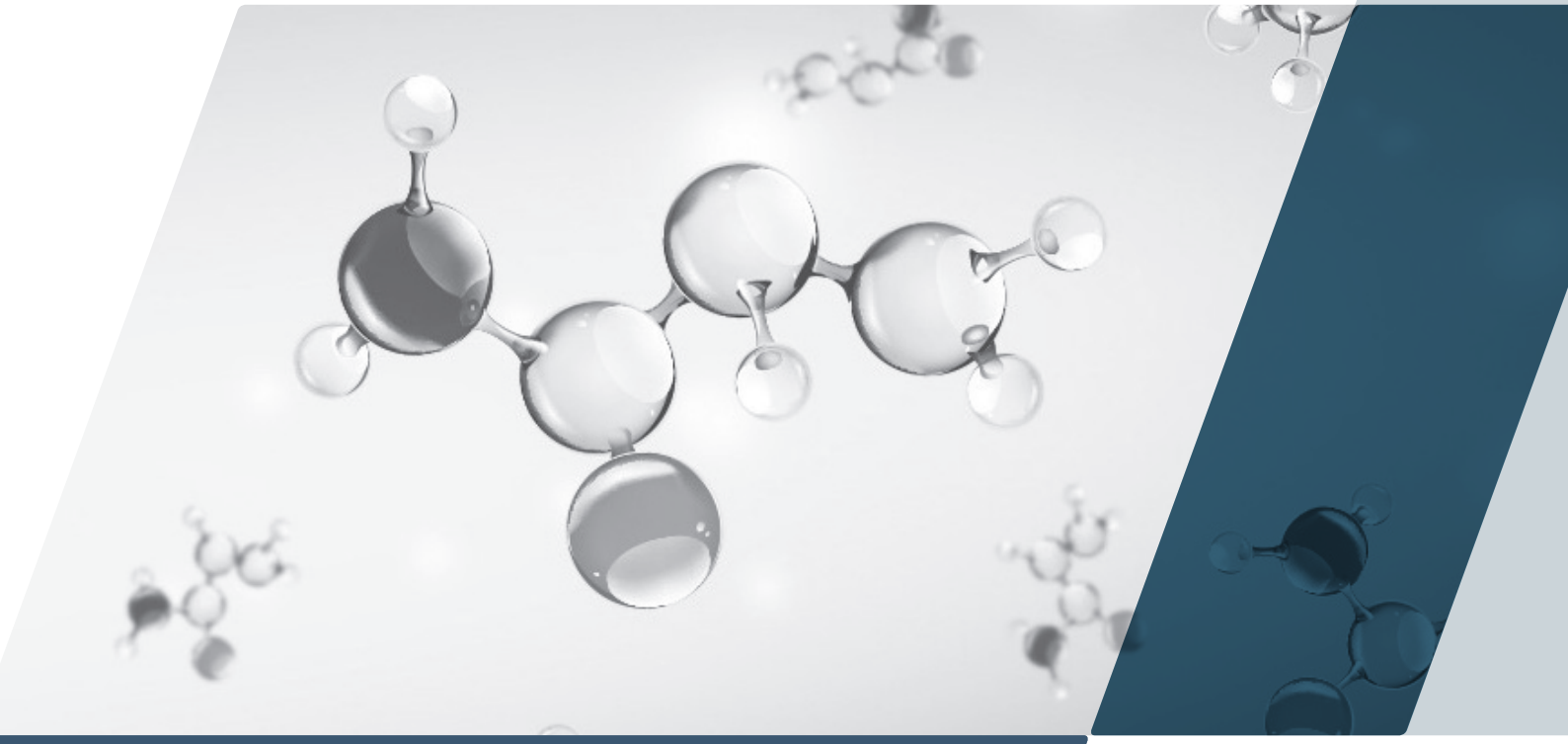
SAFE HANDLING, USE, AND STORAGE OF AQUEOUS ACRYLAMIDE



Providing guidelines for safe handling and storage of acrylamide at 50% and 30% aqueous solutions. Detailed information on the toxicological and physical properties of acrylamide monomer can be found in the Safety Data Sheet.

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KEY FACTS

Acrylamide is a reactive monomer, and though it is not self-polymerizing, it can polymerize when in the presence of contamination such as iron salts, excessive heat >32°C (>90°F), or UV light, and the resulting exothermic reaction can generate heat and pressure. Dissolved oxygen (from the air) in the acrylamide solution provides good stabilization. At low temperatures <13°C (<55°F), a 50% aqueous solution of acrylamide can crystallize and must be dissolved again before use. Acrylamide must be handled with care.

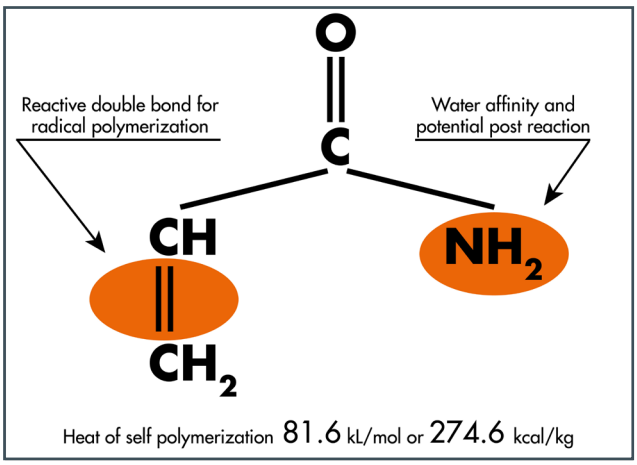
INTRODUCTION

Industrially, acrylamide can be used as a building block to manufacture hydrosoluble polymer products with applications in many industries such as water treatment, agriculture, oil & gas, mining, paper, textiles, home care, personal care, and others.

SNF markets acrylamide monomer as an aqueous solution at 50% and 30% concentrations. It is manufactured using a proprietary enzymatic process that produces pure monomer with low levels of impurities. As of 2019, SNF uses this technology at all of its major facilities in the US, France, India, China, and Korea for a total capacity exceeding 800 kt/year.

PHYSICAL PROPERTIES

IUPAC	Prop-2-enamide
CAS	79-06-1
Formula	C_3H_5NO
Molar Mass	71.078 g/mol
pH	6.0 - 8.0
Density of Aqueous Solution @ 50% @ 30%	 1.04 g/cm^3 1.02 g/cm^3
Crystallization Temperature @ 50% @ 30%	 13°C (55°F) -7°C (19°F)



SAFETY CONSIDERATIONS

Acrylamide is a toxic substance and high acute exposure can cause serious injury to the nervous system. For this reason, any human contact (eyes, skin, inhalation, or ingestion) can be hazardous and should be avoided. Only adequately informed, trained, and equipped personnel should be involved in storage, loading, unloading, or process activities with acrylamide monomer.

STORAGE OF AQUEOUS ACRYLAMIDE

SNF supplies acrylamide solutions in IBCs (totes) or in bulk. IBCs must be stored and protected from direct sunlight and extreme temperatures; above 32°C (90°F) and below 18°C (64°F) for 50% acrylamide or 0°C (32°F) for 30% acrylamide. Used and empty IBCs should be stored in a safe place before return or disposal by a specialized company.

A schematic guideline for unloading and bulk storage facilities for acrylamide is provided at the end of this document. This guideline is presented only to assist in the design of a safe and adequate facility. It is required that all acrylamide storage facilities, as well as all lines and equipment (pumps, etc.), be dedicated for acrylamide use. This dedication is essential to minimize the possibility of cross-contamination. When properly stored, SNF guarantees a 6 months shelf-life for its acrylamide solutions. If the stated shelf-life is exceeded, please contact your SNF sales representative to address further use or disposal of Acrylamide Monomer.

CONSTRUCTION MATERIALS

- All product piping should be stainless steel (304L or 316L)
- All product lines and valves should be stainless steel (304L or 316L). Seal and packing material should be Teflon resin, Viton resin, reinforced graphite, or neoprene. Ball valves are recommended because they open and close quickly and easily, seal well, and do not hold residual liquid if it is a cavity-filled ball valve.
- Never use unlined steel, copper, iron, aluminum and its alloys, and nickel-clad steel in contact with acrylamide. **Doing so creates a risk for self-polymerization**.
- Unloading hoses must be rated for chemical service and have an inner liner compatible with acrylamide such as PTFE or neoprene.
- Recommended gasket materials include those made with Teflon resin, Viton resin, reinforced graphite, or neoprene. Stainless steel spiral wound gaskets are also recommended.
- Storage tanks should be stainless steel (304L or 316L) or iron-free, glass-lined steel.
- Explosion-proof equipment is not necessary.

All stainless-steel tanks and piping should be passivated before being used in contact with acrylamide. All piping and tanks should be inspected annually for signs of rust or damage, as free iron can lead to self-polymerization. Any signs that the passivation layer has been compromised should result in re-passivation of the tank and/or piping before putting the equipment back into service.

Other materials, such as fiberglass tanks and plastic-lined tanks, are not recommended. They may cause a high incidence of polymer formation.

INSTRUMENTATION (MONITORING)

The amount of instrumentation (interlocks, automation, remote readouts, etc.) is a customer/owner decision. However, the following minimum instrumentation level is recommended:

- Sparge low airflow alarm
- A High-level alarm on the storage tank
- Temperature monitoring and/or high-temperature alarm
- Temperature-indicating control system for heat transfer fluid, or equivalent heat exchange system (for temperature control of tank contents)
- pH indicating system

ACCESSORIES

PRODUCT FILTERS

As with other reactive monomers, acrylamide has a nucleating site, polymer-forming tendency. Hence, removal of even trace quantities of gel particulates and keeping the system free of this type of polymeric formation reduces its generation rate. It is recommended to have filtration (10-50 micron range) installed between the delivery vehicle and storage tank, and between the storage tank and process. The filters should be constructed of compatible materials such as polypropylene felt filter bags or materials named above.

AIR AND WATER FILTRATION

The use of clean, dry air is highly recommended for sparging to avoid rust formation on the surfaces in contact with acrylamide. Additionally, demineralized or potable water is recommended to prevent contamination.

PUMPS

Sealless centrifugal pumps with magnetic drives are recommended. Pump materials coming into contact with aqueous acrylamide monomer should be stainless steel (304L or 316L) or Tefzel™ (modified ETFE fluoroplastic resin). A blocked-in detector cut-off is recommended to prevent running the pump with feed and/or discharge valves closed to avoid possible overheating of acrylamide in the pump body (dry running).

OPERATIONAL NOTES

CLEANING OF PIPING AND TRANSFER LINES

After each transfer of acrylamide from the storage tank to the process, **the transfer line should be blown completely clear with dry air into the process vessel**. The use of dry air at this step is required to ensure that no rust forms in the process piping or tanks. Pressure and time of purge must be adapted to each installation.

Rigorous attention to this operation after each transfer should eliminate the risk of stagnant acrylamide and prevent any plugging of piping and transfer lines. It is recommended that the piping system be designed so that the acrylamide recirculates and no liquid remains in stagnant areas without aeration for extended periods.

After air blowing, it is recommended to flush the line with water to remove any acrylamide traces left in dead legs. **Purge lines after each transfer.**

Great attention should be paid to piping exposed to high temperatures, e.g., summer in hot climates, pipe racks under roofs, or external pipe racks exposed to direct sunlight which can easily exceed 50°C (122°F). **High temperature and low oxygen content are key factors that can lead to self-polymerization of acrylamide.** Correct insulation for acrylamide requires a sun shed + heat tracing + Armaflex™ elastomers for pipes. For tanks, SNF uses PU (polyisocyanurate) 100 mm + aluminum cladding (Isoxal™).

As a minimum, storage tanks and piping should be cleaned and inspected annually. **It is recommended to leave approximately 25% free volume in the tank to allow for dilution with water and intensive air mixing if polymerization occurs.** Provisions should be made for the addition of large amounts of water.

OXYGEN CONTROL

A controlled air sparge of acrylamide is necessary and essential in preventing polymerization in the storage tank. The main objectives of this air sparge are to maintain the dissolved oxygen level at or near saturation (approx. 10 ppm) and to provide gentle agitation. Without oxygen, the inhibition package is not sufficient. Oxygen is a natural polymerization inhibitor and is necessary for the activation of the inhibitor package. **Stagnant Zones in the storage tank must be eliminated.**

A ring sparger for a vertical tank will provide the best air distribution. Controlled continuous sparging at 0.09 Nm^3/h per m^3 of acrylamide (0.2 SCFM per thousand gallons) is sufficient for inhibition purposes. As part of the sparging system, installation of an alarm to detect malfunctions is recommended.

Do not sparge or blanket acrylamide in storage with an inert gas such as nitrogen. An inert gas will deactivate the inhibitor package and can lead to self-polymerization.

TEMPERATURE

The temperature of acrylamide solutions should be maintained between 18°C (64°F) and 27°C (81°F). At temperatures below 15°C, acrylamide 50% will crystallize out of solution and at temperatures above 50°C (122°F), self-polymerization could occur. Storage tanks should include temperature probes and an independent temperature alarm system for early detection of polymerization.

The self-polymerization reaction is exothermic. Temperatures that are observed to be steadily increasing should be taken seriously, and the storage tanks inspected.

For IBC (tote) storage, where temperatures could be near 32°C (90°F) for extended periods and an air sparge is not possible, storage has to be limited to three months. If storage temperatures above 32°C are likely to be reached, cooling water spray systems over IBC (tote) storage areas are recommended.

FREEZING OR CRYSTALLIZATION

During cold weather, transportation time can result in freezing and consequent crystallization of the 50% aqueous solution of acrylamide monomer. If crystallization has occurred, do not pump off any aqueous material until the crystals are re-dissolved using the steps outlined in the temperature section of this document, as the product may be less stable due to inhibitors not being homogeneously mixed throughout the shipment.

If crystallization of acrylamide occurs in transit or storage due to low product temperature, the material can be re-dissolved (thawed) by carefully applying mild heat. In storage tanks, railcars, and tank trucks, heated water (maximum 40°C or 104°F) may be introduced into the heating coils. Packaged material should be moved to a warm environment until crystals are entirely re-dissolved. Using air sparge and agitation will increase the rate of dissolution. **Do not apply steam to heating coils or direct heat to packaged material. Hot spots must be avoided!**

pH

As supplied, 50% aqueous acrylamide solution has a pH of 6.5 to 8.0 and 30% aqueous acrylamide solution has a pH of 6.0 to 8.0.

Note: A decrease in pH below 6.0 significantly reduces stability. Increasing pH to 8.0 does not affect stability but can generate ammonia release. Periodic monitoring of pH is recommended and necessary. The pH of acrylamide solutions should be adjusted with dilute amounts of sodium hydroxide. Addition of base should be carried out with adequate mixing and careful monitoring of pH to maintain the stability of the acrylamide.

CONTAMINATION

As with other reactive monomers, contact or exposure of acrylamide solutions with known initiators such as peroxides and azo compounds must be avoided. Strong oxidizing agents such as persulfates can also initiate polymerization of acrylamide. Reducing agents such as sulfites and bisulfites under certain conditions can cause polymerization.

Acids lower the stability of acrylamide, increasing the possibility of self-polymerization. Bases hydrolyze acrylamide, thus generating ammonia.

Contamination with any metal, particularly ferrous salts (rust), must be avoided since self-polymerization of acrylamide is then catalyzed.

UNLOADING AND HANDLING

UNLOADING

Every shipment of acrylamide must be correctly identified before unloading takes place. The tank truck must always be vented during the unloading operation to prevent a collapse of the tank.

To begin the unloading process, the pump may be primed by pressurizing the car with clean, dry air at low pressure (5-10 psi), or the connected unloading line and pump can be filled with clean (potable) water. It is highly recommended that only hoses and connections dedicated to acrylamide be used to avoid contamination.
When unloading is complete, the unloading line should be blown clear with clean air and then washed with water to the storage tank to clear residual acrylamide from the unloading line.

If a spill of acrylamide occurs, clean immediately using best practices. Dry acrylamide sublimates and can present an inhalation risk to personnel if the solution is allowed to dry.

SHIPPING

DRUMS

SNF does not supply acrylamide in drums.

IBCS (TOTES)

Large scale use of acrylamide in totes is not encouraged due to storage concerns. Protect the totes from heat, cold, and UV exposure. Maintain strict First-In-First-Out (FIFO) inventory practice to avoid prolonged storage periods.

BULK TANK TRUCKS

Commercially available tank trucks made of stainless steel (304L or 316L) are used for transport. Tanks are thoroughly cleaned and inspected before each filling. Trucks are loaded from a storage tank with an air sparge (to ensure an adequate dissolved oxygen level). Contents of the tank truck are clearly identified with compliant labeling.

IN CASE OF SELF-POLYMERIZATION IN A STORAGE TANK

If in spite of all precautions taken, an accidental self-polymerization occurs, it is preferable to dilute the solution with water to absorb energy, cool it as much as possible, and let the solution polymerize completely in order to handle afterward a non-toxic gel instead of a hazardous mixture.

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UNLOADING AN
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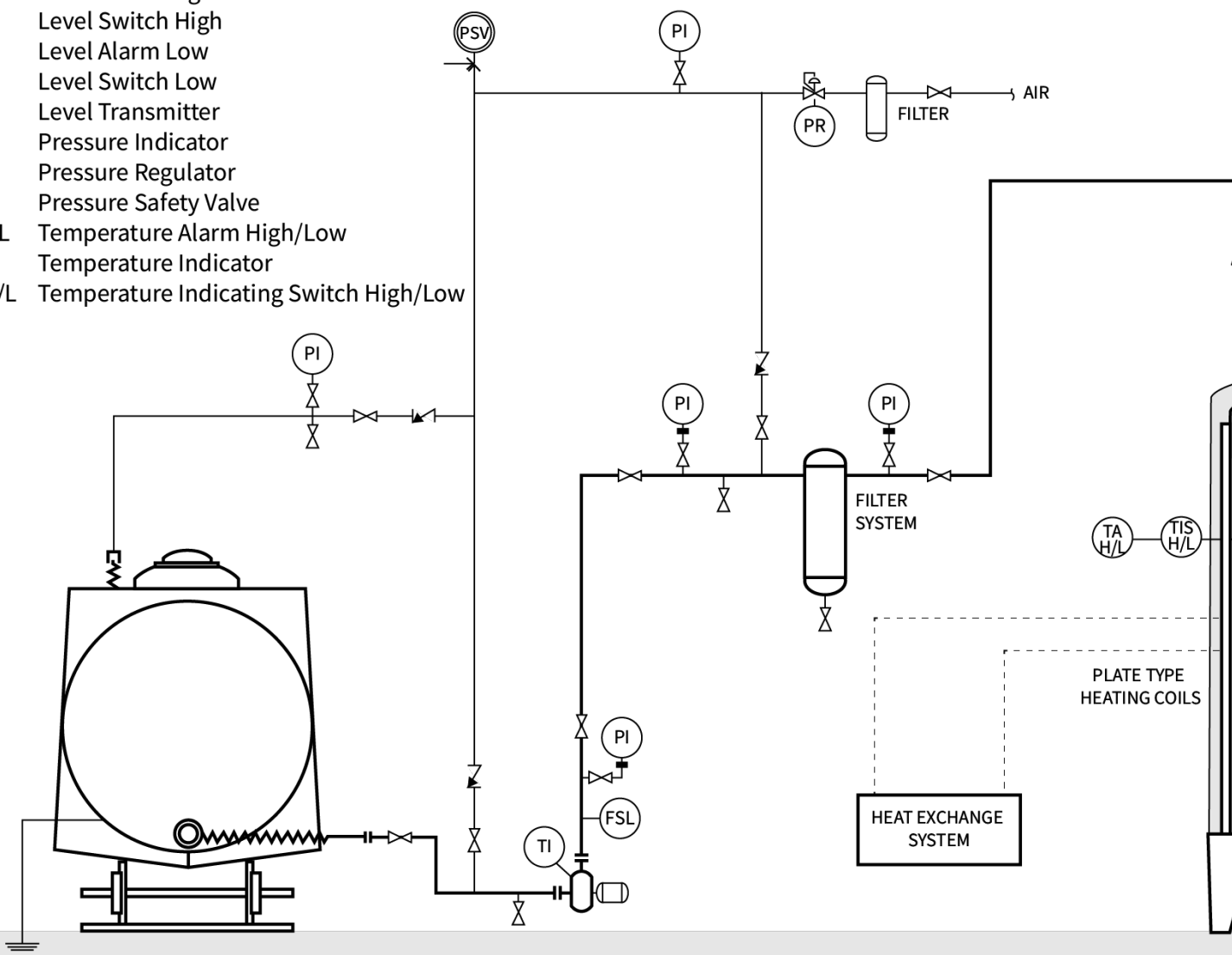
FAL	Flow Alarm Low
FSL	Flow Switch Low
LI	Level Indicator
LAH	Level Alarm High
LSH	Level Switch High
LAL	Level Alarm Low
LSL	Level Switch Low
LT	Level Transmitter
PI	Pressure Indicator
PR	Pressure Regulator
PSV	Pressure Safety Valve
TAH/L	Temperature Alarm High/Low
TI	Temperature Indicator
TISH/L	Temperature Indicating Switch High/Low

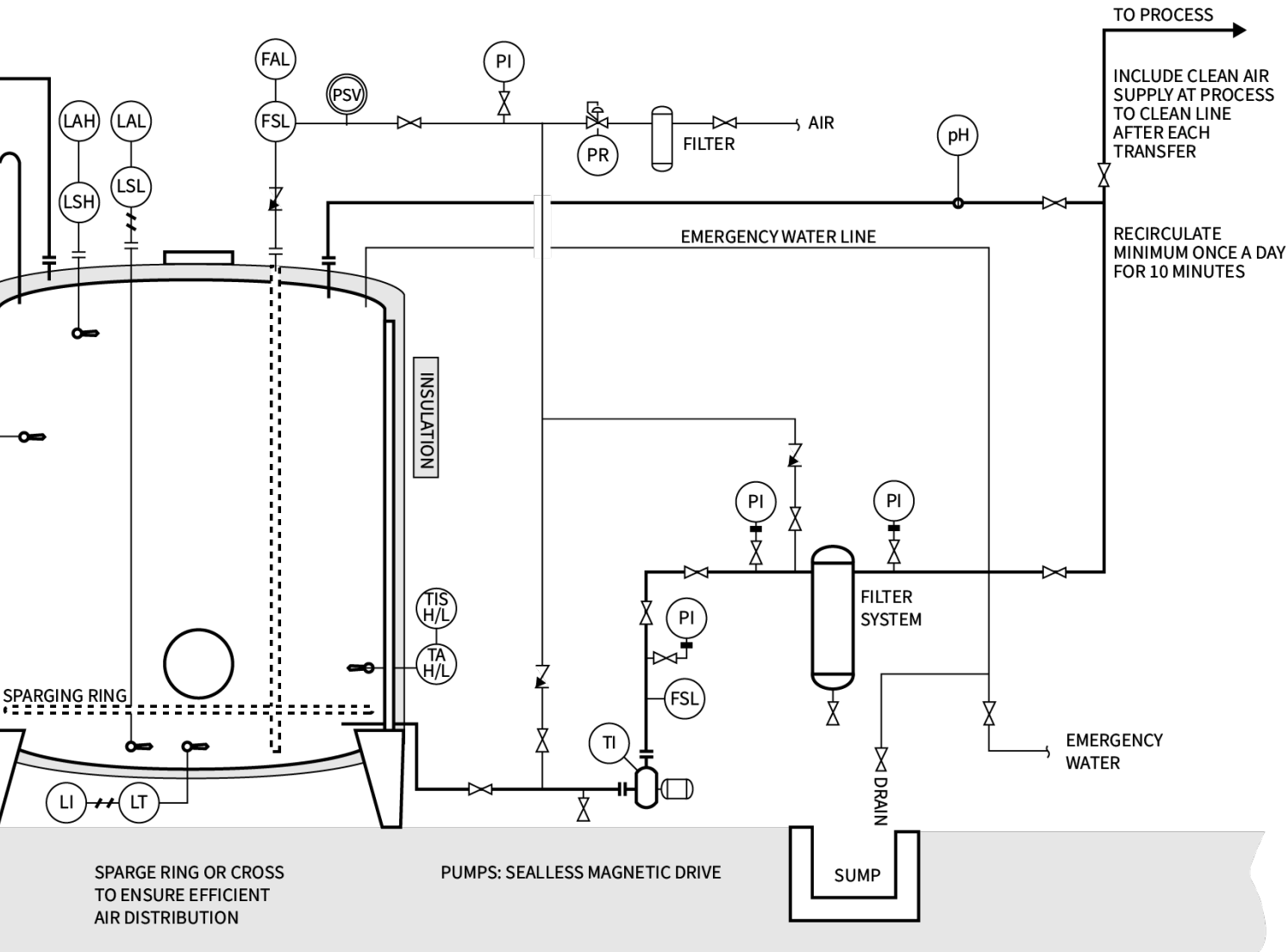


LEAKAGE OF ANY ACRYLAMIDE MUST BE CONTAINED FOR PROPER DISPOSAL

PUMPS: SEALLESS MAGNETIC DRIVE

IMPERVIOUS DIKE & FLOOR
FLOOR SLOPED TO SUMP

UIDELINE FOR
ND STORAGE OF
ACRYLAMIDE



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