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Manchester Wastewater Treatment Plant Enhanced Nutrient Removal

NORTHEASTERN UNIVERSITY

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Abstract

The Town of Manchester, Maryland, has a 57-year-old wastewater treatment plant that treats 0.27 million gallons of wastewater a day (MGD). The plant's National Pollution Discharge Elimination System (NPDES) Permit will expire in 2027, requiring the plant to meet stringent nutrient removal limits for total nitrogen (TN < 3 mg/L) and total phosphorus (TP < 0.3 mg/L). A&E Consulting (A&E) designed an upgraded enhanced nutrient removal (ENR) process for the Town. Projecting a design flow of 0.5 MGD, A&E chose a 4-Stage Bardenpho system for ENR and designed the primary aerobic tank using a solids retention time value of 14.7 days. The rest of the tanks were designed using the hydraulic retention time. After sizing via hand calculations, A&E then contacted vendors to determine accurate pricing for processes such as a combined headworks and filtration. Using BioWin, the effluent was found to meet these TN (2.92 mg/L) and TP limits (<0.3 mg/L). With town engagement and sustainability in mind, A&E also prioritized Class III effluent discharge limits which allow for water reuse on parks and other open spaces. The newly treated effluent was able to meet the Class III limits (<10 mg/L BOD_5 and <5 mg/L total suspended solids).

Summary of Project Team Effort

A&E Consulting is comprised of six engineers with a passion for providing clients with reliable, innovative, and sustainable engineering solutions. A&E engineers attended Northeastern University and completed degrees in Environmental Engineering in Spring 2026. By valuing integrity, technical excellence, and equity-focused design, A&E Consulting strives to lead the next generation of innovative and sustainable wastewater and water reuse solutions that strengthen both ecosystems and communities.

Sydney Scott, Project Manager

Sydney is an Environmental Engineer with a background in wastewater, drinking water and stormwater projects. She primarily contributed to the preliminary treatment design. Sydney also coordinated manufacturer connections and team meetings, as well as contributing to the alternate analysis of preliminary design and biological nutrient removal. She also utilized her CAD skills by developing the 3D rendering of the plant.

Ingrid Alikaj, Water Resource Engineer

Ingrid is an Environmental Engineer with experience in water chemistry and biological nutrient removal. Ingrid's role focused on the design of biological nutrient removal system, which included analyzing existing plant data, as well as the effluent reuse schemes.

Julia Ariano, Environmental Engineer

Julia is an Environmental Engineer with an interest in water treatment, wastewater treatment, and waste management. Experience includes GIS field work of sewer systems, community outreach, and cost estimating. Julia focused on the biological unit design of the Bardenpho system, which consisted of extensive BioWin modeling. She also contributed to the design and analysis of the disinfection unit.

Sylvia Burns, CAD/GIS Specialist

Sylvia is an Environmental Engineer with a keen interest in CAD and GIS software, as well as water resource engineering. During this project, Sylvia primarily worked on the filtration system, secondary clarification tanks, and equalization basin design. This included manufacturer coordination, engineering calculations, and alternate analysis. Additional contributions included the layout design and drafting of full plant design.

Chelsea Penetra, Environmental and Policy Lead

Chelsea is an Environmental Engineer with a minor in Law and Public Policy. She has hands-on and academic experience reviewing, editing, and designing site plans for various treatment processes. For this project, Chelsea focused on the sludge treatment and dewatering, as well as the reuse design.

Calvin Vasicek, Data Engineer

Calvin is an Environmental Engineer and data scientist. He has experience with municipal utility operations and regulatory compliance frameworks, as well as site planning and details. His experience in data science and activated sludge modeling provided him with the expertise needed for wastewater treatment system design and optimization. Calvin also worked on the design for the sludge treatment and dewatering portion of the plant.

A&E Consulting would like to thank our mentor, Emily Korot, PE, and our Senior Design professor, Annalisa Onnis-Hayden, PhD, for their assistance throughout this design process.

Project Description

1.0 Introduction

This report, prepared for the town of Manchester, Maryland (the Town), details the design of a new Wastewater Treatment Plant (WWTP) with Enhanced Nutrient Removal (ENR) capabilities. The design was made to meet stringent local and national laws and permits, such as the National Pollution Discharge Elimination System (NPDES) permit, that regulate effluent discharge.

Wastewater treatment for Manchester is provided by a 57-year-old facility with a NPDES permit set to expire in 2027. The existing WWTP sits on a 3.5-acre lot and currently treats 0.27 million gallons of wastewater a day (MGD). The Town is interested in upgrading the plant to meet the anticipated need for ENR of total nitrogen (TN) and total phosphorus (TP). Aging infrastructure is another consideration behind upgrading the plant.

1.1.1 Project Site

Manchester is a town in Carroll County, Maryland, located along the state's northern border, with a population of 5,408 as of the 2020 US Census. [1] The Town is mainly suburban and is home to 82 acres of parkland. Christmas Tree Park, the largest developed parkland in the Town, has several baseball diamonds, a football field, and picnic areas, which require water for irrigation. [2] Three public schools are present in the town of Manchester, including Manchester Valley High School (MVHS), which is located adjacent to the wastewater treatment plant and contains five irrigated turf athletic fields. Figure 1-1 displays Christmas Tree Park, MVHS, and the WWTP parcel, including its existing outfalls.



Figure 1-1: Manchester Locus Map with End Use locations and Outfalls

1.2 Project Goals

A&E Consulting designed the new Manchester WWTP with the following three goals:

1. Meet NPDES Enhanced Nutrient Removal requirements
2. Facilitate the reuse of wastewater for non-potable applications
3. Promote engagement with the Town

Adequate nutrient removal was at the forefront of design due to rigid NPDES permit limits. As wastewater treatment technologies advance, producing reusable effluent has become a goal for WWTP designs. Water reuse promotes a circular economy and conserves freshwater resources that would otherwise be depleted. A&E

Consulting prioritized this throughout the design process. To promote community engagement with the Town, the design incorporates effluent reuse to irrigate the Town's public parks and high school athletic fields.

1.3 Project Scope

Using historical flows and loads data from the WWTP and flow projections for the following 25 years, an upgraded ENR plant was designed to meet the community's needs and fit within the existing 3.5-acre parcel. A&E Consulting used Excel, BioWin simulations, and hand calculations to size the following plant components and ensure that future effluent limits and Class III water reuse guidelines were met:

1. Preliminary Treatment
2. Biological Nutrient Removal
3. Filtration
4. Disinfection
5. Sludge Dewatering
6. Sludge Digestion

The team conducted alternative analyses on the above components to meet future NPDES permit limits and produce Maryland Class III reuse water.

2.0 Existing Conditions

The following chapter summarizes the existing conditions of the Manchester WWTP, including the current structures and systems, and relevant permits and regulations. Historical influent flows, loads, and effluent water quality measurements are described in detail.

2.1 Project Characteristics

2.1.1 Site Layout

The existing WWTP consists of a headworks building, a chemical building, two multi-chambered tanks, a control room, chlorine and UV contact chambers, and sludge handling equipment. The two multi-chambered tanks contain designated regions for aeration, reaeration, sludge digestion, and a central zone for clarification. Effluent is disinfected with UV light and discharged into Georges Run or chlorinated and used for spray irrigation. The most recent changes to the plant occurred in 1992 with the addition of the second multi-chambered tank. Space was left for future tertiary treatment if needed. Existing conditions are further outlined in Appendix A.

2.1.2 Population Characteristics

The Town's most recent comprehensive report was published in 2018 and detailed a strong desire to "maintain Manchester's small-town character and appeal." [3] Commercial growth, if any, is to be concentrated in existing business centers with less emphasis placed on new developments. U.S. Census Bureau data showed a 64% increase in Manchester's population since 2000. [4] A&E used this existing data to estimate the population at the design year of 2046 to be 7,700 persons.

2.2 Permit and Regulation

2.2.1 NPDES Permit

The NPDES permit was created under the Clean Water Act in the United States. These permits regulate effluent discharge to protect neighboring communities and ecosystems. The existing NPDES permit regulates the current Manchester WWTP outfall from two point sources – discharge to Georges Run (Outfall 001A) and groundwater discharge to neighboring land via spray irrigation (Outfall 002). Regulated under the NPDES permit are 5-Day

Biological Oxygen Demand (BOD_5), Total Suspended Solids (TSS), Total Nitrogen (TN), Total Phosphorus (TP), pH, and Fecal coliform. Figure 1-1 displays the two outfalls.

The plant anticipates stricter ENR constraints upon renewal of the expiring permit. To prepare, the plant plans to upgrade its treatment processes accordingly. The expected ENR discharge limits include a TP limit of 0.3 mg/L and a TN limit of 3 mg/L for the stream discharge into Georges Run. No changes in NPDES permit limits are anticipated for Outfall 002. The full NPDES permit for the existing WWTP is found in Appendix B.

2.2.2 Maryland Water Reuse Guidelines

The Maryland Department of the Environment has three classes for reclaimed water from I to IV. Classes I through III can be used for irrigation if it is non-residential, has an appropriate buffer zone, and has appropriate restricted access. Class IV effluent can be used for additional commercial and industrial purposes, including fire protection and cooling water systems. Current groundwater discharge via spray irrigation from the existing Manchester WWTP falls into the Class I category. Existing spray irrigation is permitted only with the presence of a minimum 200-foot buffer zone between the wetted perimeter of the irrigation area and property lines. Minimum buffer zones for spray applications decrease with the discharge of higher-quality effluent. Table 2-1 denotes the requirements from the NPDES permit and the Class III guidelines. Appendix C contains the full guidelines for Class I through III reuse.

Table 2-1: Effluent Water Quality

Water Quality Parameter	Expected Future NPDES Limits	Class III Guidelines
BOD_5	-	10 mg/L
TSS	-	2 NTU
TN	3 mg/L	-
TP	0.3 mg/L	-
Fecal coliform	-	2.2 MPN / 100 mL

An upgrade to Class III effluent categorization permits additional non-residential irrigation, including the irrigation of lawns, parks, playgrounds, school yards, and other green open spaces. This allows for treated effluent from a new Manchester WWTP to be used for irrigation of the town's many parks and school fields, highlighted in Figure 1-1. Utilizing effluent for these applications requires a significant increase in effluent quality, which can be achieved through an upgraded WWTP.

2.3 Existing Manchester WWTP Process

Preliminary treatment is currently conducted inside a combined headworks building that contains a mechanical bar screen, grit removal, and a pump station with a comminutor, which divides influent flow before travel to the multi-chambered tanks. The multi-chambered tanks were implemented in place of separate clarification, aeration, and sludge digestion tanks to conserve space within the 3.5-acre parcel. Influent enters the contact stabilization unit and moves to the inner section of the unit for clarification. After the clarifier unit removes the solid materials, the flow is directed out of the unit, and the sludge is stabilized through reaeration.

The water is disinfected using chlorination or UV radiation based on the outfall to which it is discharged. When discharged via spray irrigation, water is disinfected through chlorination. When discharged to Georges Run in the winter months, water is disinfected with UV disinfection. This is due to NPDES permit requirements prohibiting

the use of chlorine when effluent is discharged to Georges Run. Existing UV disinfection infrastructure consists of a flume that measures flow into a tank where UV lamps disinfect water.

2.3.1 Reason for Rebuild

Updates to the Manchester WWTP have been proposed due to the plant's aging infrastructure, operation past its design period, and projected population growth. A&E Consulting intended to meet stricter nutrient effluent regulations that will come with the renewal of the plant's expiring NPDES permit and expand its current water reuse scheme by producing cleaner effluent that can irrigate sports fields and parks. Rebuilding the plant and implementing new unit operation designs is in the Town's best interest to meet these goals.

2.4 Flows and Loads Analysis for Manchester WWTP

The existing WWTP underwent a special sampling event in 2020 that produced extensive data on influent water quality parameters and daily flow measurements for the year. This data was used to determine peaking factors and project flows and loads for a new WWTP, summarized below. Full sampling data are available in Appendix D.

2.4.1 Average Plant Flow

The average annual flow for the existing WWTP is 0.27 MGD. Peaking factors, determined from the historical data provided, were used to calculate the design flows for various flow criteria, summarized in Table 2-2. There are no seasonal changes in flow that will need to be accounted for in the design of a new WWTP. The average design flow for the plant was estimated as 0.5 MGD based on the 2046 population.

Table 2-2: Historical and design flows for the new Manchester WWTP

Flow Criteria	Historical Flow (MGD)	Peaking Factor	Design Flow (MGD)
Minimum Day	0.19	0.7	0.36
Average Annual	0.27	1.0	0.50
Maximum Average Month	0.30	1.1	0.57
Maximum Average Week	0.32	1.2	0.61
Maximum Average Day	0.35	1.3	0.66
Maximum Peak Hourly	1.05	3.9	1.98

2.4.2 Influent Loads

Accurate characterization of wastewater loading is essential to properly size treatment processes at the new WWTP. Plant sampling was conducted to calculate the following water quality parameters: Total BOD_5, Total Chemical Oxygen Demand (Total COD), TSS, Volatile Suspended Solids (VSS), Total Kjeldahl Nitrogen (TKN), TP, and alkalinity. Maximum daily and maximum monthly concentrations were determined using peaking factors found in Section 2.4.1. Table 2-3 presents summary values for each parameter, with average annual, maximum daily, and maximum monthly loadings. A comprehensive flows and loads analysis is found in Appendix E.

Table 2-3: Projected Loading of Manchester WWTP

Water Quality Parameter	Average Annual Loading (lbs/day)	Maximum Daily Loading (lbs/day)	Maximum Monthly Loading (lbs/day)
BOD_5	1254	2431	1519
COD	1947	3294	2449
TSS	946	1847	1015
VSS	835	1739	972
TKN	212	430	231
TP	32	70	39

3.0 Design Considerations

This chapter explores the technologies considered by A&E to achieve the new WWTP's goals of treatment and reuse. Decision matrices were created for each technology, guided by the following common performance criteria: footprint, capital cost, operation and maintenance cost (O&M cost), and maintenance demand. The existing plant sits on a small lot and requires minimal oversight of its multi-chambered tanks. Due to this, the design was created to limit maintenance demand and costs and fit within the existing footprint. Additional performance criteria were also considered and presented when applicable to the specific technology discussed. Decision matrices were made quantitatively, with scores of one through five assigned per criterion. Supplementary qualitative decision matrices are presented in Appendix F.

3.1 Preliminary Treatment

The function of this system is to remove inorganics like sticks, stones, grit, and sand from wastewater to reduce wear on downstream equipment. Headworks equipment includes pumps, grit removal, bar screens, fine screens, and grit washing systems. A&E focused on grit removal as the leading component for determining preliminary treatment technologies. Grit typically consists of larger organic particles, including those with specific gravities greater than that of oxidizable organic material in wastewater. [5] Characteristics like composition, particle size, and settling characteristics must be considered when designing for grit removal. No primary treatment will be considered in the design of this plant, due to size constraints and the need for carbon sources in the downstream nutrient removal process. This is explained in the following nutrient removal section.

The following design options were evaluated by A&E consulting: Horizontal-Flow Grit Chambers, Aerated Grit Chambers, and Vortex-type Grit Chambers. Odor control, grit removal, and the system's ability to handle varying flows were also considered when evaluating these systems. Table 3-1 presents the decision matrix for preliminary treatment.

Table 3-1: Preliminary Treatment Quantitative Matrix

	Footprint	Capital Cost	O&M Cost	Maintenance Demand	Odor Control	Grit Removal	Ability to handle varying flows	
Weight	5	2	3	3	4	5	3	**Final Score**
Horizontal-Flow Grit Chambers	1	3	3	3	4	3	1	**63**
Aerated Grit Chamber	3	3	1	1	1	3	3	**55**
Vortex-Type Grit Chamber	5	1	3	4	4	5	3	**86**

A&E decided to continue with the Vortex-Type Grit chamber design for implementation. Overall, vortex grit chambers can remove high percentages of fine grit and have consistent removal efficiencies over a wide range of flows. They also have a smaller footprint compared to the other technologies. For the Vortex design, Smith and Loveless' packaged headworks system, the PISTA®Works™ Screening and Grit Removal Headworks Package, was considered.

3.2 Nutrient Removal

The presence of nutrients in WWTP effluent is strictly regulated. A&E has identified three nutrient removal techniques for further evaluation, described below. A&E was limited to evaluating Bardenpho systems due to the primary consulting firm requiring this option.

3.2.1 4-Stage Bardenpho

Following the preliminary design for the new Manchester WWTP, a 4-Stage Bardenpho process (4-Stage) was considered as a biological reactor to provide nitrogen removal, with chemical precipitation to remove phosphorus.

The 4-Stage system consists of pre-anoxic, primary aerobic, post-anoxic, and secondary aerobic tanks (Figure 3-1). The pre-anoxic tank undergoes denitrification and uses BOD in the influent to meet organic carbon demand. Nitrate produced in the aerobic tank gets recycled to the pre-anoxic tank and undergoes denitrification. To further remove nitrogen and meet the expected 3 mg/L limit, the 4-Stage system adds a post-anoxic and second aerobic tank. Due to the lack of BOD in the post-anoxic tank, supplemental organic carbon must be added to facilitate denitrification. [6] Ferric chloride addition in the post-anoxic tank will create phosphorus flocs that are settled out in the secondary clarifier. Chemical phosphorus removal in the 4-Stage system will not meet NPDES permit limits, making a polishing step necessary after biological treatment.

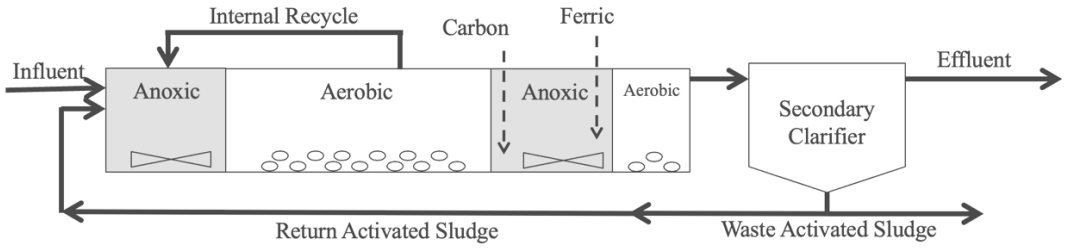


Figure 3-1: Schematic of 4-Stage Bardenpho system

3.2.2 4-Stage Bardenpho with MBR

The 4-Stage Bardenpho with MBR system (4-Stage MBR) adds a membrane bioreactor (MBR) in the last aerobic tank of a standard 4-Stage (Figure 3-2). The MBR aids in solid and liquid separation. MBRs typically operate as a low-pressure system with a higher mixed liquor suspended solids (MLSS) concentration. The separation of membranes allows for greater suspended solids removal, typically below 1.0 mg/L, and greater phosphorus removal. [7] The use of an MBR lowers the footprint of the overall system by removing the need for a secondary clarifier. As such, a 4-Stage MBR carries a lower footprint than a 4-Stage system.

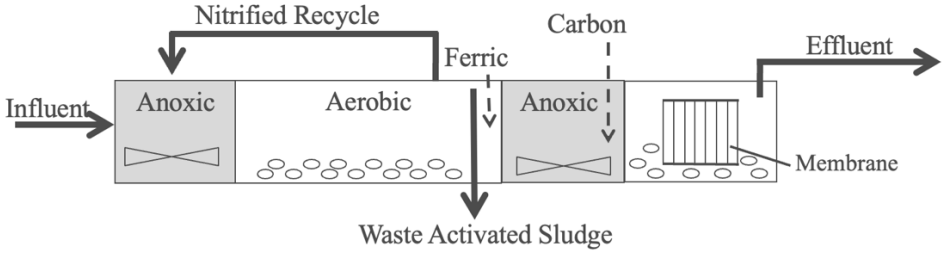


Figure 3-2: Schematic of 4-Stage Bardenpho System with MBR

Considerations for the design of a 4-Stage MBR system include air scouring techniques to limit buildup on membranes and periodic cleaning requirements. Operating issues include membrane biofouling, which is the unwanted accumulation of biofilm, chemical costs for cleaning, loss of membrane function during the cleaning process of the membranes to remove the accumulation of biofilm, and increased electricity costs to maintain pressure in the membrane. When operated at a similar solids retention time (SRT) to conventional systems, MBRs produce slightly more sludge due to higher TSS capture. [7] Similar to a 4-Stage system, other requirements include the choice of organic carbon addition in the post-anoxic tank and the addition of ferric chloride, a chemical coagulant, to aid in phosphorus removal prior to the MBR. Chemically precipitated phosphorus is then filtered out in the MBR, resulting in low phosphorus effluent.

3.2.3 5-Stage Bardenpho

With the addition of an anaerobic tank at the start, the 5-Stage Bardenpho (5-Stage) process adds biological phosphorus removal to the 4-Stage system (Figure 3-3). Phosphorus removal is facilitated by providing phosphorus-accumulating organisms (PAOs) with an advantage over other microbes in the anaerobic zone. [6]

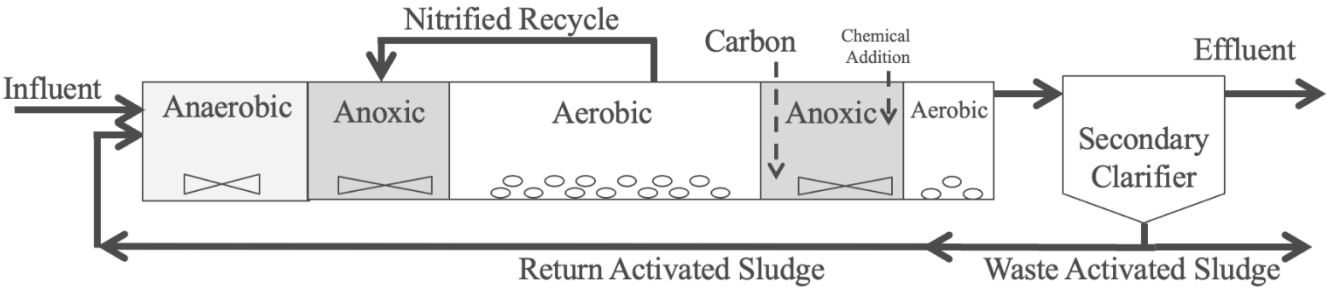


Figure 3-3: Schematic of 5-Stage Bardenpho System for biological removal of nitrogen and phosphorus

Under aerobic conditions, PAOs incorporate phosphorus into their cells as phosphorus and polyphosphates, which lowers phosphorus concentrations in the water. Under anaerobic conditions, PAOs use stored phosphorus as an energy source to consume COD. PAOs in recycled activated sludge will have sufficient phosphorus sequestered in their cells to consume COD, grow, and multiply while other microbes are limited by the lack of an available energy source (O_2). Across the growth phase in the anaerobic and anoxic tanks, phosphorus levels increase as phosphorus is released by PAOs. Phosphorus levels alternate between high and low through the system until the final aerobic tank, where phosphorus is sequestered within microbes and settled out in the secondary clarifier.

5-Stage systems achieve the same TN concentrations as a 4-Stage system if organic carbon is appropriately supplemented. Considerations for limiting the intrusion of dissolved oxygen into the anaerobic zone are necessary, as this will reduce the availability of the volatile fatty acids (VFAs) that PAOs consume. Furthermore, pretreatment must not remove excessive amounts of VFAs. [8] The 5-Stage system will be able to reach TP levels of 1 mg/L, but chemical addition and a filtration step will still be necessary to achieve the 0.3 mg/L TP requirement. While this configuration requires an extra tank compared to the 4-Stage, it can reduce chemical cost and sludge production.

3.2.4 Decision Matrix

In addition to the common criteria, A&E also considered the amount of chemical addition and the need for post-reactor polishing. Both are important considerations that directly impact plant operations, associated costs, and footprint. Table 3-2 presents the decision matrix for nutrient removal.

Table 3-2: Nutrient Removal Quantitative Matrix

	Footprint	Capital Cost	O&M Cost	Maintenance Demand	Chemical Addition	Post-Reactor Polishing	
Weight	5	2	3	3	3	4	**Final Score**
4-Stage Bardenpho	4	5	4	4	4	3	**78**
4-Stage Bardenpho with MBR	5	2	2	2	4	5	**73**
5-Stage Bardenpho	3	4	4	4	4	4	**75**

A&E proceeded with modeling the 4-Stage and 5-Stage processes on BioWin, analyzed more deeply in Section 4. A low maintenance demand ensures that the WWTP upgrade does not negatively impact the Town, which currently operates a plant with relatively low maintenance. The high upkeep associated with a membrane bioreactor was deemed unnecessary for the new plant.

3.3 Carbon Addition

Two forms of supplemental carbon were considered, methanol (CH_3OH) and Environmental Operating Solutions' (EOSi) manufactured carbon source MicroC™ (glycerol-based, $C_3H_8O_3$). The choice of supplemental carbon depended on site needs such as safety, cost, handleability, and sludge yield. Most methanol is generated as a byproduct of natural gas refining, which contributes heavily to global warming and the depletion of natural resources. The production of methanol has a high carbon footprint; a kilogram of methanol produces 2.20 kg of CO_2. [9] Agriculturally sourced carbon, like MicroC™, has less variation in price but is more expensive than methanol and has limited research available. Furthermore, they have stark differences in carbon to nitrogen ratio—this is important because a greater concentration of carbon (i.e., 5:1 compared to 3:1) produces more sludge, taxing the sludge processing equipment and becoming more expensive to dispose of. [10] Methanol produces less sludge than MicroC™.

In addition to O&M cost, three unique matrix categories were used in analyzing forms of supplemental carbon: sustainability, carbon-to-nitrogen ratio, and specific storage and handling costs. Table 3-3 presents the decision matrix for carbon addition.

Table 3-3: Carbon Addition Quantitative Matrix

	Sustainability Score	O&M Cost	C:N	Storage and Handling	
Weight	2	2	3	5	**Final Score**
Methanol	2	3	4	3	**37**
Micro-C	4	4	3	4	**45**

Due to the ease of storage and handling, lower operation and maintenance costs, and a more sustainable production method, MicroC™ was chosen as the carbon source of the new plant.

3.4 Filtration

To comply with Maryland water reuse guidelines and future NPDES permit limits, filtration is necessary to reduce turbidity and remove phosphorus flocs. Filtration can be done using cloth media or sand. A cloth media filter suitable for the Manchester WWTP is Aqua-Aerobic's AquaMiniDisk®. [11] In addition to phosphorus removal, this filter will also help remove other remaining suspended solids due to the cloth media's very small pore size, plus, the AquaMiniDisk® requires less space than a typical sand filter. The cost of the AquaMiniDisk® is higher due to the specialized components and cloth media; however, it is well-suited for the low flow rates as required by the Manchester WWTP.

Other technologies considered were the gravity sand filter and the continuous sand filter. The traditional gravity filter's size limits applicability on site and was therefore disregarded. The continuous sand filter is smaller in size, and the technology is self-cleaning. However, the sand filter relies on airlift pumps to continuously circulate the sand from the bottom to the top. If the flow is too low, there is not enough hydraulic energy to keep the sand recirculating. Additionally, the sand filter is limited by the porosity of the sand. As a result, very fine particles can still pass through.

In addition to the common performance criteria, the filter's ability to handle varying flows and its removal efficiency were considered. Table 3-4 is the decision matrix used to evaluate both media.

Table 3-4: Filter Quantitative Matrix

	Footprint	Capital Cost	O&M Cost	Maintenance Demand	Varying Flow	Removal Efficiency	
Weight	5	2	3	3	4	5	**Final Score**
Aqua-Aerobic Cloth Media Filter AquaMiniDisk®	4	3	4	4	5	5	**107**
Continuous Sand Filter ASTRASAND®	4	4	5	5	4	4	**101**

The cloth and sand filter both achieve adequate levels of phosphorus in the effluent. A&E selected the cloth filter as it is slightly better at removing very fine particles. The cloth filter's dense pores, compared to the void space in the sand, captures more particles. The gentler hydraulics of the cloth filter are less likely to shear the fragile flocs formed during chemical addition upstream, improving the likelihood that precipitated particles are captured and removed.

3.5 Sludge Digestion

The purpose of this step is to reduce total sludge volume, eliminate odors, and eliminate pathogens. Digestion is achieved with either an aerobic or anaerobic system. A&E focused on aerobic digestion for their design due to the plant's low flow rates, small parcel size, and the ability to repurpose the existing multi-chambered treatment tanks. Aerobic digestion uses aeration to promote the breakdown of organic matter in the sludge through microbial respiration. [6] Factors like sludge percent solids, temperature, solids reduction, oxygen demand, retention time, pH, odor controls, and foam control must be considered when designing aerobic digestion systems.

Conventional aerobic digestion and Autothermal Thermophilic Aerobic Digestion (ATAD) were evaluated by A&E for implementation in the Manchester WWTP. Footprint, capital cost, operation and maintenance cost, maintenance demand, pretreatment requirements, sludge volume reduction, and oxygen demand were used to evaluate both aerobic digestion methods. Table 3-5 is the decision matrix used to evaluate both methods.

Table 3-5: Sludge Digestion Quantitative Matrix

	Footprint	Capital Cost	O&M Cost	Maintenance Demand	Pretreatment	Volume Reduction	Oxygen Demand	
Weight	5	2	3	3	3	5	3	**Final Score**
Conventional Aerobic	2	4	4	4	5	3	4	**84**
ATAD	4	2	2	2	1	4	2	**65**

A&E selected conventional aerobic digestion for use at the Manchester WWTP. While ATAD has higher volume reductions compared to conventional aerobic digestion, the need for foam controls and higher maintenance demands and costs make it less attractive than the conventional method. The proximity of residential buildings would also require additional design considerations for odor control for an ATAD system. Lastly, the existing multi-chambered treatment tanks could be repurposed into a conventional aerobic system and gravity thickener, reducing its capital cost.

3.6 Sludge Dewatering

Dewatering is used to further reduce the quantity of sludge that must be disposed of. It is a physical process that separates the solids and liquid sludge portions to produce a high solids content cake. [6] Chemical dosing is often used to increase liquid removal. Sludge type, disposal method for the dewatered sludge, and availability of space are important to consider when selecting a dewatering method.

A&E evaluated three dewatering technologies: volute dewatering presses, centrifuges, and belt filter presses. The following parameters were used to evaluate the three technologies: footprint, capital cost, operation and maintenance cost, pre-thickening requirement, solids recovery, volume reduction, and maintenance demand. Table 3-6 is the decision matrix used to evaluate all three methods.

Table 3-6: Sludge Dewatering Quantitative Matrix

	Footprint	Capital Cost	O&M Cost	Maintenance Demand	Solids Recovery	Volume Reduction	Pre-Thickening Requirement	
Weight	3	2	3	3	5	5	5	**Final Score**
Volute Press	5	5	4	5	4	3	5	**117**
Centrifuge	1	1	1	2	5	5	1	**70**
Belt Filter Press	3	3	2	1	5	5	1	**82**

A&E implemented the volute press in the design for the Manchester WWTP. Unlike the centrifuge and belt filter press, the volute press thickens sludge internally and does not need a pre-thickening step. While the centrifuge and belt filter press have greater solids recovery and volume reduction, the volute press achieves adequate performance in these categories. Given Manchester WWTP's small footprint and modest daily flow, the volute press's compact size and low maintenance demand made it the most practical dewatering choice.

3.7 Disinfection Strategies

Disinfection is necessary to kill any remaining bacteria or viruses before the treated water is discharged into Georges Run or used for spray irrigation. The WWTP currently uses a combination of a chlorine disinfection tank for spray irrigation and UV radiation for water discharging to George's Run. Residual disinfection helps maintain a level of disinfectant throughout the system and protects against re-contamination, which is necessary for Class III reuse spray irrigation. However, the release of free chlorine into surface waters is prohibited. Environmental risk is a vital characteristic to consider with disinfection, especially because of the effluent outfall into Georges Run and the use of the treated effluent for irrigation. [12] A&E decided to evaluate chlorine gas, sodium hypochlorite, and UV radiation for disinfection strategies. Additional matrix categories considered when picking disinfection strategies included residual disinfection capabilities and general safety and health. The quantitative matrix below compares the different options in Table 3-7.

Table 3-7: Disinfection Quantitative Matrix

	Footprint	Capital Cost	O&M Cost	Maintenance Demand	Residual Disinfection	Safety and Health	
Weight	4	2	3	3	2	5	**Final Score**
Chlorine Gas	5	5	2	2	5	2	**62**
Sodium Hypochlorite	5	5	3	2	4	3	**68**
UV Radiation	4	5	4	5	1	5	**80**

When assessing the matrix, A&E decided that two methods of disinfection, sodium hypochlorite and UV radiation, should be considered for the Manchester WWTP due to the two effluent locations. Additionally, the WWTP currently has systems already built for two methods of disinfection. Residual disinfection is vital to maintaining Class III water reuse standards, and sodium hypochlorite is best suited to disinfect effluent for spray irrigation. For outfall into George's Run, UV radiation would be used due to the environmental benefits compared to chlorine. UV radiation avoids the need for de-chlorination. Chlorine is not allowed to be released into surface waters as it is toxic to aquatic wildlife and forms toxic DBPs.

3.8 Water Reuse

An alternatives analysis was conducted on each class of water reuse available to the Town. Four unique matrix categories were used in analyzing water reuse: benefit to Town, additional technology requirement, additional monitoring requirement, and permit upgrade. Benefit to Town was considered due to the Town's comprehensive plan prioritizing sustainability and water resource conservation. [3] Additional technology and monitoring requirements reflect the capital costs and effort required to implement upgrades to existing water reuse. The steps required for a permit upgrade under Maryland DEP rules do not provide a significant challenge to the town but do affect the ease and quickness of implementing a reuse scheme. Table 3-8 is the decision matrix used to evaluate the three available reuse classes.

Table 3-8: Water Reuse Quantitative Matrix

	Benefit to Town	Additional Technology Requirement	Additional Monitoring Required	Permit Upgrade	
Weight	5	3	2	2	**Final Score**
Class I	1	5	5	5	**40**
Class II	1	4	4	2	**29**
Class III	5	3	2	2	**42**

A&E moved forward with implementing Class III reuse for the Town. Additional technology requirements are partly offset due to the already existing need to meet stricter NPDES permit requirements. Permitting and monitoring requirements are also offset from the overall benefit that irrigating athletic fields and parks will bring to the Town.

The Maryland Department of the Environment (MDE) has strict categories, uses, and regulations for reclaimed water from treated municipal sources. An application for a Maryland State Groundwater Discharge Permit is necessary for Class III reuse. The requirements for application are outlined in the *Class I-III Water Reuse Guidelines MD,* in Appendix C. This permit must include the water demand data for any vegetation planned to be

irrigated. Soil information must be collected prior to the application to understand the landscape being irrigated. A letter to the MDP will be sent requesting a site evaluation, including maps, project flows, acreage, and proposed application rates. In turn, a preliminary site visit with the Project Manager will take place, prompting the completion of a hydrogeologic study. Once the study is complete, it will be sent back to the MDP for review, possibly requiring a public hearing with the town. Finally, once the permit is approved, a State Construction Permit must be applied for to begin construction of the proposed irrigation system. Signs with "Reclaimed Water, Do Not Drink" written must be posted in and around the planned irrigation area on site. Senninger® F-luent Master sprinklers, designed specifically for wastewater effluent discharge, will be used in spray irrigation throughout Manchester.

3.9 Summary of Recommendations

A&E's extensive alternative analysis resulted in the selection of the following technologies, outlined in Table 3-9 for further consideration.

A&E's recommended alternatives for the Manchester WWTP balance regulatory compliance, operational simplicity, and community needs. The technologies reflect the need for low maintenance demand, minimal footprint and long-term sustainability. The two disinfection approaches adhere to reuse and discharge requirements. Sludge handling incorporates infrastructure reuse which can reduce capital cost. Class III water reuse supplements the stringent NPDES permit requirements, and the Town can benefit from field irrigation.

The processes outlined above were sized in the following chapter using hand calculations. Biological nutrient removal was further modeled using BioWin software to ensure effluent met desired limits.

Table 3-9: Alternatives Analysis Selection Summary

Unit Process	Technology Selected
Preliminary Treatment	Vortex Design: Smith and Loveless' packaged headworks system, PISTA®Works™ Screening and Grit Removal Headworks Package
Nutrient Removal	4-Stage and 5-Stage Bardenpho
Carbon Addition	MicroC™
Filtration	AquaMiniDisk® Cloth Media Filter
Sludge Digestion	Aerobic Digestion
Sludge Dewatering	PW Tech Volute Press
Disinfection	Georges Run: UV Radiation Spray Irrigation: Sodium Hypochlorite
Water Reuse	Class III Reuse

4.0 Unit Process Modeling and Sizing

This chapter details the modeling and hand calculations used to size every unit process in the new Manchester WWTP. Using BioWin (an EnviroSim product), A&E modeled the 4-Stage and 5-Stage Bardenpho processes to determine the nutrient removal capabilities of each and receive more detailed sludge information. A&E provided a final recommendation on the biological treatment process to be used in the new plant, considering BioWin modeling and design considerations outlined in Chapter 3.

4.1 Biological Modeling

4.1.1 Model Layout and Inputs

BioWin was used to model biological processes occurring in the new plant. The anoxic tanks were modeled by a bioreactor with zero airflow. Chemical addition was modeled as methanol additions (with the chemical formula changed to match MicroC™) and ferric chloride additions. The 4-Stage Bardenpho included an anoxic tank, a primary aeration tank, a post-anoxic tank, and a secondary anoxic tank (Figure 4-1). The 5-Stage Bardenpho added a primary anaerobic tank at the beginning of the train (Figure 4-2).

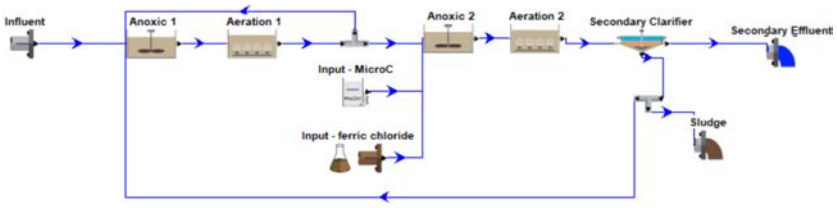


Figure 4-1: 4-Stage Bardenpho BioWin Model

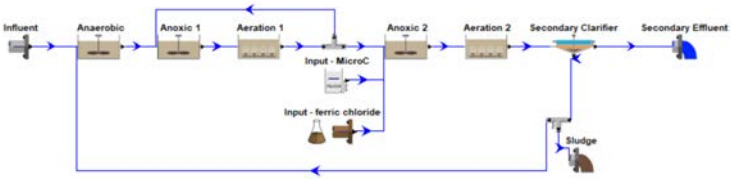


Figure 4-2: 5-Stage Bardenpho BioWin Model

The wastewater fractions, stoichiometric values, and BOD model parameters were determined using the BioWin Influent Characterizer. Due to the lack of complete historical influent information, the VSS and TSS values were slightly out of range and calculated to be lower than the acceptable average values. Nonetheless, these values were used in the BioWin simulations to stay true to the historical data. Simulations were run for conditions at which the plant performs the least efficiently — maximum monthly loads of TSS, BOD, TP, and TN at the lowest temperature, 12°C.

4.1.2 Results

After several iterations of changes to chemical loads, recycle percentages, and setting a control SRT of 14.7 days, the effluent characteristics of the two systems could be compared at 20°C (Table 4-1). The calculation of a control SRT is described in Section 4.2.2.

Table 4-1: Effluent Characteristics Comparison

Effluent Quality	4-Stage	5-Stage	Unit	Effluent Quality	4-Stage	5-Stage	Unit
Flow	1813	1813	m3/d	P - Soluble Phosphate	0.75	0.13	mgP/L
N- Ammonia	0.01	0.01	mgN/L	P - Total P	0.97	0.59	mgP/L
N - Nitrate	1.02	0.54	mgN/L	TSS	6.59	12.4	mg/L
N - Nitrite	1.91	2.40	mgN/L	COD - Total	73.7	85.6	mg/L
N - Filtered TKN	1.56	1.68	mgN/L	cBOD - Total	7.35	11.3	mg/L
N - Total N	2.92	2.94	mgN/L	Sludge Production	79.4	79.7	m3/d

The BioWin model does not factor in the filtration step, which would remove approximately 10 mg/L TSS and approximately 0.5 mgP/L. Thus, both systems reach similar levels of nutrient reduction (meeting the NPDES and Class III water reuse limits of 5 mg/L TSS, 10 mg/L of total BOD, 3 mg/L of total N, and 0.30 mg/L of total P), achieving the main goal of the upgrades. However, due to the size constraints on-site, the inability of the 5-Stage Bardenpho to meet Class III requirements at low temperatures, the 4-Stage Bardenpho is a more effective option for the Manchester site. The rest of the chapter uses calculations based on the 4-Stage Bardenpho process unless otherwise noted.

4.2 Unit Process Design

Calculations were performed to determine unit process sizing, chemical dosages, and sludge production and handling, with all equations referenced in Appendix G.

4.2.1 Equalization Basin

The equalization basins were designed based on the maximum average daily flow, as defined by the Maryland Department of the Environment, Engineering and Capital Project Program Design Guidelines for Wastewater Facilities. [13] The design flow, therefore, is 0.66 MGD, and the hydraulic residence time chosen is 4 hours. To meet the requirements, the equalization basin in the new Manchester WWTP will be two rectangular chambers with a total volume of 150,000 ft^3. Each tank will have a height of 20 ft, and side lengths of 15 ft by 28 ft. Aeration in this tank is required at a rate of 0.015 m^3 air/m^3-min for maintaining aerobic conditions. [6] 220 ft^3 of air per minute is required for the two equalization basins.

4.2.2 Biological Treatment

Mixing Tank

Immediately prior to biological treatment, influent is mixed with Return Activated Sludge (RAS) inside a mixing tank. This was sized using Equation 1 to hold the combined influent and RAS flows for 5 minutes. The mixing tank will have a height of 10 ft, and side lengths of 10 ft by 5ft.

Bardenpho Process

To size Bardenpho processes, the volume of the aeration tank had to be determined first. Utilizing a biokinetic process, the solids retention time (SRT) was determined to be around 14.7 days (Equations 3 through 7). The production rate of biomass produced by the aeration tank was determined to be 470 kg/VSS/d (Equation 8). Assuming a volatile suspended solids (VSS) mass of 0.025 lbs/gal, the volume of the aeration tank was

determined to be about 606,000 gallons (Equation 11) with a width of 25 ft, total length of 183 ft (91 ft per train), and a depth of 18 ft with 2 ft of freeboard. These dimensions remain the same for both the 4-Stage and 5-Stage Bardenpho processes.

While the aeration tank was determined using a biokinetics method, the other tanks in the Bardenpho process were determined using a hydraulic retention time (HRT) method, which involved multiplying the flow by the HRT. Using the suggested retention times for each step as found in the Maryland BNR Guide, the volumes of the 4-Stage and 5-Stage Bardenpho tanks were determined for both the total system and the individual trains. [13] Presented are the approximate volumes—the exact, unrounded values are found in Appendix H.

While the Maryland BNR requirements recommend a 1:5 width-to-length ratio, due to the small size of the Manchester site, practicality and footprint were favored rather than these suggested ratios, and the tanks were sized to fit within the site. Each tank was designed to be 18 feet deep with an added 2 feet of freeboard, as per the design criteria. For the 4-Stage Bardenpho, the first anoxic tank was designed to be 27 ft total (13 ft per train), the second anoxic tank was 14 ft total (7 ft per train), and the second aeration tank was 7 ft total (3.5 ft per train).

Oxygen Demand

The average and minimum mass of oxygen that must be provided to the aeration tank were determined to be 493 kg per day and 329 kg per day, respectively (Equations 12 and 13). These values serve as the Actual Oxygen Transfer Rate (AOTR) and were used in Equations 15 and 16 to determine the Standard Cubic Feet per Minute (SCFM) of oxygen that must be supplied by blowers. For the aeration tanks, blowers must be able to provide a combined average of 3324 CFM.

Chemical Addition

Using historical information, the MicroC™ dosage was determined (Equations 17 through 19). This value was determined by solving for a methanol dose and determining the carbon load of MicroC™ as compared to methanol. This value was a baseline to input into the BioWin simulation, and to achieve the desired results, a MicroC™ dose of 48 lbs/day was needed.

Assuming the ferric chloride used was 92% pure, to achieve the final results, a value of about 21 lbs/day was needed (Equations 20 through 22).

Soda ash was added to maintain alkalinity when other chemicals, like ferric chloride, were added. Assuming the soda ash was 95% pure, the soda ash dosage was determined to be about 189 lbs/day to keep the wastewater around a pH of 7.2 (Equation 23). This value may be subject to change depending on weather and other onsite conditions.

Mechanical Mixing

The power input requirement for mixers in the pre-anoxic and post-anoxic tanks was determined using the tank volumes and a chosen design velocity gradient of 60 s^{-1} (Equation 24). The mechanical mixers must have a power input of 900 W in the pre-anoxic tank and 350 W in the post-anoxic tank.

Internal Recycle and Sludge Pumping

Pumps were designed for internal recycling within the 4-Stage Bardenpho system, return activated sludge pumping, and waste activated sludge pumping. Equations 25 through 27 were used to determine the total dynamic head that pumps must overcome.

4.2.3 Secondary Clarifier

The new WWTP will have two 40 ft diameter circular tanks, with a height of 14 ft. 12 ft will be for water depth, with an additional 2 ft will be for freeboard. Sizing for the secondary clarifier was determined based on the hydraulic loading, as it was the limiting term compared to the solids loading rate (Equation 28). Using the average

design flow of 0.5MGD, the surface area was calculated to be 1250 ft^2. Based on the Maryland design guidelines, an average overflow rate of 400 gal/day/ft^2 was used. [13] The volume of each tank will be 112,000 gallons.

4.2.4 Disinfection

During the 9 months of spray irrigation, the water will be treated with chlorine. A total of two chlorination contact chambers will disinfect the water, where one chamber is for redundancy. They will each have 3 baffles, and the entire structure will have a 12 ft depth, 12 ft width, and 28 ft length. Each baffle will be 4 ft wide with 4 ft openings (Equations 31-33)

The chlorine load was determined to be about 27 lbs/day (Equation 30). This concentration was determined by calculating the dosage of chlorine based on residual NH3-N entering the chlorine contact basin and the molecular ratio N:NH_4. It was then converted to a load.

4.2.5 Sludge Handling

Gravity Thickener

The clarifiers in the two existing multi-chambered treatment tanks will be repurposed for use as gravity thickeners. The repurposed clarifiers will have a volume of 46,930 gallons, a depth of 15 ft, and a surface area of 420 ft^2. Gravity thickener design is based on the peak solids loading and hydraulic overflow rates [6]. Equation 44 calculated the solids load rate for each thickener to be 3.5 lb./ft^2d under peak conditions. This value is acceptable as it is below the recommended range of 4 to 8 lb./ft^2d. The hydraulic loading rate for each tank was found to be 38 gal./ft^2d using equation 45. This is acceptable and is below the range of maximum hydraulic overflow rates for waste activated sludge of 100 to 200 gal./ft^2d.

Conventional Aerobic Digester

The aeration and digestion chambers from the existing multi-chambered treatment tanks will be repurposed into conventional aerobic digesters. Each repurposed tank has a volume of 146,700 gallons and a depth of 15 feet. Peak monthly loading conditions were used to ensure the tanks would be adequate. The minimum and maximum temperatures were found to be 12 and 30°C, respectively. The SRT for each tank was found to be roughly 39 days. Volatile solids reduction during the winter and summer was 38 percent and 48 percent, respectively. A conservative assumption of 2 % was used for the percent solids in the sludge leaving the thickeners. An air supply of 30 ft^3/min*1,000ft^3 or 590 ft^3/min per tank was selected as it would meet both the oxygen requirements and provide sufficient mixing to the tanks. [14] The discharge pressure was calculated with Equation 46.

4.2.6 Effluent Storage

Effluent storage for spray irrigation will be necessary for the 9 months that spray irrigation is permitted. This tank will be circular and hold the average daily flow of 0.5 MGD for 24 hours. A 60-ft diameter tank that is 25 ft deep will hold effluent in the plant.

4.3 Summary

Due to the small size of the Manchester WWTP site and the primary consulting firm's requirements, the 4-Stage Bardenpho was the best option for biological nutrient removal. BioWin simulations proved that the combination of the cloth media filter with the 4-Stage Bardenpho meets the nutrient removal limits set by the new NPDES permit and Class III water reuse requirements. Remaining unit processes were sized to provide accurate estimates for product specifications and to determine the site layout.

5.0 Manufacturer Components

Table 5-1 lists the technologies chosen and sized by selected manufacturers. Appendix I provides full manufacturer reports for each technology.

Table 5-1: Summary of technologies sized by manufacturers

Technology	Product	Manufacturer	Technology	Product	Manufacturer
Influent Pumps	S-Series 62 Frame S1.40.A50.700.4	Smith and Loveless INC.	**Cloth Filter**	Aqua MiniDisk®	Aqua-Aerobic Systems, INC
Packaged Headworks	PISTA®Works Complete Screening and Grit Removal	Grundfos	**Ultraviolet Disinfection**	AquaRay® S 4Mx4L	Veolia
Blowers	GM90S blower package	Aerzen	**Sludge Handling**	Volute Dewatering Press	PWTech
Mixers	Submersible Mixer Type ABS RW 300	Sulzer	**Sprinkler System**	Medium flow pressure regulator PMR50MF4F4FV	Hunter® Irrigation

6.0 Layout Design

This section outlines the considerations behind the layout design of the new plant. The existing raw water influent location and existing outfall locations remain where they were due to the connected off-parcel locations. The multipurpose contact stabilization tanks were kept and converted for sludge digestion. A&E decided to demolish all other existing structures based on building quality. The scope of the project did not include a hydrologic profile; however, A&E used general knowledge of the site topography to maximize gravity flow and minimize regrading. More investigation into the site layout and facility optimization is required prior to construction efforts.

6.1 Process Flow

The proposed Manchester WWTP design is outlined in the process flow diagram in Appendix A.

Raw water enters the parcel from the west road entrance via the pump station and is sent to Building A, which houses the combined headworks, equalization tanks, and volute screw press. Pumps are used to move the wastewater through the combined headworks, removing large pieces of grit and solids, and into equalization tanks for flow control.

The wastewater will move from the combined headworks building (Building A) to a mixing box for alkalinity adjustment, before entering the 4-Stage Bardenpho for biological treatment. The Bardenpho structure was placed on the north edge of the parcel due to the natural eastward slope, which allows for gravity driven flow. The two secondary clarifiers sit at the top northeast section of the parcel.

The water then moves from the clarifiers down to the bottom section of the parcel and into Building B, which houses the cloth filters, chemical storage, blowers, ultraviolet disinfection, and chlorine contact chambers. Sludge from the secondary clarifiers will go directly to the digestion tanks (the repurposed contact stabilization tanks). From the digester, the sludge will be pumped back to the combined headworks building, where the volute press will remove any additional water. The water from the volute press will be recycled back to the headworks, and the solids will be removed off-site. A concrete loading pad will be located nearby to allow trucks to back up and load the solids.

Chemical buildings will be needed to store the different chemicals used throughout the treatment process. There will be a storage room adjacent to the headworks building to hold the polymers required by the volute press. Chemical storage will also be in two additional areas. Soda ash, methanol, and ferric chloride will be stored next to the Bardenpho. Soda ash and ferric chloride will be stored in Building B.

For three months of the year, the treated wastewater will undergo UV disinfection and then be discharged to George's Run. For the other nine months, the treated water will be disinfected through the serpentine chlorine contact chambers. The effluent will then be sent to the effluent storage tank before being used as spray irrigation.

The main office building and maintainable area will be in the center of the parcel, allowing the operators quick access to each of the structures and surrounding buildings. There will also be an office administration building with a laboratory area attached. The control room will be adjacent to the office administration building with generators and a fuel tank. Additionally, a maintenance building will be available to store supplies and tools. There will be access on the south side of the building for truck loading and unloading. Each of these building sizes were determined from the existing building's footprint multiplied by a factor of 1.5 to account for the increase in technologies and maintenance, as well as the new SCADA system. This resulted in the office building being 1,500 ft^2, the control room being 1,000 ft^2, and the maintenance building being 2,400 ft^2. Building A is 45 ft by 75 ft, and Building B is 50 ft by 65 ft.

Spaces surrounding the office buildings and technology buildings were left empty for car access. Small pump stations will be needed throughout to move the water and are denoted in the layout plan. See Appendix H for full layout design and process flow diagram.

6.2 Water Reuse

Effluent will be divided between sprinklers that discharge a maximum of 20 gallons per minute (gpm). Sprinklers will be located throughout Christmas Tree Park and the MVHS athletic fields. A minimum of two sprinklers will be located at each athletic field, baseball diamond, and remaining open space.

Per Maryland Class I-III water reuse guidelines, at least two monitoring wells must be installed to detect groundwater contamination. At least one monitoring well must be in an area upgradient to the disposal site so that it will not be affected by potential contaminants. Both discharge sites will receive two upstream monitoring wells. Downstream monitoring wells will be installed throughout fields where sprinklers are used to discharge effluent. Appendix J contains a detailed water reuse plan.

7.0 Cost Estimate

The costs associated with each process within the Manchester WWTP have been broken down in Appendix K. The team's cost estimation was divided by individual components within the plant, including preliminary treatment, nutrient removal, filtration, disinfection, sludge, and construction. Each of these individual cost estimates is composed of multiple variables such as capital cost, building excavation and construction, chemical doses, piping, and pumps. The estimates don't include mobilization and demobilization values, the average cost of personnel, and the cost of transportation of personnel/materials in Maryland. The total capital investment for the entirety of the WWTP upgrades is roughly $5.3 million.

8.0 Final Recommendations

A&E was tasked with designing a new plant that could achieve enhanced removal of nitrogen and phosphorus and increased treatment demand in line with the growth of the town.

A&E suggests the PISTA®Works™ Screening and Grit Removal Headworks Package be used for preliminary treatment. A 4-Stage Bardenpho process using MicroC™ as a carbon source is recommended for nutrient removal. For chemical phosphorus removal, Aqua-Aerobic's Cloth Media Filter AquaMiniDisk® was selected. A conventional aerobic digestion system was selected for handling sludge digestion. PWTech's Volute dewatering press was selected to dewater the digested sludge. A&E suggested both UV radiation and chlorination with sodium hypochlorite be used for disinfection to allow for both spray discharge and release to Georges Run.

References

[1] "Census Bureau Profiles Results." Accessed: Mar. 12, 2026. [Online]. Available: https://data.census.gov/profile?g=160XX00US2449950

[2] "Parks & Rec," Manchester, Maryland. Accessed: Mar. 12, 2026. [Online]. Available: https://manchestermd.gov/parks-rec/

[3] Town of Manchester, "2018 Manchester Comprehensive Plan," 2018.

[4] U. C. Bureau, "City and Town Population Totals: 2020-2024," Census.gov. Accessed: Mar. 12, 2026. [Online]. Available: https://www.census.gov/data/datasets/time-series/demo/popest/2020s-total-cities-and-towns.html

[5] Camp, Dresser, & McKee and US EPA, *Process Design Manual: Wastewater Treatment Facilities for Small Sewered Communitites*. 1977.

[6] Metcalf & Eddy Inc., *Wastewater Engineering: Treatment and Resource Recovery*, Fifth. McGraw-Hill Education, 2014.

[7] "Nutrient Control Design Manual August 2010." Accessed: Mar. 12, 2026. [Online]. Available: https://www.epa.gov/sites/default/files/2019-08/documents/nutrient_control_design_manual.pdf

[8] M. Ross, "What every operator should know about biological phosphorus removal".

[9] "CARBON-FOOTPRINT-OF-METHANOL-PAPER_1-31-22.pdf." Accessed: Mar. 13, 2026. [Online]. Available: https://methanol.org/wp-content/uploads/2022/01/CARBON-FOOTPRINT-OF-METHANOL-PAPER_1-31-22.pdf

[10] "Wastewater Treatment Fact Sheet: External Carbon Sources for Nitrogen Removal".

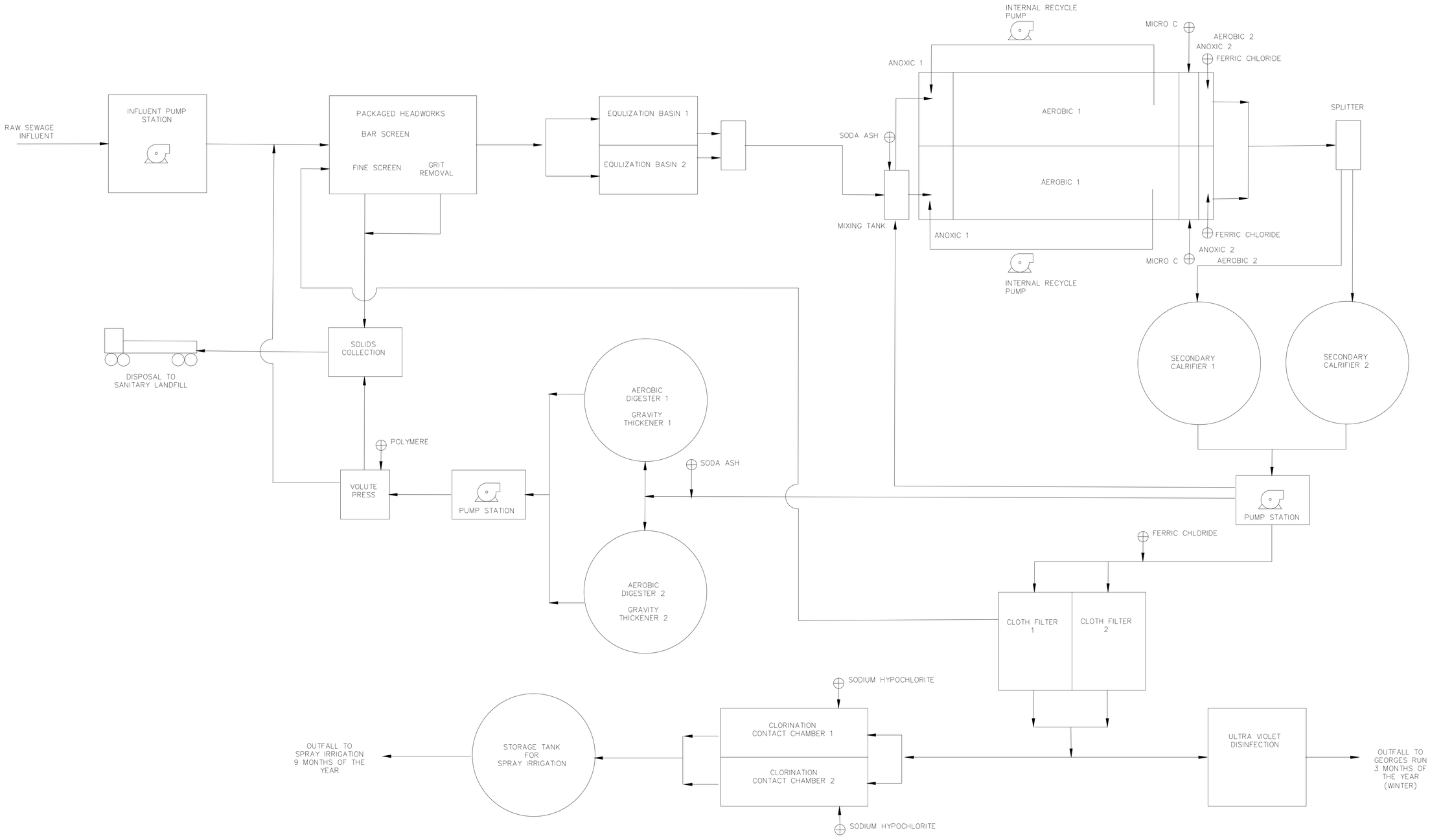
[11] "Aqua MiniDisk® - Aqua-Aerobic Systems | Cloth Media Filtration," Aqua-Aerobic Systems. Accessed: Mar. 12, 2026. [Online]. Available: https://aqua-aerobic.com/filtration/cloth-media/aqua-minidisk/

[12] "Wastewater Technology Fact Sheet - Disinfection for Small Systems EPA 832-F-03-024." Accessed: Mar. 12, 2026. [Online]. Available: https://www.epa.gov/sites/default/files/2015-06/documents/disinfection_small.pdf

[13] Maryland Department of the Environment, *Design Guidelines for Wastewater Facilities*, 2016.

[14] *10 States Standards - Recommended Standards for Wastewater Facilities*, Albany, NY., 2014.

Appendix A – Project Drawings



NO.	DESCRIPTION	DATE	BY
0	ISSUED FOR REVIEW	04/17/2026	S. SCOTT

PROJECT ENGINEER: S. SCOTT
DESIGNED BY: S. BURNS
DRAWN BY: S. BURNS
CHECKED BY: A. ONNIS HAYDEN
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO FULL SCALE 0 1/2" 1"

PRELIMINARY DRAWING
DO NOT USE FOR CONSTRUCTION

A&E Consulting
A&E CONSULTING
360 HUNTINGTON AVE
BOSTON, MA, 02115

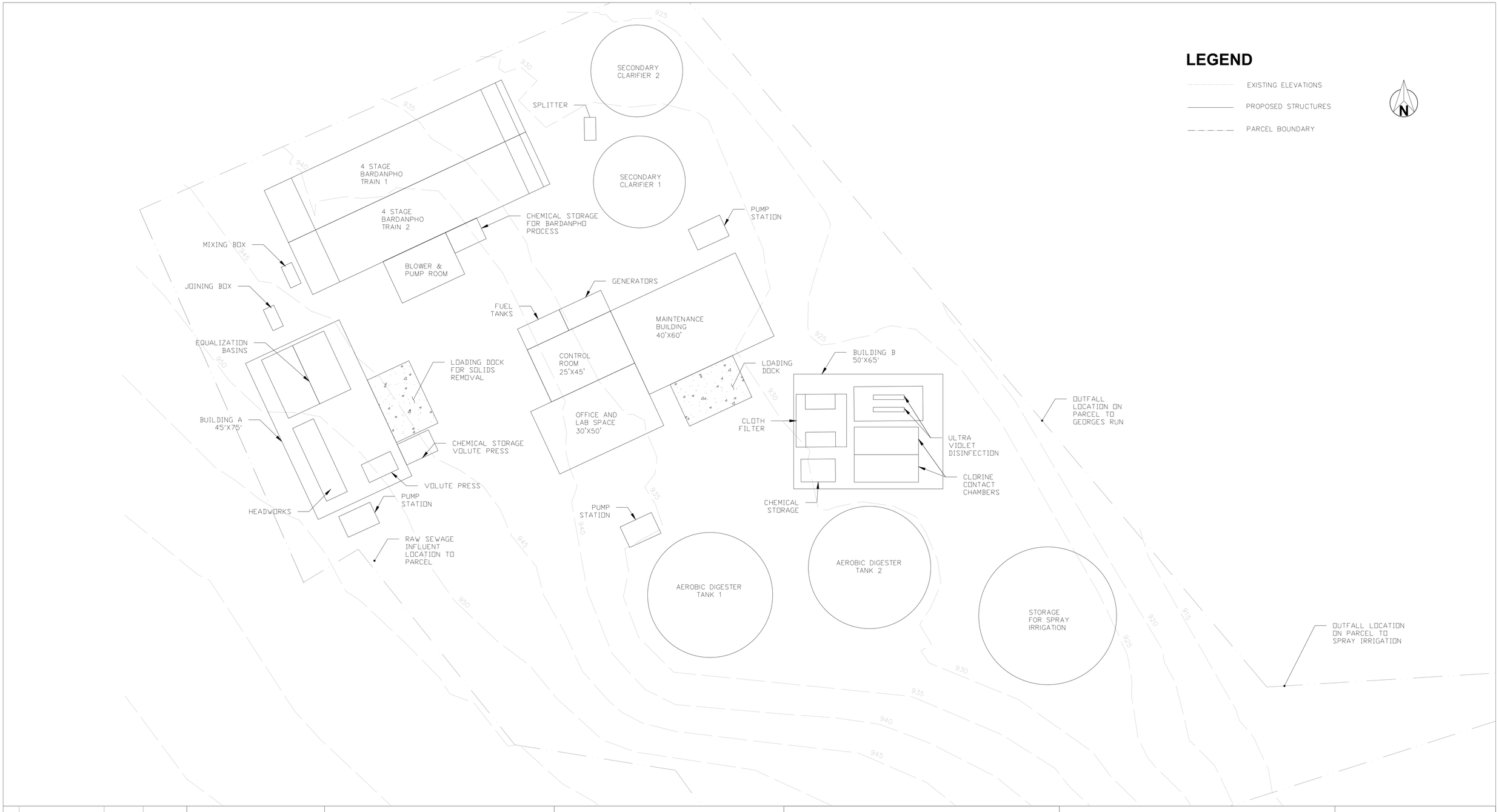
TOWN OF MANCHESTER
CARROLL COUNTY, MARYLAND

MANCHESTER WWTP ENHANCED NUTRIENT REMOVAL

PROCESS FLOW

NTS

DATE: APRIL 2026
A&E CONSULTING NO.: 20260101
CONTRACT NO.: 1
DRAWING NUMBER: GN-2



NO.	DESCRIPTION	DATE	BY
0	ISSUED FOR REVIEW	04/17/2026	S. SCOTT

IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO FULL SCALE — 0 1/2" 1"

PROJECT ENGINEER:	S. SCOTT
DESIGNED BY:	S. BURNS
DRAWN BY:	S. BURNS
CHECKED BY:	A. ONNIS HAYDEN

PRELIMINARY DRAWING
DO NOT USE FOR CONSTRUCTION

A&E CONSULTING
360 HUNTINGTON AVE
BOSTON, MA, 02115

TOWN OF MANCHESTER
CARROLL COUNTY, MARYLAND

MANCHESTER WWTP ENHANCED NUTRIENT REMOVAL

PROPOSED LAYOUT

NTS

DATE:	APRIL 2026
A&E CONSULTING NO.:	20260101
CONTRACT NO.:	1
DRAWING NUMBER:	GN-1



A&E Consulting

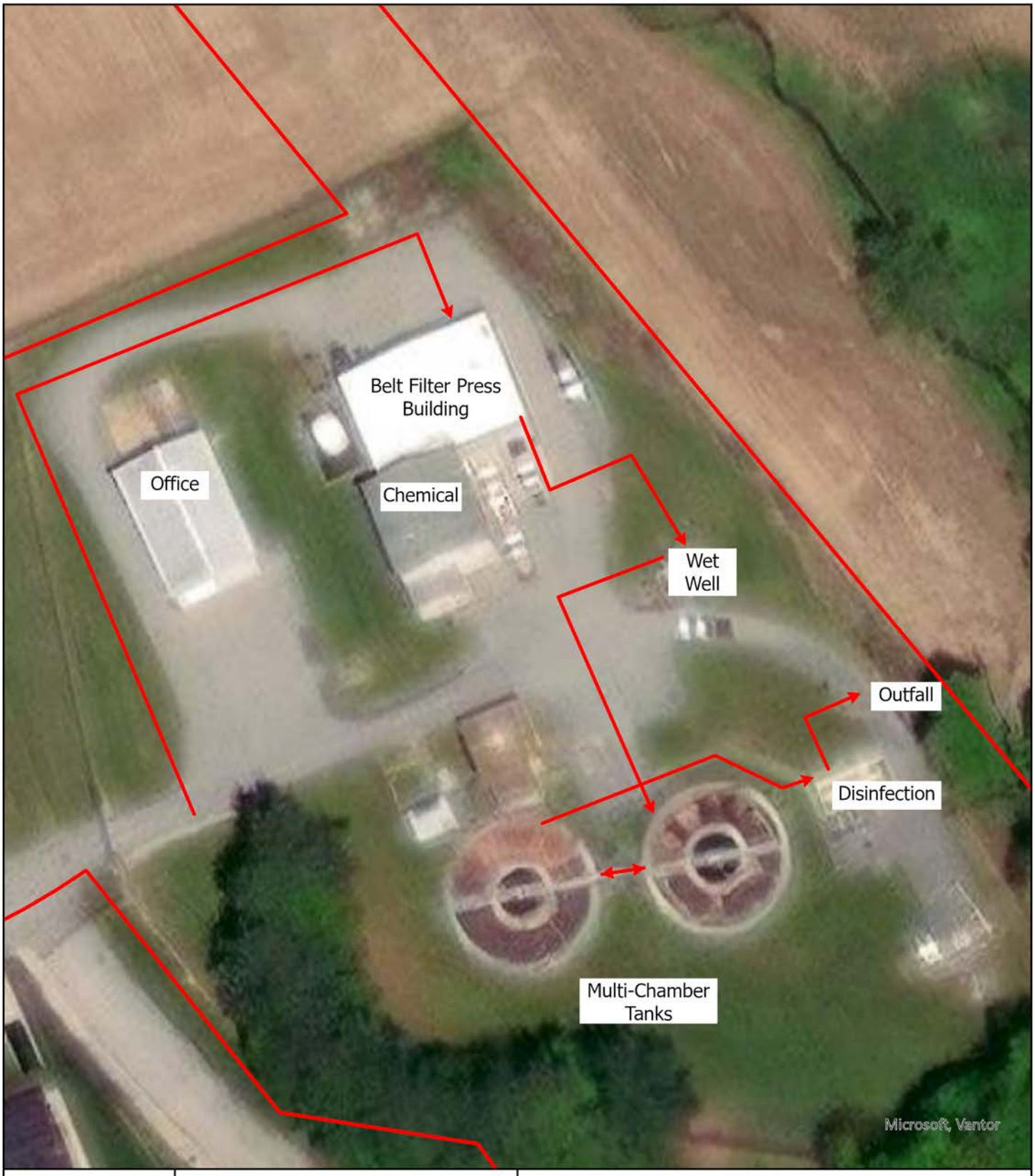
End Use Water Locations
Manchester WWTP ENR
Manchester, MD

N

0 0.1 0.2 Miles

Legend

- Manchester WWTP Parcel Boundary
- Irrigated Fields
- Approximate Area of Spray Irrigation



A&E Consulting

N

0 35 70 Feet

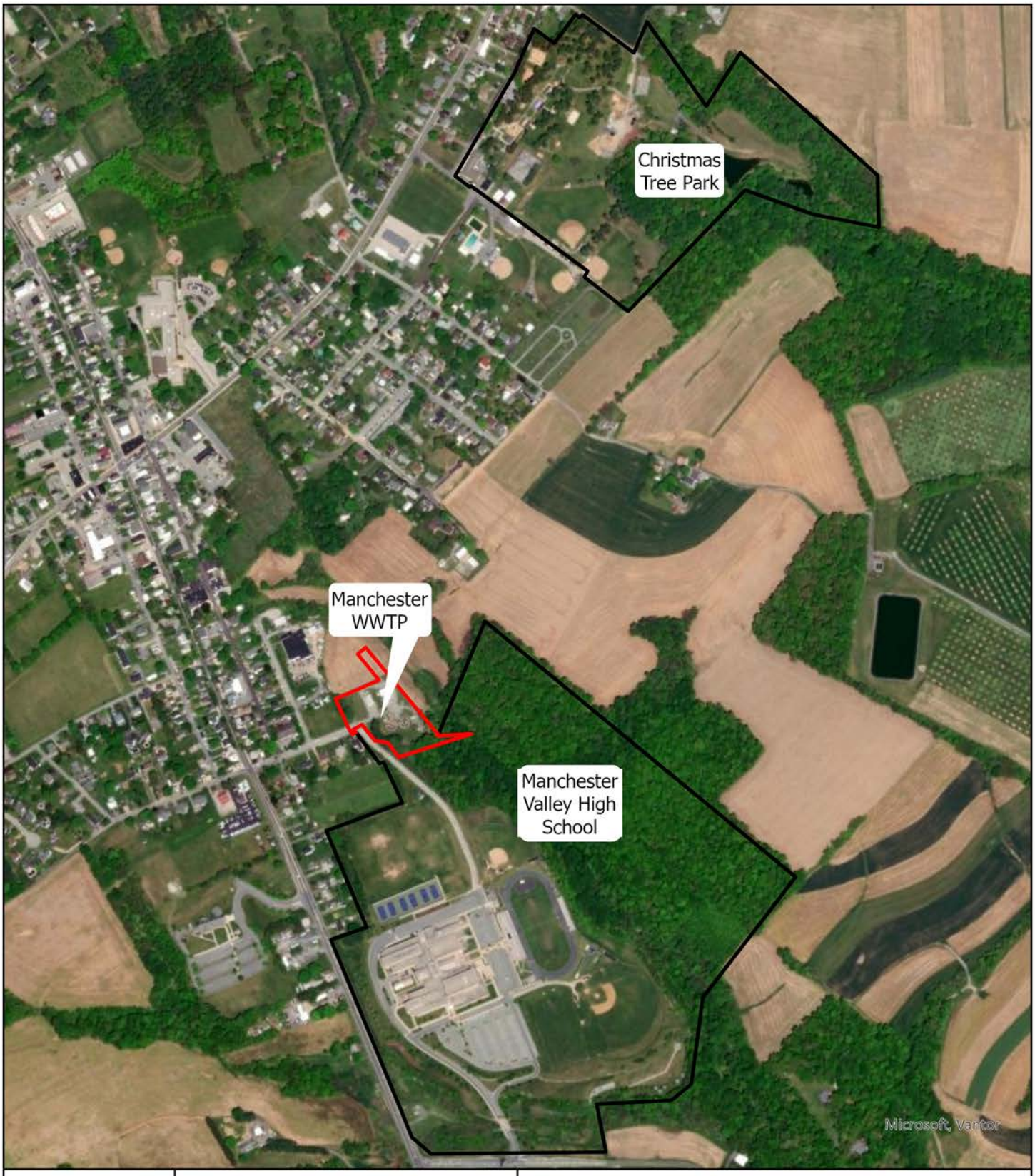
Legend

Manchester WWTP Parcel Boundary

Existing Flow

Manchester WWTP
Enhanced Nutrient Removal
Manchester, MD

Existing Conditions



A&E Consulting

N

0 500 1,000 Feet

Legend

- Manchester WWTP Parcel Boundary
- Christmas Tree Park Parcel Boundary
- MVHS Parcel Boundary

Locus Map

Manchester WWTP
Enhanced Nutrient Removal
Manchester, MD

3D Rendering of Proposed Manchester Wastewater Treatment Plant



Appendix B - NPDES Permit

NPDES Permit Summary Tables

Table B-1: Current and expected NPDES permit limits on Outfall 001A – Georges Run

Water Quality Parameter	Monthly Average Loading Rate (lbs/day)	Monthly Average Concentration (mg/L)	Weekly Average Loading Rate (lbs/day)	Weekly Average Concentration (mg/L)	Expected Future Limits (mg/L)
BOD_5	125	30	188	45	-
TSS	125	30	188	45	-
TN	19	4.6	-	-	3
TP	4.2	1.0	6.3	1.5	0.3

Table B-2: Current NPDES permit limits on Outfall 002 – Spray Irrigation

Water Quality Parameter	Monthly Average Concentration
BOD_5	70 mg/L
TSS	90 mg/L
pH	6.5
Fecal coliform	200 MPN/100 mL

Dec 16, 2021

VIA ELECTRONIC MAIL

Steven L. Miller
Town Administrator
Mayor and Council of Manchester
P.O. Box 830 3337 Victory Street
Manchester, Carroll County, Maryland 21102

Re: Manchester Wastewater Treatment Plant (WWTP)
State Discharge Permit 18-DP-0642; NPDES Permit MD0022578

Dear Mr. Miller:

Enclosed is the above discharge permit with the effective date indicated on the cover page. The permittee is responsible for complying with all permit conditions. You are therefore advised to read the permit carefully and become thoroughly familiar with the requirements in order to maintain compliance with the permit.

Your facility has been approved by MDE to electronically submit Discharge Monitoring Report (DMR) through NetDMR. Therefore you are required to submit monthly DMRs by the 28th of the following month and all other documents as listed in the discharge permit electronically through NetDMR. Should you encounter problems in electronic submission for any month, please consult the MDE's Compliance Program by calling at (410) 537-3510 to avoid missing the deadline for submission of the above stated documents.

You will also find enclosed a copy of the Federal Register published on May 19, 2021 with final rule to update the Code of Federal Regulations (CFR), Title 40, Part 136 - "Guidelines Establishing Test Procedures for the Analysis of Pollutants" which is in effect from July 19, 2021. For future reference, please be advised to visit the U.S Government Publishing Office (USGPO) website **https://mdewwp.page.link/40CFR136** (this link is case-sensitive) regularly to obtain updated guidelines. Unless otherwise specified, the most updated guidelines in 40 CFR Part 136 are required to be used for the analyses of pollutants specified in this permit.

In addition, we have enclosed a copy of the table of the Minimum Monitoring Requirements. Also, enclosed is a copy of transmittal cover sheet for the WWTP Effluent Toxic Chemical Monitoring Data, copy of the most updated Department's "Toxic Pollutant Monitoring Protocol

and Reporting Requirements for Toxic Chemical Testing Analytical Data (amended on 12/02/2019)", and a copy of the most updated Department's "Effluent Biotoxicity Testing Protocol for Industrial and Municipal Effluents (amended on 1/23/2019). Please visit Maryland Department of the Environment (MDE) website link below for future updates of these guidance documents:
https://mde.maryland.gov/programs/Permits/WaterManagementPermits/Pages/waterpermits.aspx (this link is case-sensitive).

If you have any questions, please contact Simin Rezai, Project Manager, Surface Discharge Permits Division, at (410) 537-3694.

Sincerely,

Heather W. Barthelmor (Dec 16, 2021 18:59 EST)

D. Lee Currey, Director
Water and Science Administration

Enclosures

cc: Ms. Rebecca K. Crane, USEPA (electronic copy)
Ms. Andrea Hanley, Director, Environmental Health, Carrol County Health Department (electronic copy)
Mr. Scott Boylan, Western Inspection Division Chief (electronic copy)
Mr. Matt Rowe (electronic copy)
Mr. Dennis Rasmussen (electronic copy)

DISCHARGE PERMIT

NPDES Discharge Permit Number:	**MD0022578**
State Discharge Permit Number:	**18-DP-0642**
Effective Date:	**03/01/2022**
Expiration Date:	**02/28/2027**
Modification Date:	**(Not applicable)**
Reapplication Due Date:	**02/28/2026**

Pursuant to the provisions of Title 9 of the Environment Article, Annotated Code of Maryland, and regulations promulgated thereunder, and the provisions of the Clean Water Act, 33 U.S.C. Section 1251 et seq., and implementing regulations 40 CFR Parts 122, 123, 124 and 125, the Department of the Environment hereby establishes conditions and requirements pertinent to the wastewater treatment plant and collection system and authorizes:

Mayor and Council of Manchester
P.O. Box 8303337 Victory Street
Manchester, Carroll County, Maryland 21102

TO DISCHARGE FROM: Manchester Wastewater Treatment Plant (WWTP)

LOCATED AT: 3286 Beaver Street
Manchester, Carroll County, Maryland 21102

THROUGH OUTFALL: 001A (WWTP Surface Water Effluent)

TO: the Georges Run, designated as Use III-P waters (non-tidal cold water and public water supply) which is protected for the growth and propagation of trout and as a public water supply; in accordance with the following special and general conditions and a map incorporated herein and made a part hereof.

002 (Facility Groundwater Effluent)

TO: Ground waters of the State in accordance with the following special and general conditions and maps incorporated herein and made a part hereof.

I. DEFINITIONS

A. "Ambient temperature" of the effluent receiving stream means the water temperature that is not impacted by a point source discharge, and it shall be measured in areas of the stream representative of typical or average conditions of the stream segment in question.

B. "Bypass" means the intentional diversion of pollutants from any portion of a treatment or collection facility.

C. "BOD_5 (Biochemical Oxygen Demand)" means the amount of oxygen consumed in a standard BOD_5 test without the use of a nitrification inhibitor at 20 degree centigrade on an unfiltered sample.

D. "Clean Water Act" means the Federal Water Pollution Control Act, as amended, 33 U.S.C. Section 1251 et seq.

E. "CFR" means the Code of Federal Regulations.

F. "COMAR" means the Code of Maryland Regulations.

G. "Department" means the Maryland Department of the Environment (MDE).

H. Discharge Limits

1. "Daily *maximum* (or *minimum)*" limitation means the *highest* (or *lowest)* allowable the daily averages in a calendar month. The daily discharge expressed as concentration (in mg/l) shall be calculated by dividing total of measurement readings by number of sample collected during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling. The daily discharge expressed as loading rate (in pounds/day) is calculated by using this formula {daily average concentration (mg/l) x the same day total flow (in million gallons) x 8.34}.

2. "Weekly average *(maximum* or *minimum)*" limitation means the *highest* or *lowest* allowable average of "daily discharges" over a calendar week, calculated as the sum of all "daily discharges" measured during a calendar week divided by the number of "daily discharges" measured during that week. Each of the following 7-day periods is defined as a calendar week: Week 1 is Days 1 - 7 of the month; Week 2 is Days 8 - 14; Week 3 is Days 15 - 21; and Week 4 is Days 22 - 28. *For weekly average maximum*, if the "daily discharge" on days 29, 30 or 31 exceeds the "weekly average" discharge limitation, MDE may elect to evaluate the last 7 days of the month as Week 4 instead of Days 22 - 28. *For weekly average minimum*, if the "daily discharge" on days 29, 30 or 31 is lower than the "weekly average" discharge limitation, MDE may elect to evaluate the last 7 days of the month as Week 4 instead of Days 22 - 28.

I. DEFINITIONS

3. "Monthly average *maximum* (or *minimum)*" limitation means the *highest* (or *lowest)* allowable monthly average concentration or waste load of a parameter over a calendar month. The monthly average is calculated as the sum of all daily discharges for a parameter sampled and/or measured in that calendar month divided by the number of days on which monitoring was performed.

4. "Minimum or maximum" limit means the lowest or highest allowable value measured during a calendar day or any 24-hour period that reasonably represents the calendar day for purposes of sampling.

5. "Monthly loading rate (in pounds/month)" means the total load of a parameter calculated for that calendar month. It is calculated using this formula {(monthly average concentration in mg/l) x (Total monthly flow in Million Gallons) x 8.34}.

6. "Year-to-date cumulative load (pounds)" value means cumulative load of a pollutant in the effluent through each reporting month in a calendar year. It is calculated as a sum of the individual total monthly loads from January through the reporting month in a calendar year.

7. "Annual Maximum Loading Rate (in pounds/year)" limit means the maximum load allowed for a pollutant in the effluent to be discharged in a calendar year. The Year-to-date cumulative load (as defined above in Definition I.H.6) shall be used to determine the compliance status of this requirement.

8. "Monthly log mean (Monthly geometric mean)" limit means the highest allowable value calculated as the logarithmic or geometric mean of all samples taken in the calendar month. The geometric mean is the antilogarithm of the mean of the logarithms.

I. Discharge Monitoring

1. "Composite sample" means a combination of individual samples obtained at hourly or smaller intervals over a time period. Either the volume of each individual sample is proportional to discharge flow rates or the sampling interval (for constant volume samples) is proportional to the flow rates over the time period used to produce the composite.

2. "Grab sample" means an individual sample collected over a period of time not exceeding 15 minutes.

3. "Estimated flow" value means a calculated volume or discharge rate which is based on a technical evaluation of the sources contributing to the discharge including, but not limited to, pump capabilities, water meters, and batch discharge volumes.

I. DEFINITIONS

4. "Measured flow" value means any method of liquid volume measurement, the accuracy of which has been previously demonstrated in engineering practice, or for which a relationship to absolute volume has been obtained.

5. "Recorded flow" means any method of providing a permanent, continuous record of flow including, but not limited to, circular and strip charts.

6. "Monthly average flow" means the total flow for a calendar month divided by the number of days in the same month.

J. "i-s (immersion stabilization)" means a calibrated device immersed in the effluent or stream, as applicable, until the temperature reading is stabilized.

K. "NetDMR" means a nationally-available electronic reporting tool, initially designed by states and later adapted for national use by EPA, which can be used by NPDES-regulated facilities to submit discharge monitoring reports (DMRs) electronically to EPA through a secure Internet application over the National Environmental Information Exchange Network (NEIEN). EPA can then share this information with authorized states, tribes, and territories.

L. "NPDES (National Pollutant Discharge Elimination System)" means the national system for issuing permits as designated by the Clean Water Act.

M. "Nondetectable Level" for total residual chlorine means a residual concentration of less than 0.10 mg/l as determined using either the DPD titrimetric or chlorimetric method or an alternative method approved by the Department.

N. "Outfall" means the location where the effluent is discharged into the receiving waters.

O. "Overflow" means any loss of wastewater or discharge from a sanitary sewer system, combined sewer system or wastewater treatment plant bypass (as defined in I.B) which results in the direct or potential discharge of raw, partially treated wastewater into the waters of the State.

P. "Permittee" means an individual or organization holding the discharge permit issued by the Department.

Q. "POTW" means a publicly owned treatment works.

R. "Sampling Point" means the effluent sampling location in the outfall line(s) downstream from the last addition point or as otherwise specified.

S. "Sanitary Sewer Overflow (SSO)" means a discharge of untreated or partially treated sewage from a separate sewer system before the sanitary wastewater reaches the headworks of a wastewater treatment facility, pursuant to COMAR 26.08.10.01.

I. DEFINITIONS

T. "Secondary Treatment" means the treatment of sewage to produce effluent equal to or better than the following quality, except as provided for 40 CFR §133.103, or paragraphs (d), (e) or (f) of the same section:

1. Five-day biochemical oxygen demand (BOD_5):

   a. 30 milligrams/liter—average for a 30-day period;

   b. 45 milligrams/liter—average for a 7-day period;

   c. The 30-day average percent removal shall not be less than 85 percent.

2. Total Suspended Solids (TSS):

   a. 30 milligrams/liter—average for a 30-day period,

   b. 45 milligrams/liter—average for a 7-day period;

   c. The 30-day average percent removal shall not be less than 85 percent.

3. Bacterial control: As required to meet water quality standards.

U. "Significant Industrial User (SIU)" is defined as any industrial user (IU) that:

1. is subject to national categorical standards; and

2. any other IU that:

   a. discharges an average of 25,000 gallons per day or more of process wastewater (excluding sanitary, non-contact cooling and boiler blowdown wastewater); or

   b. contributes a process wastestream that makes up 5% or more of the average dry weather hydraulic or organic capacity of the POTW; or

   c. is designated as such by the POTW on the basis that the IU has a reasonable potential for adversely affecting the POTW's operation or for violating any pretreatment standard or requirement; or

   d. is found by the POTW, the Department, or the Environmental Protection Agency (EPA) to have significant impact either individually or in combination with other contributing industries to the POTW, on the quality of the sludge, the POTW's effluent quality, or air emissions generated by the system.

I. DEFINITIONS

V. "TKN (Total Kjeldahl Nitrogen)" means organic nitrogen plus ammonia nitrogen.

W. "TSS (Total Suspended Solids)" means the residue retained on the filter by an analysis done in accordance with Standard Methods or other approved methods.

X. "Upset" means the exceptional incident in which there is unintentional and temporary noncompliance with technology-based permit effluent limitations because of factors beyond the reasonable control of the permittee. An upset does not include noncompliance to the extent caused by operational error, improperly designed treatment facilities, inadequate treatment facilities, lack of preventive maintenance, or careless or improper operation.

II. SPECIAL CONDITIONS

A.1. Effluent Limitations, Outfall 001A [1] [2] [3] [4]

The quality of the effluent discharged by the facility at the discharge location- 001A[1] [2] [3] shall be limited at all times as shown below. If the sampling point is other than the outfall- 001A, the permittee shall ensure that the effluent samples are representative of the effluent quality being discharged at the outfall- 001A. These limitations shall be applicable from December through March only. No discharge is permitted from April 1 through November 30. Surface discharge to the stream is allowed during March if spray irrigation is prohibited due to severe cold conditions.

	Maximum Effluent Limits					
Effluent Characteristics	Monthly Average Loading Rate, Pounds/day	Weekly Average Loading Rate, Pounds/day	Daily Average Loading Rate, Pounds/day	Monthly Average Concentration, mg/l	Weekly Average Concentration, mg/l	Daily Average Concentration, mg/l
BOD_5	125	188	N/A	30	45	N/A
BOD_5, Percent Removal [9]	85 % minimum monthly average					
TSS	125	188	N/A	30	45	N/A
TSS, Percent Removal [9]	85 % minimum monthly average					
Total Ammonia Nitrogen as N	19	N/A	58	4.6	N/A	14
Total Phosphorus (TP) [4]	4.2	6.3	N/A	1.0	1.5	N/A

	Maximum Effluent Limits		
Effluent Characteristics	Total Monthly Loading Rate, Pounds/Month	Annual Maximum Loading Rate, Pounds/Year	Monthly Average Concentration, mg/l
Total Phosphorus-P (TP) [4] [5] [6] [7]	REPORT	506	1.0
Total Nitrogen-N (TN) [5] [6] [7]	REPORT	REPORT	REPORT

	Effluent Limits	
Effluent Characteristics	Maximum	Minimum
E. Coli [5]	126 MPN/ 100 ml monthly geometric mean value	N/A
Total Residual Chlorine [8]	The use of chlorine or any chorine containing compound is prohibited in the treatment process.	N/A
pH	8.5	6.5
Dissolved Oxygen	N/A	6.0 mg/l at anytime
Temperature	REPORT	N/A

II. SPECIAL CONDITIONS

A.1. Effluent Limitations, Continued

An annual average flow of 0.5 million gallons per day (mgd) was used in waste allocation calculations (expressed as waste loading rate limit), and this unit shall be used when reporting on the Discharge Monitoring Report (DMR) as required by General Condition III.A.2. Notification is to be provided to the Department at least 180 days before the annual average flow is expected to exceed this flow level. If a permit modification is required, the Department will initiate the public participation NPDES process.

Footnotes for surface discharge effluent limitations:

(1) When this permit is renewed, the new limitations may not be equal to the above limitations.

(2) There shall be no discharge of floating solids or visible foam other than trace amounts.

(3) The permit may also be reopened in accordance with the requirements of MDE's Watershed Permitting Plan under which all discharge permits in a watershed are issued the same year.

(4) The concentration and annual load limits for total phosphorus (TP) are based on the Prettyboy Reservoir TMDL.

(5) The receiving stream is Georges Run, which flows into the Prettyboy Reservoir. The Prettyboy Reservoir is on the 303(d) list as the impaired waters for total phosphorus (TP), fecal bacteria, mercury in fish tissue, and temperature.

TMDL of mercury for the Prettyboy Reservoir was approved by EPA on August 16, 2004. This facility is not required to monitor for mercury.

TMDL of phosphorus for the Prettyboy Reservoir was approved by EPA on March 27, 2007. The TP limitations in this permit are in conformance with this TMDL.

TMDL of fecal bacteria for the Prettyboy Reservoir Basin was approved by EPA on October 8, 2009. The E. coli limit in this permit is in conformance with this TMDL.
This permit is in conformance with the "**Chesapeake Bay TMDL for Nitrogen, Phosphorus and Sediment"** established on December 29, 2010.

When TMDLs for other remaining parameters are completed, limits may be imposed, after the public participation process, to incorporate any TMDL requirements.

II. SPECIAL CONDITIONS

(6) The Annual Maximum Loading Rate (Definition I.H.6) for nutrients is a calculated value to be reported monthly as the year-to-date cumulative loads (Definition I.H.7) from January through December of the current calendar year. Under Chesapeake Bay TMDL, the Manchester WWTP has been assigned the Annual Maximum nutrient loads of 5,462 lbs/year for total nitrogen (TN) and 196 lbs/year for total phosphorus (TP) as part of the aggregate waste load allocation assigned to the minor wastewater treatment facilities in the GUNOH Chesapeake Bay segment. As long as the design flow of the WWTP does not increase, these loads will remain as goals only without limitations. The permittee, however, shall make an effort to optimize the operation of the existing WWTP to meet these goals. The above nutrient WLA (5,462 lbs/year TN and 196 lbs/year) for this facility will be incorporated to establish the limits, if the existing facility is expanded in future.

(7) The permittee may request that the permit be reopened and modified to include nutrient trading consistent with all applicable regulations and requirements in effect at that time.

(8) The use of chlorine or any chlorine-containing compound in the treatment of wastewater is prohibited.

(9) In accordance with 40CFR §133.102, the 30-day average percent removal for BOD_5 and TSS shall not be less than 85 (eighty-five) percent as the minimum level of effluent quality attainable by the secondary treatment. Refer to the footnotes 20 and 21 for further details for calculations and reporting requirements toward compliance to the BOD_5 and TSS percent removal effluent limitations (See Definition I.T).

II. SPECIAL CONDITIONS

A.2(1). Effluent Limitations, Outfall 002

1. The permittee is authorized to discharge treated wastewater via spray irrigation to groundwaters of the State from March 1 through November 30 at the site shown on attached maps. Surface discharge during the month of March is allowed only when spray irrigation is prohibited due to severe cold conditions. For surface discharge limitations refer page 7.
2. Screening device may be needed at intake structure to prevent excessive solids from clogging sprinkler nozzles.
3. Prior to discharge at the spray irrigation site, all wastewaters shall be treated to produce an effluent which does not exceed the following limitations:

EFFLEUNT CHARACTERISTICS	MONITORING LIMITATIONS					MONITORING REQUIREMENTS	
	Loadings		Concentrations			Monitoring Frequency	Type of Sample
	Yearly Average	Monthly Average	Monthly Average	Weekly Maximum	Unit		
Flow [2] (50050)	0.5	**(1)**	N/A	N/A	million gallons/day	Continuous	Recorded
BOD_5 (00310)	N/A	N/A	70	N/A	mg/L	Weekly	Grab[4]
Total Suspended Solids	N/A	N/A	90	N/A	mg/L	Weekly	Grab[4]
pH (00400)	N/A	N/A	6.5 (daily minimum)	8.5 (daily maximum)	units	Daily	Grab[4]
Fecal coliform (74055)	N/A	N/A	200 [5]	N/A	MPN/100ml	Weekly	Grab[4]
Total Nitrogen (00600)[3]	N/A	N/A	(1)	N/A	mg/l	Weekly	Grab[4]

(1) Monitoring and reporting are required without limits.
(2) The yearly average flow is to provide operational flexibility to accommodate the water demand variation of vegetation.
(3) A permit modification is required for any future expansion of this facility. The modification shall include a limitation of yearly nitrogen load to groundwater based on 0.5 mgd average daily flow and an appropriate effluent nitrogen concentration to be determined based on the nitrogen monitoring data from the wastewater treatment system. This nitrogen loading cap is not an assigned allocation for discharge to the Bay via groundwater because the permit assumes vegetation uptake and other natural processes that reduce the amount of nitrogen reaching the Bay from this system. The factsheet of this permit includes the vegetation uptake and the nitrogen transport assumptions for estimating the amount of nitrogen delivered to the Bay from this system. Total nitrogen is defined as the sum of Nitrate plus Nitrite and Total Kjeldahl Nitrogen (TKN). The concentration of each constituent shall also be reported.
(4) Grab samples shall be obtained from the effluent line just prior to spray irrigation.
(5) The fecal coliform shall be determined as a geometric mean of the monthly data.

II. SPECIAL CONDITIONS

A.2(2). Groundwater Quality Limitations, Outfall 002

Groundwater samples taken from fourteen (14) groundwater monitoring wells per requirements of Section II.I.3 shall be monitored by the permittee according to the following limitations.

1. The discharge of the wastewater authorized in this permit shall not cause groundwater quality to exceed the limitations listed below, as measured in the designated down gradient monitoring wells (MWs 2, 3, 5, 7, 8, 9, 12, 13 and 14). The Table below includes limitations based on the drinking water standards for Nitrate (00620), Nitrite (00615), Total Dissolved Solids (70295), Chloride (00940), and Fecal Coliform (74055).

Parameter	Groundwater Quality Limitations(2) (3)	Measurement Frequency	Type of Sample
NO3 (Nitrate 00620)	10 mg/l (4)	One/month	Grab
NO_2 (Nitrite 00615)	1 mg/l	Once every 3 months	Grab
TKN (00625)	(1)	Once every 3 months	Grab
Total Nitrogen (00600)	10 mg/l	Once every 3 months	Grab
pH (00400)	(1)	Once every 3 months	Grab
PO4 (Total Phosphate 00650)	(1)	Once every 3 months	Grab
Total Dissolved Solids (70295)	500 mg/l	Once every 3 months	Grab
Chloride (00940)	250 mg/l	Once every 3 months	Grab
Fecal coliform (74055)	Non-detect	Once every 3 months	Grab

(1) Monitoring and reporting are required without limits.

(2) For any reported exceedance at the downgradient wells, if the average groundwater quality in the background upgradient wells exceeds the groundwater quality limitations and the effluent discharge limitations are not being consistently met, the Department may evaluate whether a violation exists on a case by a case basis.

(3) The groundwater quality limitations are not applicable to the upgradient wells MWs 1, 4, 6, 10, and 11 as shown on Map B.

2. For other parameters not included in A.2. (2). 1. above, the discharge of the treated wastewater, which is authorized in this permit, shall not cause an exceedance of the groundwater quality standards adopted by the Department of the Environment in COMAR 26.04.01, and 26.08.02.09.C. For any exceedance, if the average groundwater quality in the background upgradient wells exceeds the groundwater discharge standards and the effluent discharge limitations are not being consistently met, the Department may evaluate whether a violation exists on a case by a case basis.

II. SPECIAL CONDITIONS

B. (1) Minimum Monitoring Requirements:

(a) For Effluent Surface Discharged at Outfall 001A:

The effluent characteristics listed below in Table B(1) shall be monitored at the sampling point (Definition I.R) located at Latitude 39° 39' 28.8" (N) and Longitude 76° 52' 47.2" (W). The permittee shall ensure that the effluent samples taken at the above stated sampling point are representative of the effluent quality discharged at the Outfall 001A.

Effluent Characteristics	Monitoring Period	Measurement Frequency	Sample Type
BOD_5 (10)(11)	During Surface Discharge	Two per week	24-hour composite
Total Suspended Solids (10)(11)	During Surface Discharge	Two per week	24-hour composite
BOD5, Percent Removal	During Surface Discharge	Once (at the end of surface discharge) (December to March)	Calculated
TSS, Percent Removal	During Surface Discharge	One per month	Calculated
Total Ammonia Nitrogen as N (10)(11)(14)	During Surface Discharge	Two per week	24-hour composite
Total Phosphorus as P (10)(11)(12)	During Surface Discharge	Two per week	24-hour composite
Total Nitrogen as N (10)(12)(13)(14)	During Surface Discharge	Once per month	Calculated
(Nitrite + Nitrate) as N (10)(13)(14)	During Surface Discharge	Once per month	24-hour composite
Total Kjeldahl Nitrogen as N (10)(13)(14)	During Surface Discharge	Once per month	24-hour compasite
Organic Nitrogen as N (10)(13)(14)	During Surface Discharge	Once per month	Calculated
Orthophosphate as P (10)(13)	During Surface Discharge	Once per month	24-hour composite
Total Residual Chlorine	N/A	See footnote 8 on page 9	N/A
E. Coli (10)	During Surface Discharge	One per week	Grab
Dissolved Oxygen (10)(15)	During Surface Discharge	Two per day	Grab
pH (10)(15)	During Surface Discharge	Two per day	Grab
Flow (10)(16)(17)	During Surface Discharge	Continuous	Recorded (17)
Total Monthly Flow (10)(18)	During Surface Discharge	Monthly	Calculated (18)

II. SPECIAL CONDITIONS

Effluent Characteristics	Monitoring Period	Measurement Frequency	Sample Type
Temperature [10][19] (Effluent + stream)	During Surface Discharge	One set per month	Grab (i-s)

B. (1)

(b) For Raw Wastewater Influent at Sampling Point 101A:
The quality of the wastewater influent entering the Manchester WWTP shall be monitored at Influent Chamber (Latitude: 39°39'29" N Longitude: 76°52'47.3" W) all the time as shown below:

Wastewater Influent Characteristics	Monitoring Period	Measurement Frequency	Sample Type
BOD_5 [10][13][20][21]	During Surface Discharge	Once (at the end of surface discharge)	Grab
Total Suspended Solids [10][13][20][21]	During Surface Discharge	One per month•	Grab

- The monitoring frequency for BOD_5/TSS in the raw wastewater influent will be based on the specified reporting period defined on a monthly, quarterly, or annual basis. The permittee shall select a minimum of one day (in any calendar month) within each reporting period to collect samples from the influent and the effluent. For the compliance determination of this requirement, these samples must be collected on the same day. If the individual results for the samples taken on this day indicate a percent removal less than 85%, then the permittee shall repeat the sampling process on a different day in the same calendar month until the 85% minimum removal requirement (calculated using the average monthly concentrations of BOD_5/TSS) has been satisfied.

For each month that samples are collected, the results for BOD_5 and TSS in the influent and effluent shall be reported as (a) individual concentrations in the Monthly Operating Report (MOR), and as (b) monthly average concentrations in the Discharge Monitoring Report(s) (DMR) submitted for that same month. The percent (%) removal of BOD_5 and TSS shall be calculated and reported in the DMR for the last calendar month of each reporting period. The quarterly monitoring periods shall end in February. The annual monitoring period shall end in December of each calendar year. (***Example: If the monitoring frequency of the percent (%) removal and raw wastewater influent is one per year and the influent sampling is performed in the month of July, the individual results and monthly average concentrations will be reported in the MOR and the DMR, respectively, for the month of July, and the percent removal will be reported in the DMR for December at the end of that same calendar year.***)

B.1. Minimum Monitoring Requirements:

Footnotes for the monitoring requirements B(1)(a) and B(1)(b):

(10) "STORET" (short for STOrage and RETrieval) is a widely-used repository for water quality data reporting and monitoring. The STORET codes for the effluent characteristics described as limitations and/or monitoring requirements are: BOD_5 (00310), BOD_5 percent removal (81010), Total Suspended Solids (00530), Total Suspended Solids percent removal (81011), TKN (00625), Total Ammonia Nitrogen as N (00610), Total Phosphorus as P (00665), Total Nitrogen as N (00600), (Nitrite + Nitrate) as N (00630), Organic Nitrogen as N (00605), Orthophosphate as P (04175), E. Coli (51040), Dissolved Oxygen (00300), pH (00400), Flow (50050), Total flow (82220), and Temperature (00011).

(11) The permittee shall distribute the timing for effluent sampling with (a) minimum of 48-hour apart for two per week monitoring frequencies. The 48 hours interval for two per week sampling shall be defined as the period between the starting times of the two consecutive effluent sample collections for the same effluent parameter.

(12) The permittee shall also calculate and report on the DMR the TN and TP total monthly loads (Definition I.H.5) plus year-to-date cumulative loads (Definition I.H.6) for the calendar year in question for the outfall- 001A.

(13) This parameter (without limitations) must be monitored, and it shall be reported on the Monthly Operating Report (MOR) as individual results and on the Discharge Monitoring Report (DMR) as monthly average concentrations.

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(14) Total nitrogen as N (in mg/l) is a calculated parameter as the sum of individual results for total ammonia nitrogen as N, organic nitrogen as N and (nitrite + nitrate) as N. Total Kjeldahl Nitrogen (TKN) is defined as the total concentration of organic nitrogen and ammonia as N. All nitrogen species must be sampled at the same day. The monitoring result for organic nitrogen may be calculated through the subtraction of the total Ammonia as N monitoring result from the result of TKN sample taken at the same day.

(15) Samples for these parameters (pH and dissolved oxygen) shall be taken at intervals evenly distributed throughout the staffed period each day to comply with the General Condition III.A for the representative sampling requirements.

(16) Flows shall be reported in millions gallons per day (mgd) to at least the nearest 1,000 gallons per day. (Example: A flow of 424,699 gallons per day shall be reported as 0.425 mgd.). For each calendar month, flows shall be reported on the MOR as daily individual results and on the DMR as monthly average (mgd) and daily maximum (mgd).

(17) Continuous electronic flow measurement and recording which can produce a permanent record are acceptable to the Department.

(18) Total flow is a calculated parameter equal to sum of the daily flow results in a calendar month. It shall be reported on the monthly DMR as Total monthly flow in millions gallons (MG) to at least the nearest 1,000 gallons. (Example: A flow of 15,524,699 gallons shall be reported as 15.525 MG).

(19) Temperatures of the effluent and stream shall be monitored and reported in accordance with the Special Condition II.G.

Refer to Definition I.J for Sample Type "i-s (immersion stabilization)". The temperatures shall be measured using a device which has accuracy of at least 0.1^{o} C and meeting the appropriate standards stated in 40CFR Part 136.

(20) Wastewater influent samples for BOD_5 and TSS shall be collected per the sampling type and reporting frequency specified in above (Special Condition II.B(1)(b), page 13). These measurements shall be utilized to calculate BOD_5 and TSS percent removed using the formula listed below in footnote 21, and results shall be used to comply with the percent removal effluent limits of BOD_5 and TSS (Special Condition II.A.1 Page 7). Any effluent excursion of the percent removal limit (Special Condition II.A.1, Page 7) reported at the end of each monitoring period will be considered as violation for the full period as specified.

Upon the effective date of the discharge permit, if the DMR records from the first 12 months indicate the average removal efficiencies for these pollutants at the facility are significantly higher than the required 85%, the permittee may petition for performance – based monitoring frequency reduction for BOD_5 and TSS in the raw wastewater influent.

(21) At the end of each reporting period, the permittee shall use the BOD_5 and TSS monthly average concentrations in the influent and effluent (both reported on a monthly DMR for the calendar month of the influent sampling), and calculate monthly percent (%) of a parameter (BOD_5 or TSS) removed using the following formula:

$$Monthly\ Percent\ (\%)\ of\ Parameter\ Removed\ = \left\{\frac{(A-B)}{A}\right\} \times 100$$

Where:
A = Monthly Average Concentration of Parameter in Influent, mg/l
B = Monthly Average Concentration of Parameter in Effluent, mg/l

The results (monthly average percent (%) of BOD_5 and TSS removed) shall be reported in the DMR submitted for the last calendar month of the reporting period. *(Example: If the monitoring frequency of the percent (%) removal is one per quarter, the results shall be reported in the DMRs for March, June, September, and December).*

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B.2 Monitoring Requirements, Outfall 002

The effluent characteristics established in Special Condition II.A.2 shall be monitored as follows:

Effluent Characteristics	Measurement Frequency	Sample Type
BOD_5	1x Week	8 hr. composite(1)
Total Suspended Solids	1x Week	8 hr. composite (1)
Fecal Coliform (2)	1x Week	Grab
pH (2)	1x Day	Grab
Flow	Continuous	Recorded

(1) Grab samples for BOD5 and suspended solids are permissible if the lagoon detention time is 30 days or more.

(2) Grab samples shall be obtained from the effluent line just prior to spray irrigation.

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C. Wastewater Capacity Management

The permittee shall report the total cumulative flow for the each calendar year for the above referenced facility. The total cumulative flow shall be reported in million gallons for the entire calendar year to the nearest thousand gallons. The annual total cumulative flow determination shall be provided to the Department using NetDMR no later than January 28th of the following year.

If the most recent three year average flow is over 80% of its design capacity or if it is anticipated to exceed 80 % in the following year, a Wastewater Capacity Management Plan (WCMP) must be submitted to the Department using NetDMR no later than January 28 of the following year. Thereafter, the "Wastewater Flow Capacity Report (WFCR)" and "worksheets (Style #1 and #2) for WFCR" shall be submitted to the Department using NetDMR tool no later than January 28th of each year. The permittee can obtain the WCMP guidance document and forms from the Department's web site links listed below: (a) http://9nl.at/MD-CMPGuidance for WCMP guidance document, (b) http://9nl.at/MD-CMPFlowCapReport for WFCR, (c) http://9nl.at/MD-CMPWorksheet1 for WFCR's Worksheet # 1, and (d) http://9nl.at/MD-CMPWorksheet2 for WFCR's Worksheet # 2 (these links are case-sensitive).

If the permittee prefers to provide the above documents in hard copies, they shall be provided to the Department postmarked by January 28th of the following year to the address below:

Attention: Calendar Year Total Cumulative Flow
Wastewater Discharge Permits Program
Water and Science Administration (WSA)
Maryland Department of the Environment
1800 Washington Boulevard, STE-455
Baltimore, MD 21230-1708

The permittee is advised to notify the Department at the above address immediately upon electronic submission of reports through NetDMR tool.

D. Influent Restriction

1 The permittee is not authorized to receive the discharge of any type or quantity of substances which may cause interference with the operation of the treatment works. The permittee is required to notify the Pretreatment Section of the Department, in writing, prior to allowing:

a. Any new introduction of pollutants into the treatment works from an indirect discharger which would be subject to Section 301 or 306 of the

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Clean Water Act and COMAR 26.08.08 if it were directly discharging those pollutants; and

b. Any substantial change in the volume or character of pollutants being introduced into the treatment works by a source at the time of issuance of this permit.

2 Adequate notice shall include information on (i) the quality, quantity and frequency of wastewater introduced into the treatment works, and (ii) any anticipated impact of the change on the quantity or quality of effluent to be discharged from the treatment works. The permittee shall also maintain an updated list of indirect dischargers which shall be available upon the request of the Department. Under no circumstances shall the permittee allow introduction of the following wastes into the waste treatment system:

a. Pollutants which cause pass through or interference;

b. Pollutants which create a fire hazard or explosion hazard in the sewerage system, including, but not limited to waste streams with a closed cup flashpoint of less than 140 degrees Fahrenheit or 60 degrees Centigrade using the test methods specified in 40 CFR 261.21;

c. Pollutants which will cause corrosive structural damage to the sewerage system; but in no case, discharges with pH less than 5.0, unless the works is specifically designed to accommodate such discharges;

d. Solid or viscous pollutants in amounts which will cause obstruction to the flow in the sewerage system resulting in interference;

e. Any pollutant, including oxygen demanding pollutants (BOD, etc.) released in a discharge at a flow rate and/or pollutant concentration which will cause interference with the treatment plant;

f. Heat in amounts which will inhibit biological activity in the treatment plant resulting in interference; but in no case, heat in such quantities that the temperature at the treatment plant exceeds 90 degrees Fahrenheit (32 degrees Centigrade) unless the Pretreatment Section of the Department, upon request of the permittee, approves alternate temperature limits;

g. Pollutants which result in the presence of toxic gases, vapors or fumes within the sewerage system in a quantity that may cause acute worker health and safety problems; and

h. Any trucked or hauled wastewater is prohibited, except for (1) domestic septage, (2) wastewater from within the collection system or within the wastewater treatment works due to blockage, breaks or malfunction in the system, (3) drinking water plant wastewater, or, (4) other sources specifically authorized by the Department. Prior to the acceptance of

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any trucked waste other than those listed in this section, the permittee must make an official written request and, if approved by the Department, must follow the conditions specified in permit requirements which may be modified or rescinded at the discretion of the Department for any reason.

E. Protection of Water Quality

It is a violation of this permit to discharge any substance not otherwise listed under the permit's "Effluent Limitations and Monitoring Requirements" special conditions at a level which would cause or contribute to any exceedance of the numerical water quality standards in COMAR 26.08.02.03 unless the level and the substance were disclosed in writing in the permit application prior to the issuance of the permit. If a discharge regulated by this permit causes or contributes to an exceedance of the water quality standards in COMAR 26.08.02.03, including but not limited to the general water quality standards, or if the discharge includes a pollutant that was not disclosed or addressed in the public record for the permit determination, the Department is authorized to modify, suspend or revoke this permit or take enforcement action to address unlawful discharges of pollutants.

F. Reapplication for a Permit

No later than 12 months before expiration of this permit, unless permission for a later date has been granted by the Department, the permittee shall submit a new application for a permit or notify the Department of the intent to cease discharging by the expiration date. In the event that a timely and complete reapplication has been submitted and the Department is unable, through no fault of the permittee, to issue a new permit before the expiration date of this permit, the terms and conditions of this permit continue and remain fully effective and enforceable. The renewal application is required by that date in accordance with the requirements of MDE's Watershed Permitting Plan under which all discharge permits in a watershed should be issued in the same year.

G. Water Temperature Requirements for Use III and III-P Waters

1. For Effluent:

The effluent temperature shall be measured in degrees Fahrenheit at the end of outfall or closest accessible location to the actual discharge location.

2. For Stream:

When the effluent temperature is 68°F or less, stream monitoring is not required. Otherwise, in order to include ambient temperatures of the effluent receiving stream with the effluent temperatures for evaluation, the permittee must measure

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the stream temperatures in degrees Fahrenheit upstream (at least 50') of the outfall location as stated below in section 3. The permittee shall also measure the stream temperature in degrees Fahrenheit downstream (approximately 100') from the outfall location. If the recommended sampling points are not accessible; the permittee can propose an alternative location with the approval of the Department. The permittee shall submit a map showing the locations of the sampling points with latitude and longitude for each sampling point with the first monthly operating report. These locations should remain the same for the duration of the permit unless the permittee notifies the Compliance Program in advance of the need for a change.

3. Timing for Effluent and Stream Sampling:

The water temperature measurements of the effluent and the receiving stream at the sampling locations as described above in Sections 1 and 2 shall be taken on the same day in the morning between 7:00 to 10:00 AM as well as in the afternoon between 2:00 to 5:00 PM. These measurements shall be reported in degrees Fahrenheit on MOR as individual results and on DMR as a Monthly Average and Maximum Daily Average.

H. Facility Improvement Plan

The permittee is required to submit a "Facility Improvement Plan" (the Plan) to the Department for approval no later than six months after the effective date of the permit. The Plan shall include (1) measures to be taken to address effluent compliance issues and (2) potential upgrades for the treatment work. A progress report for efforts made toward the facility improvement shall also be submitted to the Department every 6 months after the approval of the Plan.

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I. Land Application Requirements and Limitations

1. The permittee shall apply the treated wastewaters by spray irrigation only on the sites outlined on the attached Maps A and B.

2. At no time shall spray irrigation be conducted on areas with bare unvegetated soils.

3. Irrigation of treated wastewater shall not take place during periods of precipitation, high winds, freezing conditions, or saturated soil. Excessive injection causing surface runoff and or ponding is prohibited. The permittee shall install or provide a storage facility designed to hold treated wastewater during periods when irrigation cannot take place. The storage facility shall be capable of containing wastewater generated during no less than 10 days of normal operation of the wastewater facility. The storage facility shall be sealed or constructed to prevent the direct seepage of stored waters into ground waters beneath the site.

4. The permittee shall ensure no winter spray irrigation application from December 16 through February 28 of the following year to allow the discharge to be consistent with the Department of Agriculture regulations at COMAR 15.20.07.02, Supplement No. 7 (May 2012, amended and effective January 2, 2017).

5. The hydraulic loading rate shall be limited to 2"/week (yearly average).

6. Spray irrigating sewage effluent shall be limited to the daytime hours only.

7. The permittee shall provide adequate means to prevent spray droplets from entering adjacent properties, either by direct application or wind carry-over. These means shall include a buffer zone that is:

    a. 200 feet from the wetted perimeter of the spray irrigation site to property lines; and

    b. 500 feet from the wetted perimeter of the spray irrigation site to houses or other

    c. occupied structures, or

    d. An alternate means, approved by the Department, which is suitable to control the movement of spray onto adjacent land (i.e., wind break of tightly placed trees; etc.)

8. Location and installation of the storage pond shall be in compliance with all applicable State and County guidelines.

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9. In addition to the approximately 65 acres required for spray fields, an additional 25% of the wetted field area shall be reserved for use in the event application rates need to be adjusted.

10. Daily logs of the response of each disposal area to the application of treated effluent shall be kept by the plant operator. Subjects to be included in the log are:

    a. area(s) or section(s) under irrigation;
    b. application rates (hourly and weekly);

    c. effect of irrigation on vegetation;

    d. instances of ponding or runoff; and

    e. weather conditions.

    The log shall be kept at the waste treatment facility and be available for inspection by the Department personnel upon request.

11. The permittee shall develop a "Manual of Operation and Maintenance". The manual shall clearly state how the entire treatment facility shall be managed to insure satisfactory treatment and operation. The manual shall include:

    a. operating and maintenance procedures for the storage pond and spray application equipment;

    b. crop management plan including: 1). Type of crop to be planted on the spray irrigation field which is amenable to the application of wastewater; 2). Schedule of crop planting; 3). Schedule of crop harvesting and 4). Nitrogen uptake rate of the crop planted in the spray irrigation field.

    The manual shall be submitted to the Department for approval prior to the system being placed in operation.

12. The Permittee shall update the nutrient management plan (NMP) according to COMAR 15.20.07.05.D. and submit the updated NMP to the Department. Operation of the spray irrigation system shall conform with the NMP.

J. Monitoring Requirements of the Land Application System

1. The wastewater treatment plant and spray irrigation system, shall be operated by a Maryland State Certified Operator in accordance with the provisions of COMAR 26.06.01 and approved operation and maintenance manual. The Operator shall be proficient in the operation of a spray irrigation system, and takes required training courses at a frequency approved by the MD Board of Waterworks and Waste Systems Operator. This training shall be specific to **the operation of spray** irrigation system in addition to any other training requirements of the operator’s class.

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2. The permittee is responsible for the operation and maintenance of 14 observation wells to be used for obtaining grab or pumped samples of the ground water. The wells are located throughout the site as shown on attached Map B.

3. The permittee shall collect and analyze one water sample from each observation well every three months. Testing results shall be submitted to the Department with the monthly monitoring report as specified in General Conditions III.A.2.a.

    a. Water samples may be obtained by either pumping or bailing the observation wells. Prior to taking the sample, a volume of water equal to 300% of the wetted volume of the casing and screen shall be removed.

    b. Each ground water sample shall be analyzed for the parameters shown in Special Condition II.A.2 (2).

    c. The permittee shall collect stream samples once per quarter from four surface water sampling stations as shown on the attached Map B. Water samples shall be analyzed for the parameters listed in Special Condition II.A.2 (2).

K. Nitrate Level Reduction Action Plan for Groundwater Monitoring Wells (Action Plan)
An action plan with contingencies shall be submitted to the Department for approval no later than 12 months after the effective date of the permit to address elevated nitrate concentration in the monitoring wells.

a. The action plan shall include (1) corrective measures to be taken to prevent the Nitrate level exceeding 10 mg/L (2) follow up contingencies if the corrective measures proposed in the plan fail to prevent the elevation of Nitrate level in the monitoring well of concern.

b. The measures proposed in the action plan shall be executed when the Nitrate concentration in the down gradient monitoring wells exceeds 9.5 mg/l for monthly average or 9.0 mg/l quarterly average, whichever comes first.

c. A follow up report shall be submitted to the Department whenever an action level is being triggered and addressed by the permittee through measures proposed in the approved Action Plan.

After receiving the approval from the Department, the permittee shall implement the action plan within 30 days whenever the action level is triggered at the monitoring location.

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A. Monitoring and Reporting

1. Representative Sampling

Samples and measurements shall be taken at times that are representative of the quantity and quality of the discharge, and at evenly spaced intervals.

2. Monthly Monitoring Results

a. Discharge Monitoring Reports

Monitoring results obtained during each calendar month shall be summarized and submitted electronically using the NetDMR tool. Results shall be submitted to the Department via NetDMR no later than the 28th of the month following the end of the reporting month.

b. Monthly Operating Reports (MOR)

The permittee shall submit monthly operating reports on a form acceptable to the Compliance Program. For each calendar month, the permittee shall submit to the Department a signed original of the MOR as an attachment to Copy of Record (COR) via NetDMR in electronic format concurrently with the Discharge Monitoring Report submission postmarked no later than the 28th day of the month following the reporting month.

c. Toxic Chemical Reporting

Any data collected according to the Department's "Toxic Pollutant Monitoring Protocol and Reporting Requirements for Toxic Chemical Testing Analytical Data" (12/2/2019) being submitted to the Department, either in fulfillment of Special Conditions II.B or pursuant to the toxic chemical testing requirement, pretreatment requirements or toxic metals or organic data collected on a voluntary basis, must be accompanied by laboratory data reports. At a minimum, these reports shall include, the name of the facility, the date(s) of sampling, beginning and ending sample time, place of sampling collection, the sample type (grab, composite, etc.), the sample description (influent or effluent), the preservation method, the analytical method used for each parameter, the analytical method detection limit, the date of analysis, the name of person performing the analysis, the analytical result, and the name and address of the laboratory performing the analyses. Chain-of-custody forms shall also be submitted.

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If the permittee prefers to submit hard copy of this information along with the supporting documentations instead of the electronic submission via NetDMR tool, they shall be submitted to:

Attention: Toxic Chemical Data
WSA – Compliance Program
Maryland Department of the Environment
1800 Washington Boulevard, STE 420
Baltimore, Maryland 21230-1708

d. Groundwater Monitoring Report (GMR) – Applicable to Outfall 002 only

Groundwater monitoring data required by this permit under Special Condition II.A.2. (2) shall be summarized on a discharge **monitoring report form supplied by the Compliance Program. The early** report shall be submitted on or before the 28th day of the month following the end of each calendar year to the address shown on III. A. 2. a. above. The permittee shall report any violations of the groundwater quality standards in accordance with General Condition III.B.1. included in this permit.

3. Sampling and Analysis Methods

Analytical and sampling methods shall conform to test procedures for the analysis of pollutants as identified in 40 CFR Part 136 - "Guidelines Establishing Test Procedures for the Analysis of Pollutants."

4. Use of Sufficiently Sensitive Test Methods

In accordance with 40 C.F.R. § 122.44(i)(1)(iv), the permittee shall use sufficiently sensitive test procedures (i.e., methods) approved under 40 C.F.R. Part 136 or required under 40 C.F.R. Chapter I, Subchapter N or O, for the analysis of pollutants or pollutant parameters limited in this permit. A method is considered “sufficiently sensitive” when either: (1) the method minimum level (ML) is at or below the level of the effluent limit established in this permit for the measured pollutant or pollutant parameter; or (2) the method has the lowest ML of the analytical methods approved under 40 C.F.R. Part 136 or required under 40 C.F.R. Chapter I, Subchapter N or O for the measured pollutant or pollutant parameter. The ML is not the minimum level of detection, but rather the lowest level at which the test equipment produces a recognizable signal and acceptable calibration point for a pollutant or pollutant parameter, representative of the lowest concentration at which a pollutant or pollutant parameter can be measured with a known level of confidence. For the purposes of this permit, the

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detection limit is the lowest concentration that can be reliably measured within specified limits of precision and accuracy for a specific laboratory analytical method during routine laboratory operating conditions (i.e., the level above which an actual value is reported for an analyte, and the level below which an analyte is reported as non-detect).

5. Analytical Laboratory

Within 30 days after the effective date of this permit, the permittee shall submit to the Department the name and address of the analytical laboratory (including the permittee's own laboratory) which is used to perform the monitoring required by this permit.

If the laboratory changes during the effective period of this permit, the permittee shall notify the Department of the new laboratory within 30 days after the change.

6. Monitoring Equipment Maintenance

a. The permittee shall calibrate and maintain all monitoring and analytical instrumentation to ensure accuracy of measurements.

b. Environment Article, Section 9-343 provides that any person who falsifies, tampers with, or knowingly renders inaccurate, any monitoring device or method required to be maintained under this permit shall, upon conviction, be punished by a fine of not more than $10,000 per violation, or by imprisonment for not more than six months per violation, or by both.

7. Recording of Results

For each measurement or sample taken pursuant to the requirements of the permit, the permittee shall record the following information:

a. the date, exact place and time of sampling or measurement;

b. the person(s) who performed the sampling or measurement;

c. the dates analyses were performed;

d. the person(s) who performed each analysis;

e. the analytical techniques or methods used; and

f. the results of such analyses.

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8. Additional Monitoring by Permittee

If the permittee monitors any pollutant at the location(s) designated herein more frequently than required by this permit, using approved analytical methods as specified above, the results of such monitoring shall be included in the calculation and reporting of the values required in the Discharge Monitoring Report. The increased frequency shall also be reported. The results of any other monitoring performed by the permittee shall be made available to the Department upon request.

9. Record Retention

All data used to complete the permit application and all records and information resulting from the monitoring activities required by this permit, including all records of sampling and analyses performed, calibration and maintenance of instrumentation, and recordings from continuous monitoring instruments, shall be retained for a minimum of three years. This period shall be extended automatically during the course of litigation or when requested by the Department.

B. General Requirements

1. Permit Noncompliance - Notification Requirements

All discharges authorized herein shall be consistent with the terms and conditions of this permit. If, for any reason, the permittee does not comply with or will be unable to comply with any permit condition, the permittee shall, within 24 hours, notify the Department by telephone at (410) 537-3510 during work hours or at (866) 633-4686 during evenings, weekends, and holidays. The permittee shall provide the Department with the following information in writing within five days of such oral notification.

a. a description of the noncomplying discharge including the name of the stream and the impact upon the receiving waters;

b. cause of noncompliance;

c. the duration of the period of noncompliance and the anticipated time the condition of noncompliance is expected to continue;

d. steps taken by the permittee to reduce and eliminate the noncomplying discharge;

e. steps to be taken by the permittee to prevent recurrence of the condition of noncompliance;

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f. a description of the accelerated or additional monitoring to determine the nature and impact of the noncomplying discharge; and

g. the results of the monitoring described in f. above.

2. Change in Discharge

The permittee shall report any anticipated facility expansions, production increases, or process modifications which will result in new, different or an increased discharge of pollutants by submitting a new application at least 180 days prior to the commencement of the changed discharge except that if the change only affects a listed pollutant and will not violate the effluent limitations specified in this permit, by providing written notice to the Department. Following such notice, the permit may be modified by the Department to include new effluent limitations on those pollutants.

3. Facility Operation and Quality Control

All waste collection, control, treatment and disposal facilities shall be operated in a manner consistent with the following:

a. Facilities shall be operated efficiently to minimize upsets and discharges of excessive pollutants.

b. The permittee shall provide an adequate operating staff qualified to carry out operation, maintenance and testing functions required to ensure compliance with this permit. Superintendents and operators must be certified by the Board of Waterworks and Waste Systems Operators located at Montgomery Park Business Center, 1800 Washington Boulevard, STE- 410, Baltimore, Maryland 21230 in accordance with Title 12 of Environmental Article, Annotated Code of Maryland, and Section 26.06.01 of the COMAR.

c. Facility maintenance work, which adversely affects or may adversely affect the discharge quality shall be scheduled during non-critical water quality periods.

4. Adverse Impact

The permittee shall take all reasonable steps to minimize any adverse impact to waters of this State, human health or the environment resulting from noncompliance with any effluent limitations specified in this permit, and must perform accelerated or additional monitoring as necessary to determine the nature and impact of the noncomplying discharge.

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5. Bypassing

Any bypass of treatment facilities is prohibited unless the bypass does not cause any violations of the effluent limitations specified in Special Condition II.A, and is for essential maintenance to assure efficient operation, or unless the permittee can prove that:

a. the bypass is unavoidable to prevent loss of life, personal injury, or substantial physical damage to property, damage to the treatment facilities which would cause them to become inoperable, or substantial and permanent loss of natural resources; and

b. there are no feasible alternatives to the bypass; and

c. the Department receives notification pursuant to General Condition III.B.1 above. Where the need for a bypass is known (or should have been known) in advance, this notification shall be submitted to the Department for approval at least ten days before the date of the bypass or at the earliest possible date if the period of advance knowledge is less than ten days; and

d. The Department may approve an anticipated bypass, after considering its adverse effects; if the Department determines that it will meet the three conditions listed above in Sections ***a*** through ***c*** of this General Condition III.B.5.

6. Conditions Necessary for Demonstration of Upset

An upset shall constitute an affirmative defense to an action brought for noncompliance with technology-based effluent limitations only if the permittee demonstrates, through properly signed, contemporaneous operating logs, or other relevant evidence, that:

a. an upset occurred and that the permittee can identify the specific cause(s) of the upset;

b. the permitted facility was at the time being operated in a prudent and workman-like manner and in compliance with proper operation and maintenance procedures;

c. the permittee submitted a 24-hour notification of upset in accordance with the reporting requirements of General Condition III.B.1 above;

d. the permittee submitted, within five calendar days of becoming aware of the upset, documentation to support and justify the upset; and

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e. the permittee complied with any remedial measures required to minimize adverse impact.

In any enforcement proceeding, the permittee seeking to establish the occurrence of an upset has the burden of proof.

7. Sewage Sludge Requirements

The permittee shall comply with all State and federal laws and regulations regarding Sewage Sludge Management, and with any regulations promulgated pursuant to Environment Article, Section 9-230 et seq. or to the Clean Water Act, Section 405 (d). A Sewage Sludge Utilization Permit is required for the collection, handling, burning, storage, treatment, land application, disposal, or transportation of sewage sludge, processed sewage sludge, or any product containing these materials in Maryland. If the sludge is hauled out of the State for disposal, a transportation permit must be obtained from the Department.

8. Power Failure

The permittee shall maintain compliance with the effluent limitations and all other terms and conditions of this permit in the event of a reduction, loss or failure of the primary source of power to the wastewater collection and treatment facilities.

9. Right of Entry

In accordance with 40 CFR §122.41(i), the permittee shall allow the Secretary of the Department, the Regional Administrator of the Environmental Protection Agency, and their authorized representatives (including an authorized contractor acting as a representative), upon presentation of credentials and other documents as required by the law, to:

a. Enter upon the permittee's premises where a regulated facility or activity is located or conducted, or where records must be kept under the conditions of this permit;

b. Have access to and copy, at reasonable times, any records that must be kept under the conditions of this permit;

c. Inspect at reasonable times any facilities, equipment (including monitoring and control equipment), practices, or operations regulated or required under this permit; and

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d. Sample or monitor at reasonable times, for the purposes of assuring permit compliance or as otherwise authorized by the Clean Water Act, any substances or parameters at any location.

10. Property Rights/Compliance With Other Requirements

The issuance of this permit does not convey any property rights in either real or personal property, or any exclusive privileges, nor does it authorize any injury to private property, invasion of personal rights, or any infringement of federal, State or local laws or regulations.

11. Reports and Information

a. Upon request, the permittee shall provide to the Department, within a reasonable time, copies of records required to be kept by this permit. The permittee shall also furnish to the Department, within a reasonable time, any information which the Department may request to determine whether cause exists for modifying, revoking and reissuing, or terminating this permit; or to determine compliance with this permit.

b. All applications, reports or information submitted to the Department shall be signed and certified as required by COMAR 26.08.04.01 and 40 CFR 122.22.

c. Except for data determined to be confidential under COMAR 26.08.04.01, all data shall be available for public inspection at the Department and the Office of the Regional Administrator of the Environmental Protection Agency. Effluent data shall not be considered confidential.

d. Environment Article, Section 9-343 provides that any person who knowingly makes any false statement, representation, or certification in any record or other document submitted or required to be maintained under this permit, including monitoring reports or reports of compliance or noncompliance, shall upon conviction be punished by a fine of not more than $10,000 or by imprisonment for not more than six months or by both.

12. Transfer of Ownership or Control

In the event of any change in ownership or control of facilities from which the authorized discharge emanates, the permit may be transferred automatically to another person only if:

III. GENERAL CONDITIONS

a. the current permittee notify the Department, in writing, of the proposed transfer at least 30 days prior to the proposed transfer date;

b. the notice includes a written agreement between the existing permittee and a new permittee containing the specific date of proposed transfer of permit coverage, and of responsibilities and liabilities under the permit; and

c. neither the current permittee nor the new permittee receive notification from the Department, within 30 days of the Department's receipt of the agreement, of its intent to modify, revoke, reissue or terminate the existing permit. If this notice is not received, the transfer is effective on the date specified in the agreement mentioned in paragraph 12(b) above.

13. New Effluent Standards

This permit shall be revoked and reissued or modified to meet any effluent standard, water quality standard or prohibition established under the Environment Article, the Clean Water Act, or regulations promulgated thereto, and the permittee shall be so notified.

14. Industrial Users

The permittee shall require all industrial users of the wastewater treatment facility to comply with user charges as established by the permittee, pursuant to Section 9-326(a)(i) of the Environment Article.

15. Noncompliance

Nothing in this permit shall be construed to preclude the institution of any legal action for noncompliance with State, federal or local laws and regulations.

16. Oil and Hazardous Substance Liability

Nothing in this permit shall be construed to preclude the institution of any legal action against the permittee or to relieve the permittee from any responsibilities, liabilities, or penalties to which the permittee is or may be subject under Section 311 of the Clean Water Act or under the Environment Article.

17. Waterway Construction and Obstruction

The permit does not authorize the construction or placing of physical structures, facilities, debris, or the undertaking of related activities in any waters of this State including the 100 year flood plain.

III. GENERAL CONDITIONS

18. Construction Permit

This permit is not a permit to construct. For a new facility, in order to make this permit valid, a construction permit shall be obtained to meet the requirements of COMAR 26.03.12.03(A) and Environment Article, Section 9-204(d).

19. Severability

If any provision of this permit shall be held invalid for any reason, the remaining provisions shall remain in full force and effect, and such invalid provisions shall be considered severed and deleted from this permit.

C. Wastewater Collection System

This permit shall not authorize discharges from the wastewater collection system for this facility.

1. Reporting Requirements

Pursuant to Environment Article Sub title 9-331.1, the permittee must report sanitary sewer overflows (SSOs) which result in the direct or potential discharge of raw or diluted sewage into the surface waters or ground waters of the State to the Water and Science Administration's Compliance Program. Concurrently, the permittee shall also notify the local health department. Such reports must be made via telephone as soon as practicable, but no later than 24 hours after the time that the permittee became aware of the event. Reportable SSOs include, but are not limited to, overflows into the surface of the ground, into waterways, storm drains, ditches or other manmade or natural drainage conveyances to surface or ground waters which are reasonably likely to reach waters of the State. Overflows that are wholly contained within buildings and not likely to discharge to waterways need not be reported. Treatment plant bypasses shall be reported under General Condition III.B.1. Telephone reports shall be made to (410) 537-3510 on weekdays between 8:00 a. m. and 5:00 p.m. After hours telephone notification shall be made to emergency response number at (866) 633-4686.

When the incident is reported to the Department, the following information needs to be included:

a. the location of the overflow, including city or county,

b. the name of the receiving water, if applicable;

c. an estimate of the volume of sewage discharged;

III. GENERAL CONDITIONS

d. a description of the sewer system or treatment plant component from which the overflow was released (such as manhole, crack in pipe, pumping station wet well or constructed overflow pipe);

e. an estimate of the overflow's impact upon public health and to waters of the State;

f. the cause or suspected cause of the overflow;

g. the estimated date and time when the overflow began and stopped or the anticipated time the overflow is expected to continue;

h. if known at the time of reporting, the steps taken or planned to reduce, eliminate and prevent reoccurrence of the overflow and a schedule of major milestones for those steps; (if unknown at the time the telephone report is made, the steps must be included in the written reports submitted under general conditions III.C.2).

i. if known at the time of reporting, measures taken or planned to mitigate the adverse impact of the overflow and a schedule of major milestones for those steps (if unknown at the time the telephone report is made, the steps must be included in the written reports submitted under general conditions III.C.2); and

j. whether there has already been a notification to the public and other City or County Agencies or Departments and how notification was done.

2. Written Reports

Within 5 calendar days following telephone notification of the event, the permittee shall provide MDE with a written report regarding the incident that includes, at a minimum, the information cited above.

The permittee shall maintain copies of all overflow records and reports, work orders associated with investigation of overflows, a list and description of complaints from customers or others related to overflows (including backups of sewage in to houses or businesses), and documentation of performance and implementation measures for minimum period of three years and shall make this information available to MDE for review upon written request.

This wastewater collection system provision may be superseded by a general permit for collection systems, when such a permit is issued by MDE and the permittee have been accepted for registration under the permit.

III. GENERAL CONDITIONS

3. Other Requirements

The permittee, as directed by the State or local health department, shall also be responsible for posting notification in close proximity to the affected area/stream and for conducting appropriate water quality sampling as deemed necessary.

D. Permit Expiration, Modification, or Revocation

1. Expiration of Permit

This permit and the authorization to discharge shall expire at midnight on the expiration date of the permit unless the permittee has submitted a timely and complete reapplication pursuant to Section II.I.

2. [Reserved.]

3. Permit Modification - Request of Responsible Permittee

A permit may be modified by the Department upon the written request of the permittee and after notice and opportunity for a public hearing in accordance with the provisions set forth in COMAR 26.08.04.10.

4. Permit Modification, Suspension, Revocation - Violation of Laws

A permit may also be modified, suspended or revoked by the Department, in the event of a violation of the terms or conditions of the permit, or of State or federal laws and regulations and in accordance with the provisions set forth in COMAR 26.08.04.10. This permit may be suspended or revoked upon a final, unreviewable determination that the permittee lacks, or is in violation of, any federal, state, or local approval necessary to conduct the activities authorized by this permit.

IV. CIVIL AND CRIMINAL PENALTIES

A. Civil Penalties for Violations of Permit Conditions

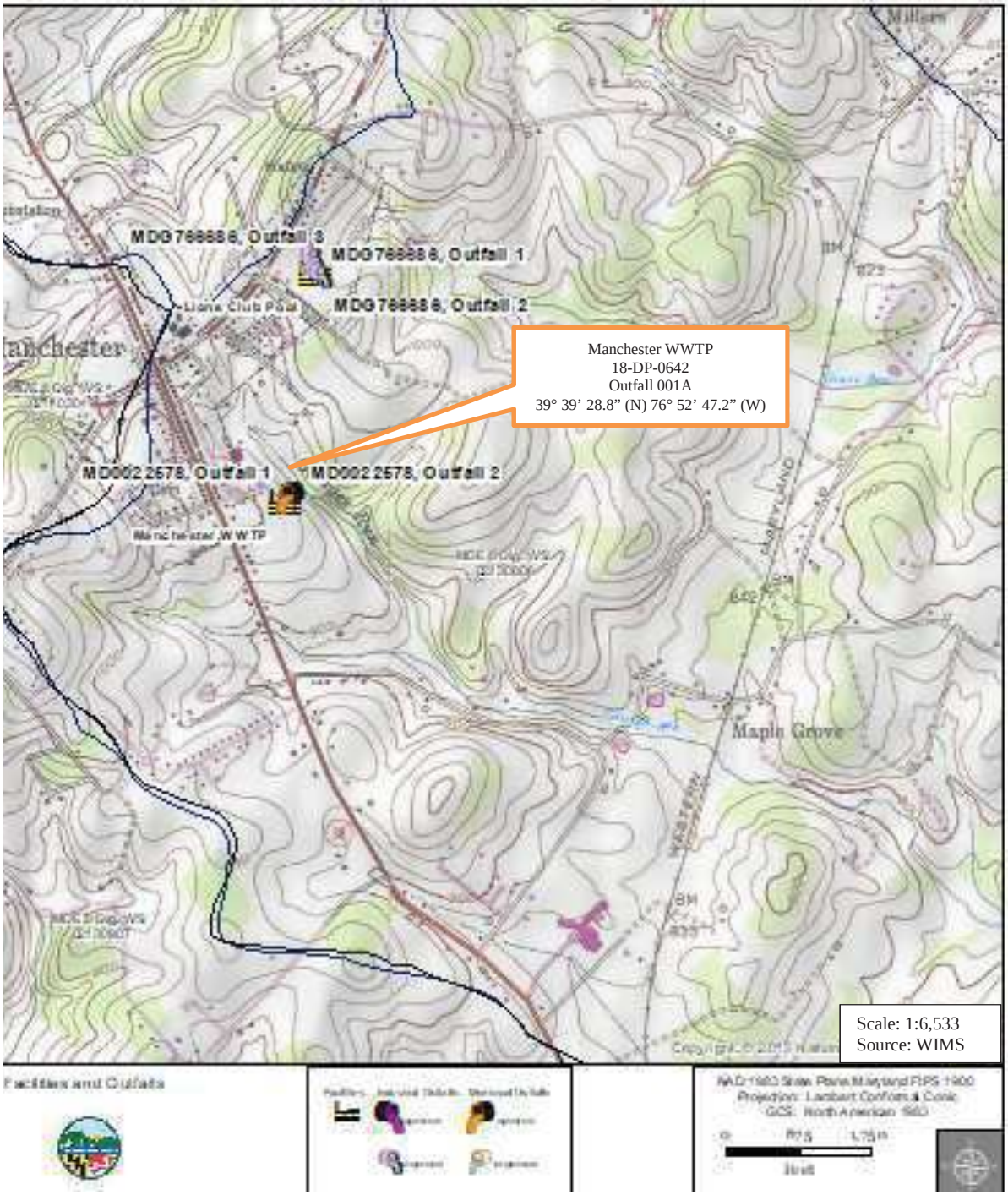
In addition to civil penalties for violations of State water pollution control laws set forth in Section 9-342 of the Environment Article, Annotated Code of Maryland; the Permittee shall be subject to civil penalty set forth in 33 U.S.C. § 1319 (d) of the Clean Water Act as adjusted for inflation according to 40 CFR §19.4.

B. Criminal Penalties for Violations of Permit Conditions

In addition to criminal penalties for violations of State water pollution control laws set forth in Section 9-343 of the Environment Article, Annotated Code of Maryland, the Permittee shall be subject to criminal penalty set forth in 33 U.S.C. § 1319 (c).

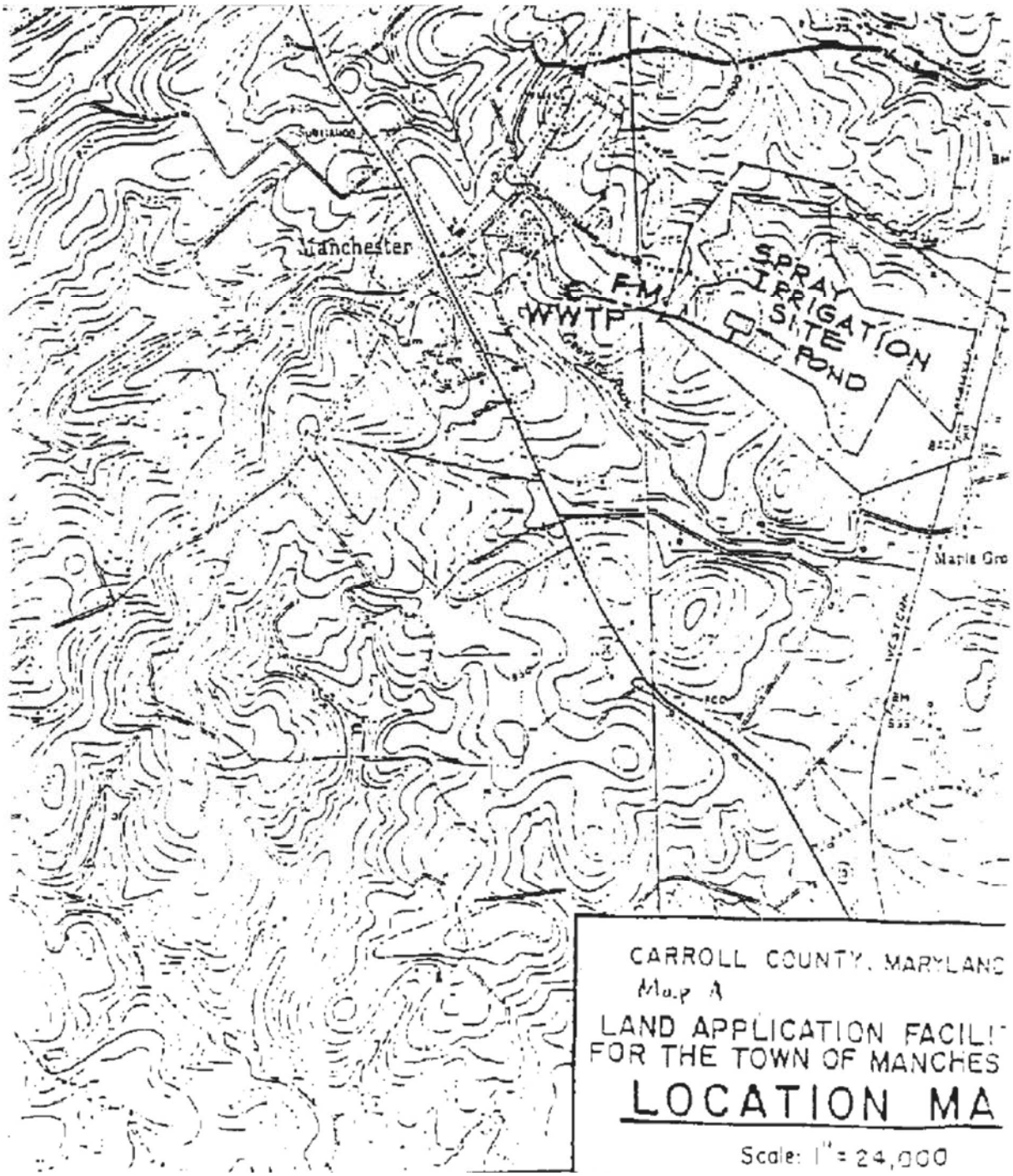
V. MAP SHOWING DISCHARGE POINT LOCATION

MAPF SHOWING LOCATION OF THE OUTFAL 001A FOR SURFACE DISCHARGE



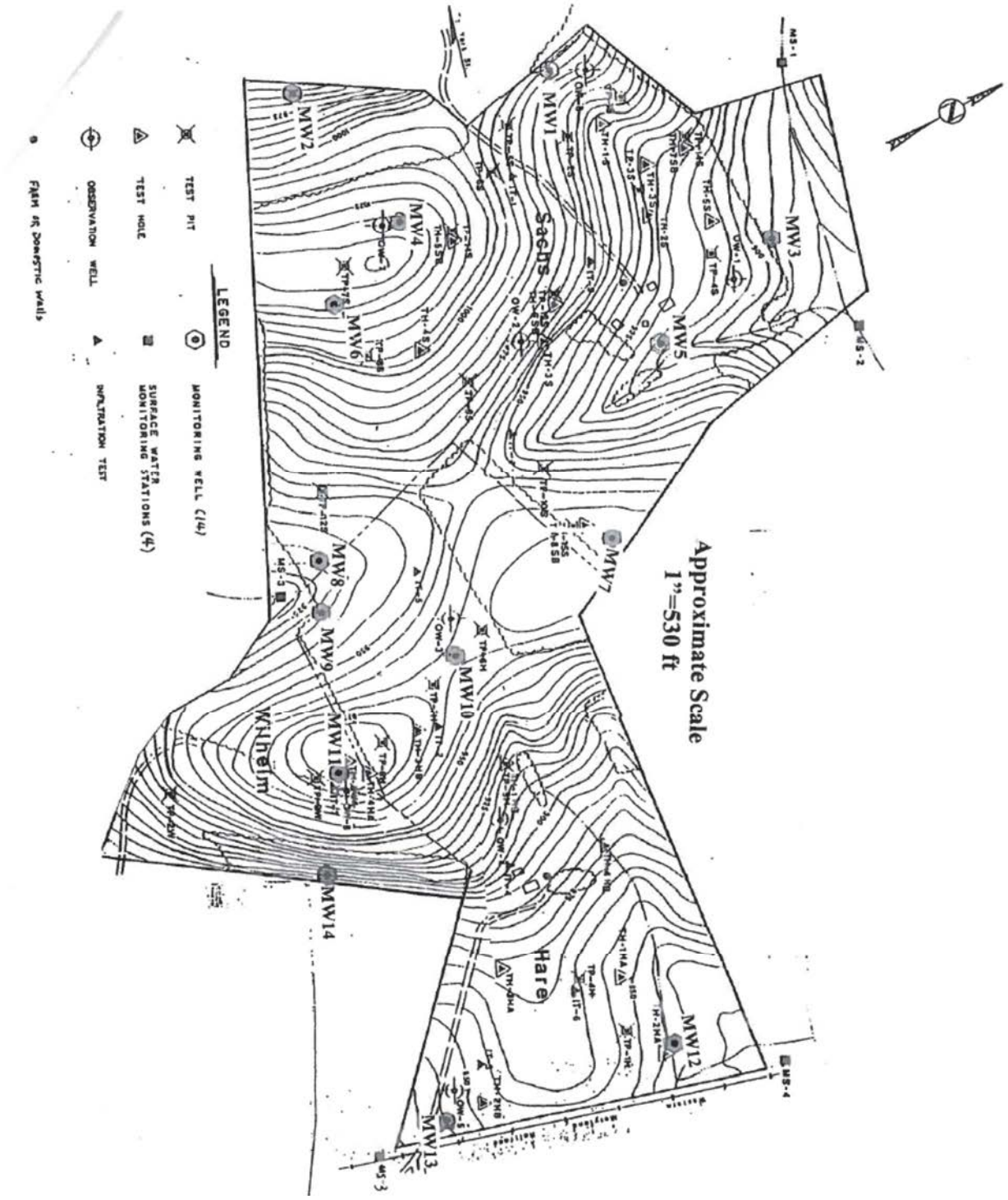
V. MAP SHOWING DISCHARGE POINT LOCATION

MAP SHOWING LOCATION OF OUTFALL 002 FOR LAND APPLICATION FACILITY (MAP A)



V. MAP SHOWING DISCHARGE POINT LOCATION

MAP SHOWING LOCATION OF THE LAND APPLICATION SITE (MAP B)



VI. NPDES PROGRAM

On September 5, 1974, the Administrator of the U.S. Environmental Protection Agency approved the proposal submitted by the State of Maryland for the operation of a permit program for wastewater discharges pursuant to Section 402 of the Clean Water Act.

Pursuant to the aforementioned approval, this discharge permit is both a State of Maryland discharge permit and an NPDES permit.

Heather W. Barthel for (Dec 16, 2021 18:59 EST)

D. Lee Currey, Director
Water and Science Administration

Appendix C - Maryland Class I-III Water Reuse Guidelines

Summary of Maryland Water Reuse Guidelines

Table C-1: Maryland water reuse treatment requirements for Class I through III reuse

Water Quality Parameter	Class I Guidelines	Class II Guidelines	Class III Guidelines
BOD_5	70 mg/L	10 mg/L	10 mg/L
TSS	90 mg/L	10 mg/L	2 NTU
pH	6.5 – 8.5	6.5 – 8.5	6.5 – 8.5
Fecal coliform	200 MPN / 100 mL	3 MPN / 100 mL	2.2 MPN / 100 mL

AMENDED: 04/2010

MARYLAND DEPARTMENT OF THE ENVIRONMENT

GUIDELINES

FOR

LAND APPLICATION / REUSE

OF

TREATED MUNICIPAL WASTEWATERS

MDE-WMA-001-04/10

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1. PURPOSE

The purpose of these guidelines is to provide information regarding the State of Maryland's coordinated approach to the land application of municipal wastewater. Major emphasis is placed on site selection and evaluation, and the procedures followed in processing applications for land-treatment systems regulated by State Groundwater Discharge Permits. The criteria presented in the guidelines apply primarily to municipal wastewaters. However, these criteria may also be helpful to individuals involved in the development of land-treatment systems for the treatment and disposal of other organic wastewaters. All criteria reported in this manual are subject to exception, and changes will be considered on a case-by-case basis. Deviation from the criteria reported herein must be discussed with the Maryland Department of the Environment prior to the incorporation of the deviations into written documents such as Facilities Plans or design processes.

This document is not intended to function as a "cookbook" for design engineers, nor is it intended to suppress the state-of-the-art by enacting overly restrictive guidelines. It is, however, intended to function as a guide for private developers or municipalities and their consultants. In summary, it is hoped that the guidelines will expedite the implementation of land-treatment systems, where appropriate, while safeguarding the integrity of surface and groundwaters of the State.

2. INTRODUCTION

Ever since the first community was established, man has had to face the problem of regional waste disposal in one form or another. In the past, surface waters provided a means of disposal. The relatively large volume of surface water usually contained in rivers located adjacent to the communities diluted the discharged wastes and transported them away from the point (or points) of entry.

As the communities grew into towns and towns into cities, the volume of wastes requiring disposal grew accordingly. The increased waste load exerted an ever-increasing stress on the surface waters to assimilate this waste. In many waterways throughout the United States and other parts of the world, the assimilative capacity has been exceeded, producing in many cases, a state of accelerated eutrophication.

Along with man's increasing numbers has come both a more thorough understanding of his environment and significant technological advances. Sewage treatment plants are now capable of producing effluent of a much higher quality than ever before. Unfortunately, as the level of treatment increases, so does the cost. From a water-resources management standpoint, discharging treated municipal wastewater directly into surface waters has two major disadvantages. First, although treated and disinfected, most wastewaters contain relatively high levels of nitrogen, phosphorous, and organics in various forms. Unless advanced treatment is performed, these constituents contribute to the eutrophic progression of the receiving waters. Second, the waters collected in a particular basin are typically used by a municipality located within that basin and transported to a sewage treatment plant also located within that basin.

However, once the sewage is treated, it is discharged into a surface waterway and removed from the basin. Consequently, the water supply basin is never recharged by water collected within that basin and must rely entirely upon natural rainfall for recharge.

An alternative method of wastewater treatment and disposal has been used for at least a century, although only recently to any significant degree. This alternative is referred to as land application. The technique involves the application of treated wastewater to the land surface in any of several methods. The three most common methods of application are: 1) spray irrigation, 2) overland flow, and 3) rapid infiltration. Through the physical, chemical, and biological mechanisms operating in the soil, several important benefits can be obtained by using land [treatment] application. The three most important benefits are: 1) the concentrations of BOD, total suspended solids, bacterial and viral organisms, as well as the nutrients responsible for the acceleration of eutrophication are all greatly reduced as the wastewater infiltrates and percolates through the soil profile; 2) the nutrients removed by the soil can be available to support or increase the growth of vegetation occupying the site; and 3) the renovated wastewater percolates through the soil profile and recharges the groundwater system.

Based upon studies conducted by universities and government agencies, land application has proven to be both a feasible and an effective method of renovating and recycling wastewater. So wide has been its acceptance that the Environmental Protection Agency, through amendments PL 92-500 and PL 95-217 to the Federal Water Pollution Control Act, has required that land application be evaluated during the waste treatment Facilities Planning stage. On October 1, 2002, Section 9-303.1 of the Annotated Code of Maryland became effective. It stipulates that the Department shall encourage the use of reclaimed water as an alternative to discharging wastewater effluent into surface waters and authorizes the Department to establish buffer and setback requirements for the use of reclaimed water. These measures are not intended to force municipalities into using land application techniques, but are intended more to insure that techniques aimed at recycling and reuse of wastewater receive appropriate attention. To promote the reuse of reclaimed water, the Department amended the guidelines in 2009 to include the irrigation of highly treated Class III effluent in the non-restricted public access areas including parks, play grounds, school yards, cemeteries, highway landscapings and other green open spaces. Similar to Classes I and II effluent shown in Table 1, a State Groundwater Discharge Permit/ General Permit is required for irrigating Class III effluent.

In accordance with COMAR 26.08.04.02 entitled “Requirements for the Issuance and Reissuance of Discharge Permits,” the Department may issue or reissue a discharge permit to a sewage treatment works if the treatment works and the sewerage systems, including the pumping stations, are in compliance with the approved county water and sewerage plan (Plan) adopted under Environment Article, Title 9, Subtitle 5, Annotated Code of Maryland. For a community or multi-use sewerage system using any class of effluent for land application of treated wastewater, the sewerage system will be considered in compliance with the Plan if that plan specifically identifies the wastewater treatment plant and its capacity, and identifies the area to be served by it as S-1 or S-2 (as defined in COMAR 26.03.01.04G(2)), and the project is otherwise in compliance with the Plan. This requirement shall not apply if a facility is not required by State and County law to be included in the county’s water and sewerage plan.

3. REQUIREMENTS FOR LAND APPLICATION

Basically, there are two types of requirements for land application/reuse of municipal and agricultural wastewaters: pre-application treatment and site requirements.

Pre-application treatment requirements pertain to the quantity and quality of the effluent or treated wastewater that is to be applied to the land. The wastewater constituents of most importance to land application are BOD (biochemical oxygen demand), SS (suspended solids), pH, total and fecal coliforms, dissolved salts, and nitrogen compounds. Generally, these constituents, more than any others, determine how effective land application will be in renovating wastewater and what effect the wastewater will have on the soils and ultimately the groundwaters of the state.

Site requirements are expressed in terms of geologic, soil, and hydrologic characteristics that have a direct or indirect influence on the ability of a site to renovate and recycle wastewater. All three characteristics are interrelated and are at least as important as effluent requirements in affecting the success or failure of a land-treatment system. For each type of land application, there exists an optimum geology-soils-hydrology scheme or combination. A scheme that works well for one type of land application may not work at all for another type.

In the following sections, each of the major types of land application will be discussed along with the important effluent and site requirements that must be satisfied to ensure its effectiveness as a treatment process. These land application types are slow rate, overland flow and rapid infiltration. For protecting the public health and groundwater quality, wastewater must be pretreated to meet the effluent quality requirements prior to land application. The minimum pre-application treatment requirements for all land application systems are shown in Table 1. In areas where site characteristics are marginal for land application, the effluent requirements shown in Table 1may be more strigent. The effluent sampling location is typically located after the pre-treatment process but prior to the land application system. For a land application system with a storage pond, effluent may be sampled prior to discharging to the storage pond. Table 2 is located at the end of the section and contains a summary of the site requirements for the major types of land application.

3.1, Slow Rate

The term "slow rate" applies to all systems that uniformly apply treated wastewater to the surface of the receiving site with the understanding that the wastewater will infiltrate into and percolate through the soil profile. Once the wastewater enters the soil, one of four consequences will be realized: (1) it will eventually return to the surface through capillarity and be lost to evaporation, (2) it will be taken up by plant roots and be lost to transpiration, (3) it will be stored within the soil and produce a change in soil moisture, or (4) it will percolate downward until the groundwater table is encountered. As the wastewater moves through the soil, most of the organic and inorganic constituents are removed, some of which will be decomposed and taken up by plants while others will be immobilized within the soil matrix.

3.1.1. Examples of slow-rate systems

1. piped irrigation
    a. spray irrigation

b. bubbling pipe irrigation
c. drip irrigation

2. open channel irrigation
a. ridge and furrow
b. flooding

. For slow rate systems, the guidelines recognize three levels of pre-application treatment as shown in Table 1. there are three classes of effluent quality. Class I with a moderate effluent quality is likely achievable by a lagoon or secondary biological treatment systems. Irrigation with Class I effluent requires a larger buffer zone than Class II and Class III which have higher effluent qualities.

Table 1. Minimum Pre-Application Treatment Requirements for Various Land Application Systems[a]

Parameter	Slow Rate			Overland Flow	Rapid Infiltration
	Class I	Class II	Class III		
5 day - Biochemical Oxygen Demand (monthly average)	70 mg/l	10 mg/l	10 mg/l	70 mg/l	Case by case
Suspended Solids (monthly average) or Turbidity (NTU) (continuous monitoring)	90 mg/l	10 mg/l	2 NTU (daily average) Not to exceed 5 NTU at any time	90 mg/l	Case by case
Fecal Coliform [a] (MPN per 100 mL; monthly geometric mean)	200 3 (golf courses)	3	2.2	200	Case by case
pH	6.5 - 8.5	6.5-8.5	6.5-8.5	6.5 - 8.5	6.5-8.5

a Higher levels of treatment and disinfection may be required under certain conditions such as a land application site located in a well head protection area with a significant amount of rock fragments in the soil.

3.1.2. Site requirements for slow-rate systems

3.1.2.1. Soils

1. minimum of four 4 feet depth to groundwater or bedrock, except on the Eastern Shore where a minimum of 2 feet should exist between the soil surface and the groundwater table.
2. moderately slow to moderately rapid permeability (0.2 to 6 inches per hour) in the most restrictive soil horizon.
3. U.S.D.A. textures ranging from clay loams to sandy loams.
4. moderately well to excessively well drained.

3.1.2.2. Slopes

Slopes not to exceed 15% on cultivated lands and 25% on uncultivated (forested) lands. For underground drip irrigation systems, higher sloped areas may be acceptable, if system installation is feasible and seepage at lower elevations can be eliminated.

3.1.2.3. Vegetation

A complete vegetational cover is required. It can be natural, as in the case of forest, or it can be planted, as in the case of cultivated fields.

3.1.2.4 Buffer

Class I Effluent

For irrigating Class I Effluent with water quality defined in Table 1**,** a minimum buffer zone of 200 feet shall be provided between the wetted perimeter of spray irrigation areas and property lines, waterways, roads, etc. For residential properties, parks, and other areas where people congregate, a 500-foot buffer between the wetted perimeter and structures on these properties shall be provided. A reduction of these buffer zone widths by up to 50% will be considered where it is demonstrated that an adequate windbreak will be provided to prevent spray from carrying beyond the irrigation area.

Class II Effluent

For irrigating Class II Effluent with water quality defined in Table 1, the buffer zone widths shall be 25 feet from property lines, housing structures, public roads and streams, 50 feet from schools and playgrounds, and 100 feet to potable wells and water intakes.

Class III Effluent

For irrigating Class III Effluent with water quality defined in Table 1, a minimum buffer zone of 100 feet shall be provided between the wetted perimeter of the irrigation areas and potable wells and water intakes. A minimum buffer zone of 100 feet shall be provided between the wetted perimeter of the irrigation areas and outdoor licensed public eating, drinking and bathing facilities.

Other Types of Slow Rate Systems

Slow rate systems not generating aerosols, such as a drip irrigation system and a ridge and furrow system, will have a minimum buffer zone of 50 feet from property lines, housing structures and public roads, and 100 feet to potable wells and streams**.**

3.1.2.5 Storage

A means for wastewater storage must be provided at each slow rate system to accommodate flows generated during those periods when the treated wastewater cannot be applied to the land. Since climatic influences vary geographically, storage capacity requirements will be dependent upon the location of the system. However, a minimum of 60 days storage should be provided for all spray irrigation systems receiving wastewater flows throughout the year. A minimum of 30 days storage should be provided for all underground drip irrigation systems receiving wastewater throughout the year. The Department will consider varying these presumptive storage requirements where Class III effluent is directly transmitted from a wastewater treatment plant for irrigation to meet vegetation water demand and an alternative means of discharge is available for periods when land apploication is not feasible.

3.1.2.6 Reserved Area

For a spray irrigation system, a reserved area of 25% of the total wetted field area shall be provided to maintain adequate capacity for wastewater disposal in the event that initial irrigation area is determined to be inadequate to meet the application needs.. For an underground drip irrigation system, a reserved area of 100% of the total wetted field area shall be provided. For Class III Effluent irrigation, no reserve area and no groundwater monitoring are required if the irrigation rate is equal to or less than the consumptive demand of the vegetation and adequate storage and/or alternative means of discharge is provided.

3.1.3. Application rates and loading cycles

The application rate or hydraulic-loading rate of a given system is dependent upon both the effluent and site characteristics. However, application rates for slow-rate systems generally range between 0 and 2 inches per week on an annual average basis. Slow-rate systems generally operate on a one-day load, six-day rest cycle. To determine the application rate suitable to the soil type at the proposed site, infiltration tests should be conducted. Infiltration tests should be conducted by using the Double-Ring Infiltrometer Method or the Basin Infiltration Method outlined in the Appendix A. The application rate shall not be greater than 4% of the steady infiltration rate measured from the Double- Ring Infiltrometer or shall not be greater than 10% of the steady infiltration rate measured from the Basin Infiltration test. Other infiltration test methods comparable to the above two methods may be acceptable upon approval by the Department.

3.1.4. Additional Class III Effluent Irrigation Requirements

1. Irrigation of Class III effluent on fruit and vegetables not commercially processed, including crops eaten raw, is prohibited.

2. Vegetation water demand varies with type of vegetation to be irrigated. The applicant shall submit vegetation water demand data with the discharge permit application to MDE. If irrigation of Class III effluent in the non-restricted public access areas is to meet the vegetation water demand only, no hydrogeological investigation of the proposed site is necessary.. If the irrigation rate of Class III effluent is greater than the vegetation water demand, the applicant shall conduct a

hydrogeological study or an irrigation pilot study to ensure that the irrigation rate will not cause persistent surface runoff, ponding, and contributions of nutrients or other health concerned chemicals to groundwater.

3. Irrigation of Class III effluent on bare soil is prohibited except for providing adequate moisture for seed germination in the seeding area. The irrigation area shall be planted with healthy vegetation cover. Irrigation on high water table or saturated soils which cause persistent surface runoff and ponding is prohibited.

4. "Reclaimed Water, Do Not Drink" signs shall be posted in the irrigation area to inform the public about irrigation of treated wastewater. A sign shall be posted at each entrance to the site and visible to the public with a size greater than 4 inches in height and 8 inches in width. Purple shall be the prominent color of the sign.

3.2 Overland Flow

The term "overland flow" applies to all systems that uniformly apply wastewater through the use of pipes or surface trenches to the sloped surface of the receiving site with the understanding that the wastewater will move laterally along the surface of the soil and be collected at the lowest point along the travel by drainage tile, surface trenches, or other collection structures. After collection, the renovated wastewater is recycled through the overland system a second time, or discharged directly into surface water, or land applied. The wastewater is renovated by physical, chemical, and biological processes present at the soil-vegetation interface as it flows in a thin film down the relatively impermeable slope.

Minimum pre-application treatment requirements for overland flow systems are given in Table 1.

3.2.1 Site requirements for overland-flow systems

3.2.1.1 Soils

1. minimum of 6 to 12 inches in depth.
2. very slow to moderately slow permeability (0.06 to 0.2 inches per hour).
3. U.S.D.A. textures ranging from clays to heavy clay loams.

3.2.1.2. Slope

Slopes should range from a minimum of 2% to a maximum of 8%.

3.2.1.3. Vegetation

A complete vegetational cover is required. It can be natural, as in the case of forest, or it can be planted, as in the case of cultivated fields.

3.2.1.4. Buffer

All types of overland flow systems should be surrounded by a minimum buffer zone of 50 feet.

3.2.1.5 Storage

A means of wastewater storage must be provided at each land-treatment system to accommodate flows generated during those periods when the treated wastewater cannot be applied to the land (e.g., frozen soil conditions, rain storms, etc.). Since climatic influences vary geographically, storage capacity requirements will be dependent upon the location of the system. However, a minimum of 60 days storage must be provided for all systems receiving wastewater flows throughout the year.

3.2.1.6 Reserved Area

Same as slow-rate system.

3.2.2. Application rates and loading cycles

The application rate or hydraulic loading rate of a given system is dependent upon both the effluent and site characteristics. Typical application rates for overland flow systems range from 2.5" to 8" per week for secondary effluent. Loading cycles for overland-flow systems generally range from 6 to 8 hours on and 16 to 18 hours off, for 5 to 6 days per week, depending upon the time of year.

3.3 Rapid Infiltration

The term "rapid infiltration" applies to all systems that apply wastewater through the use of excavated and/or bermed structures to subsurface soils under a positive hydraulic head with the understanding that the applied wastewater will move in a predominately vertical direction through the soil until the groundwater table or bedrock is encountered. The wastewater is renovated by physical, chemical, and biological processes present in the soils through which it moves. In rapid-infiltration systems, over 90 percent of the wastewater applied eventually reaches and recharges the groundwater. The remainder is lost to evaporation or is stored in the soils beneath the structure and above the underlying groundwater table.

As shown in Table 1, the pretreatment requirements for the rapid infiltration system are determined on a case- by -case basis depending on infiltration rate, water table depth and proximity to the drinking water source.

3.3.1 Site requirements for rapid-infiltration systems

3.3.1.1.Soils

1. a minimum of 10 feet of unsaturated soil between the bottom of the infiltration pond and the underlying groundwater or bedrock.
2. moderately rapid to very rapid permeability (2.0 to 20 inches per hour).
3. U.S.D.A. textures ranging from sandy loams to sands.

3.3.1.2. Buffer

All types of rapid infiltration systems should be surrounded by a minimum buffer zone of 50 feet.

3.3.1.3. Reserved Area

Same as slow-rate system.

3.3.2 Application rates and loading cycles

The application rate or hydraulic loading rate of a given system is dependent upon both the effluent and site characteristics. In general, application rates for standard rapid infiltration systems range from 5 to 100 inches per week. The systems are typically loaded for 1 to 2 days then allowed to rest for 1 to 14 days, depending upon the hydraulic conductivity of the soils and the depth to groundwater. Determination of application rate is the same as slow-rate system described in the previous section.

Table 2. Summary of Site Requirements for Various Types of Land Application Processes.

Site Requirements	Land-Application Processes		
	Slow Rate	Overland Flow	Rapid Infiltration
Soils			
Depth to Groundwater	4 ft. min. 2 ft. min. (Eastern Shore)	Not Critical	10 ft. min. (standard)
Permeability	mod. slow to mod. rapid	very slow to mod. slow	mod. rapid to very rapid
USDA Texture Class	clay loam to sand loam	clay to heavy clay loam	sandy loam to sand
Slopes	15% max. for cult. 25% max. for uncult.	2-8%	--
Buffer Requirements			
to property lines, roads, etc.	Class I effluent: 200 ft. for spray, 50 ft. for drip; Class II effluent: 25 ft; Class III effluent: no buffer required	50 ft.	50 ft.
to buildings	Class I effluent: 500 ft. for spray, 50 ft. for drip; Class II effluent: 25 ft; Class III effluent: 100 ft to licensed public eating, drinking and bathing facilities	50 ft.	50 ft.
to potable wells and water intakes	100 feet	100 feet	100 feet
Storage	60 days min. for spray irrigation and 30 days for drip irrigation, No storage is required for irrigating Class III effluent in meeting vegetation demand and alternative discharge is available during inclement weather	--	--
Annual Average	0-2 in./week	2.5-16 in./week	5-100 in./week

Site Requirements	Land-Application Processes		
	Slow Rate	Overland Flow	Rapid Infiltration
Application Rates			
Loading Cycles	1 day load, 6 days rest	6-8 hrs. load, 16-18 hrs. rest	1-2 days load, 1-14 days rest

4. STATE AND COUNTY COORDINATED APPROACH TO LAND APPLICATION

Systems involved in the land application/reuse of municipal wastewater fall within the administrative jurisdiction of the Maryland Department of the Environment. In addition, each county government has the responsibility of evaluating any new development with respect to incorporation of the new development into their Ten-Year Comprehensive Water and Sewerage Plan. State processing of a groundwater discharge permit application for a new development project will not be started until the development project is incorporated into the approved County Water and Sewerage Plan as indicated in the "Introduction" section of this document.

The Maryland Department of the Environment regulates the development and operation of land-application systems through the Groundwater Discharge Permit Program and regulates the design, funding, and installation of land-application systems through the MDE Wastewater Construction Permit Program.

A hypothetical situation has been developed to clarify the procedures involved in obtaining State and County authorization for the development, design, installation, and operation of land-application systems. The following example applies to both privately and publicly owned facilities.

A community has increased in size to such a point that their sewage treatment plant, which ultimately discharges into a nearby river, can no longer handle the increased flows. Consequently, the community is faced with an expansion and possible upgrading of their treatment facility. An engineering consultant is employed by the community to develop a Facilities Plan for the new sewage treatment plant. An important phase of the Facilities Plan is to investigate and evaluate the feasibility and cost effectiveness of land application as an alternative to surface discharge. The following is an outline of the major steps to be followed by the consultant and community planners:

Step	Action
1.	Contacts State (Maryland Department of the Environment) and local agencies for information regarding land-application systems.
2.	Acquires soils information from Soil Conservation Service and other pertinent information necessary to identify prospective land-application sites.
3.	Acquires necessary permission from appropriate landowners for site evaluations.
4.	Sends a letter to the Maryland Department of the Environment requesting a site evaluation. The letter includes the following: a. map(s) of proposed area(s) in scale of 1 inch equals 200 feet or larger scale; b. project flows; c. acreage of site(s); d. proposed application rate(s).
5.	Sets up preliminary site visit. The Project Manager request that a backhoe be available for preliminary site evaluation (at applicants expense). Based upon outcome of preliminary site evaluation, the Project Manager will make one of three recommendations: 1) that site is acceptable; 2) that site is conceptually acceptable, but a more detailed hydrogeologic study must be completed (at applicants expense); or 3) that site is not acceptable for land application. An

Step	Action
	outline for the comprehensive hydrogeologic study can be found in Appendix **B**. The detailed study is conducted by a qualified consultant chosen by the applicant.
6.	If conceptual approval is given for a particular site by the project manager, the applicant may proceed with a hydrogeologic study and addresses the items outlined in Appendix B in a hydrogeological report. At the same time, an application should be filed to appropriate County agencies for the inclusion of the project in the County Ten-Year Water and Sewerage Plan and any other appropriate planning and zoning programs.
7.	Upon completion of a hydrogeologic study, the applicant shall forward a copy of the hydrogeologic report to the Department for review and approval. The applicant may file a groundwater discharge permit application to the Department if the project is incorporated into the County Master Water and Sewerage Plan. If a public hearing is requested after publication of a tentative determination, the Department may schedule a hearing. At the public hearing, all pertinent testimony, both for and against the permit, will be taken by the hearing officer. If information is presented at the hearing which indicates that the land application system will result in adverse effects on the environment or public health, the permit may be modified or canceled. If no adverse information is presented, the permit will be finalized and issued, usually for a period of 5 years.
8.	After the applicant receives a State Groundwater Discharge Permit, appropriate applications should be made to the Maryland Department of the Environment for a State Construction Permit.

The preceding procedure will be followed whether it be in relation to a waste treatment Facilities Plan (as in the above hypothetical situation), an investigation resulting from an enforcement action taken against a violator unable to meet State Surface Water Discharge Permit requirements, a new privately owned development, or any other application for a permit to discharge wastewaters into the groundwater of the State via land application.

The comprehensive outline for the hydrogeologic study (given in Appendix B) is presented as a guide. The actual information that will be requested in the detailed study for any given project will depend upon the volume of wastewater, and the effluent and site characteristics of the project.

Two important parameters of any land-application system are the water and nutrient balances. The major components of a water balance are natural precipitation wastewater loading, and surface runoff. An example of the calculation of a water balance is given in Appendix **C.**

In some land-application systems, the nutrient input and not the hydraulic input is the deciding factor as to whether the system will have a detrimental effect on the environment. Nitrogen generally seems to be the most limiting nutrient with respect to groundwater quality. For this reason, an example of a nitrogen balance is given in Appendix D. To meet the drinking water standard of nitrate, a 10 mg/l nitrogen concentration in the percolate should be used for nitrogen balance calculations. However,

groundwater discharge that may impact impaired surface water body, the Department will determine the nitrogen input from the percolate on a case by a case basis.

There are many different methods used to calculate both water and nitrogen balances. Those described in the Appendices are two of the more common methods.

Besides water and nitrogen balances, where a land application system receives wastewater containing heavy metals from industrial discharges, a study to evaluate the potential impact of heavy metal discharge on groundwater quality must be conducted.

5. GROUNDWATER QUALITY MONITORING REQUIREMENTS

5.1 Monitoring Networks:

One of the basic or prime objectives of a monitoring program is to detect existing groundwater degradation caused by disposal of municipal wastewater. Where a potential for contamination exists, an assessment of the problem must be made to determine control strategies for a particular disposal site. Groundwater monitoring will play an important part in assessing and providing long-term verification of the integrity of the system.

5.2 Monitoring Design:

The following data should be carefully evaluated in designing a monitoring network: 1) groundwater flow direction; (2) location of nearby private wells; (3) subsurface geology including the hydraulic conductivity and porosity of each soil and rock formation; (4) present or future effects of domestic or commercial pumping on the flow system; and (5) existing groundwater quality. The existing groundwater quality would serve as a basis for later comparison. Analysis should include dissolved solids, nitrate, total phosphorus, and total nitrogen, depending on the chemical composition of waste.

5.3 Numbers of Monitoring Wells:

To detect groundwater contamination, a monitoring-well network should consist of the following:

(1) At least two wells, adjacent to the Property line downgradient from the disposal site, which are screened from the seasonally high groundwater table downward 15 feet.

(2) Monitoring wells (at least one) completed in an area upgradient from the disposal site so that it will not be affected by potential contaminants.

5.4 Specifications for Installation of Groundwater Monitoring Wells

Each monitoring well must be constructed utilizing 4" I.D., schedule 40, PVC pipe or casing satisfactory to the Department.

All related permits must be obtained before wells are installed by a well driller licensed by the State of Maryland in accordance with all laws and regulations.

The well shall be gravel packed to at least five feet above the top of the screen unless multiple aquifers are affected.

The screened interval must consist of at least 15 feet of schedule 40, 4" (103 mm), slotted PVC well screen.

Wells must penetrate a minimum of 15 feet below the groundwater table.

The well shall be continuously pressure grouted from top of gravel pack to ground surface. The well shall also be developed and disinfected prior to sampling according to Maryland well construction regulations, COMAR 26.04.04.

A copy of the well completion report must be submitted to the Maryland Department of the Environment.

5.5 Additional Monitoring:

Whenever the original monitoring network indicates groundwater degradation, steps must be taken to determine cause and if necessary the corrective measures taken. These measures may include construction of additional wells to determine lateral and vertical extent of contamination direction, rate of movement, dilution and attenuation, etc. Further quantitative studies can be performed to determine the exact nature of contamination. These studies will aid in determining the proper corrective measures needed to abate the problem.

5.6 Sampling Techniques:

The primary concern in sample withdrawal methods is to obtain a representative sample of groundwater. Stagnant water shall be removed so that the sample collected is fresh. Normally three volumes of stagnant water are pumped out prior to taking samples. Withdrawal methods may include pumps, compressor air, or boilers.

To protect against collection of non-representative, stagnant-water sample withdrawal, the guidelines and techniques outlined in EPA's Procedures Manual for GW Monitoring at S.W. Disposal Facilities pp. 220-237 "Sample Withdrawal, Storage and Preservation" is helpful. Other useful references for sample collection and preservation are also included in the references section.

5.7 Monitoring Frequency:

Monitoring frequency for a disposal site may be influenced by a number of factors and thus will be addressed on a case-by-case basis through individual State groundwater discharge permits.

6. REFERENCES

1. Culp, R.L., G.M. Wesner, and G.L. Culp (1978). "Handbook of Advanced Wastewater Treatment," Van Nostrand Reinhold Company.

2. Delaware Department of Natural Resources and Environmental Control (1981). "Field Manual for Ground Water Sampling," Dover, Delaware.

3. Sopper, W.E. and L.T. Kardos (1973). "Recycling Treated Municipal Wastewater and Sludge through Forest and Cropland," pp. 479. The Pennsylvania State University Press, University Park and London.

4. Stone, J.E. (1976) "Land Application of Wastes: Nitrogen Considerations". Module 15. Educational Program. Cornell University, New York State College of Agriculture and Life Sciences, Ithaca, New York.

5. U.S. Environmental Protection Agency (1987), "Handbook, Ground Water", EPA 625/6-87/016.

6. U.S. Environmental Protection Agency (2006) "Process Design Manual, Land Treatment of Municipal Wastewater Effluents," EPA 625/R-06/016

APPENDICES

Appendix A

Methods for Soil Infiltration Test

(1). Double-Ring Infiltrometer Test

ASTM Standard D-3385 entitled "Standard Test Method for Infiltration Rate of Soils in Field Using Double-Ring Infiltrometer," ASTM International, www.astm.org.

(2). Basin Test - Excerpted from U. S. E. P. A. "Process Design Manual – Land Treatment of Municipal Wastewater Effluents" EPA/625/R-06/016 (September, 2006).

All infiltration tests should always be run at the actual locations and depths that will be used for the operational system. This is especially important for SAT systems. Pilot-scale basin tests are strongly recommended. These should be at least 9.3 m2 (100 ft2) in area, located in the same soil zone that will be used in the full-scale system. Construction of the test basin should be done with the same techniques that will be employed full scale. The test basin should then be operated for several weeks using the same wet and dry cycles that are planned for full scale. A typical small-scale pilot test basin is illustrated in Figure 3-12.

The number of test basins required will depend on the system size and the uniformity of the soils and topography. One will serve for relatively small systems with uniform soils. In larger systems a separate basin should be used for every major soil type, which may require one basin for every 2-4 ha (5-10 acres) of total system area. When extremely variable conditions are encountered, the test basin should be full sized (0.4 to 1.2 ha or 1 to 3 acres) to insure reliability. If successful, it can then be incorporated into the operational system.

A smaller-scale basin type test has been developed by the U.S. Army Corps of Engineers (Abele et al., 1980). The purpose was to have a reproducible procedure with a larger surface area and zone of influence than existing infiltrometers and permeameters. The test facility prior to flooding (note the cylinder infiltrometer in the right foreground) is illustrated in Figure 3-13. The metal ring is aluminum flashing and is 3 m (10 ft) in diameter. Installation details are provided in Figure 3-14 and Figure 3-15.

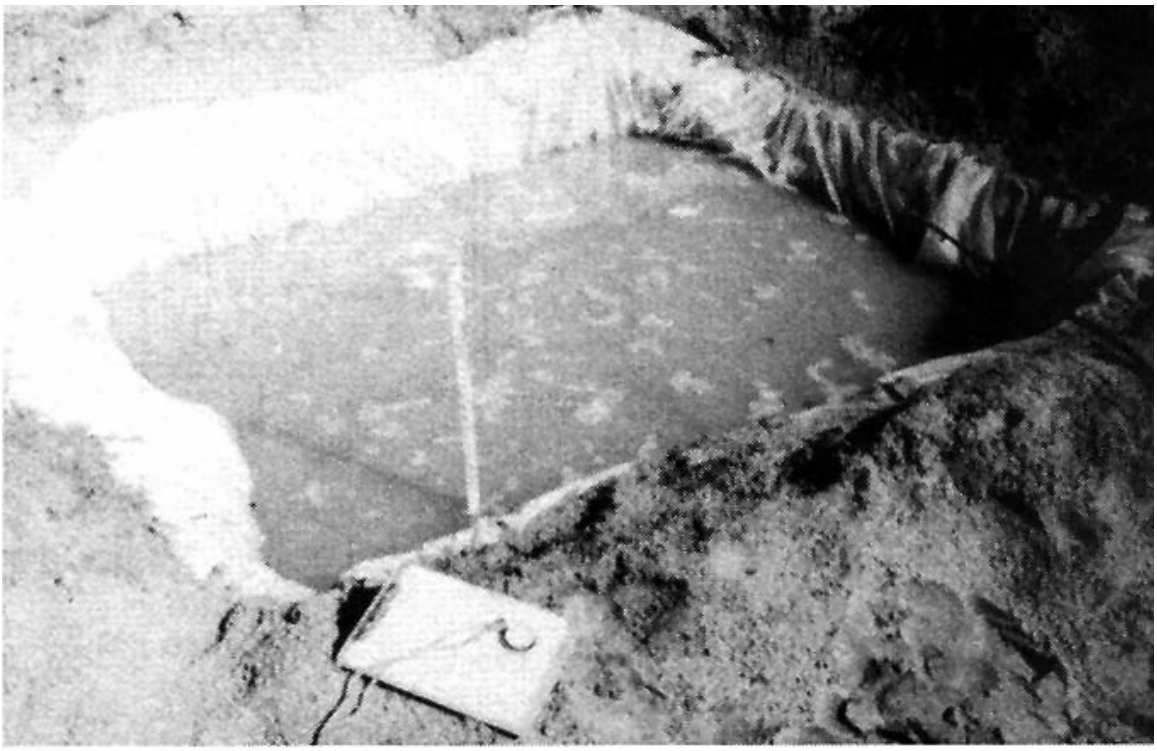


Figure 3-12. Small-scale Pilot Test Basin (Crites, et. al., 2000).



Figure 3-13. U.S. Army Corps of Engineers (USACE) Basin Test.

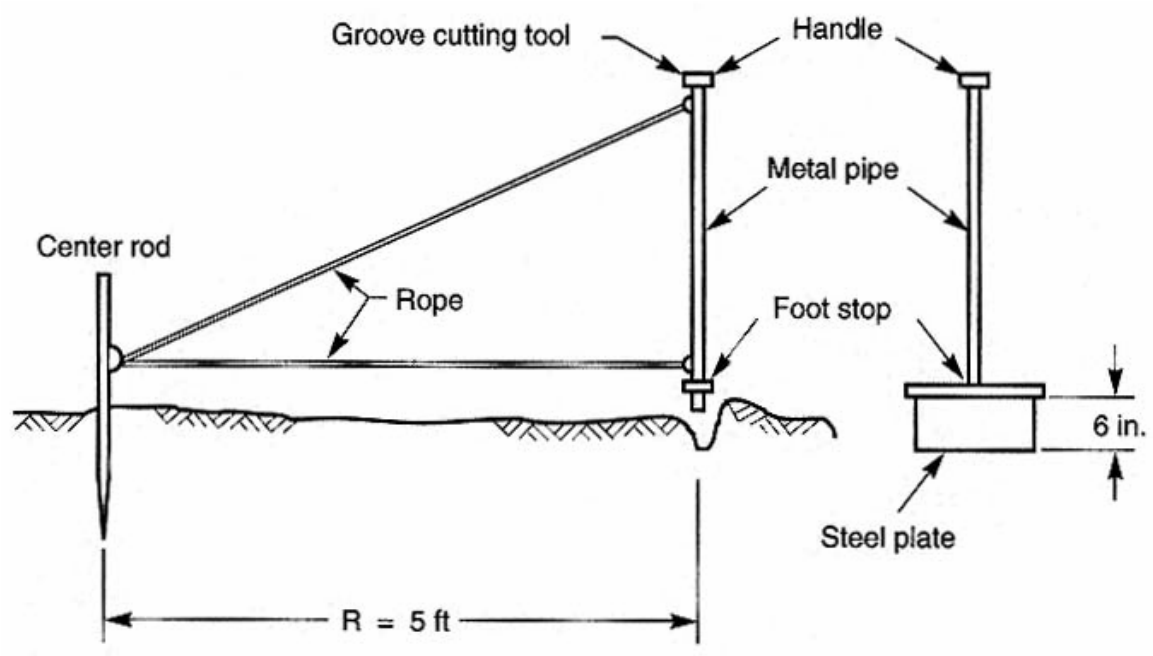


Figure 3-14. Grove Preparation for USACE Test.

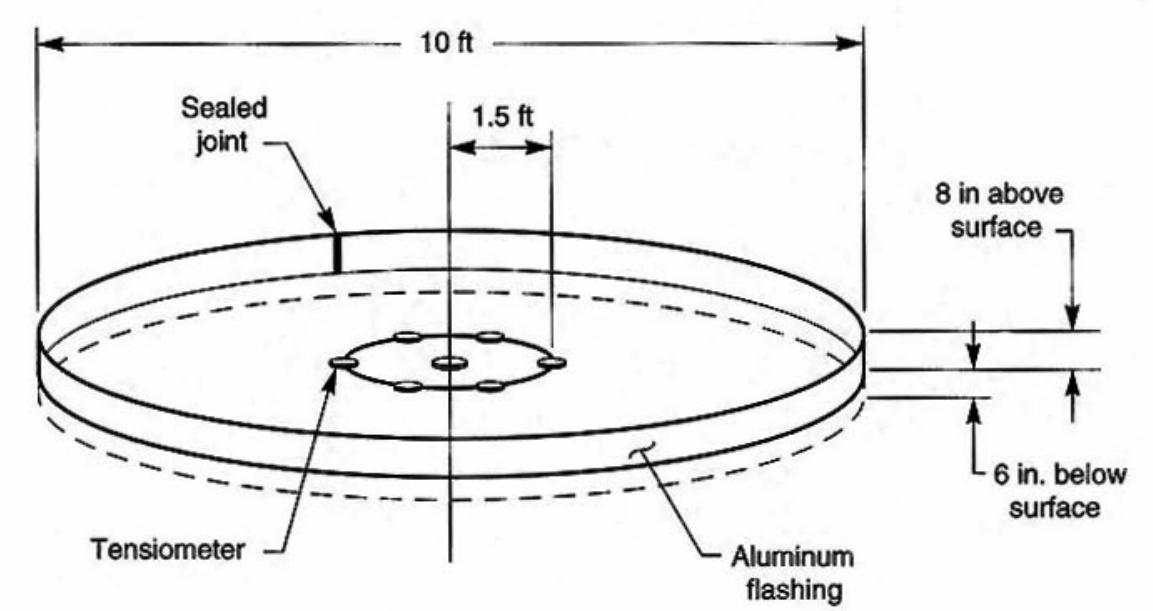


Figure 3-15. Grove Preparation for USACE Test.

Tensiometers are used in the central part of the test area to insure that saturated conditions prevail during the test period. One should be placed in each soil horizon. In soils lacking well-developed horizons, a uniform spacing down to about 0.6 m (2 ft) will be suitable. Following installation and calibration of the tensiometers, a few preliminary flooding events are executed to achieve saturation. Evidence of saturation is the reduction of tensiometer readings to near zero through the upper soil profile. Then a final flooding event is monitored to derive a cumulative intake versus time curve.

Typical test results are illustrated in Figure 3-16. The "limiting" value of 6.35 mm/h (0.25 in./h) was selected for design in this case.

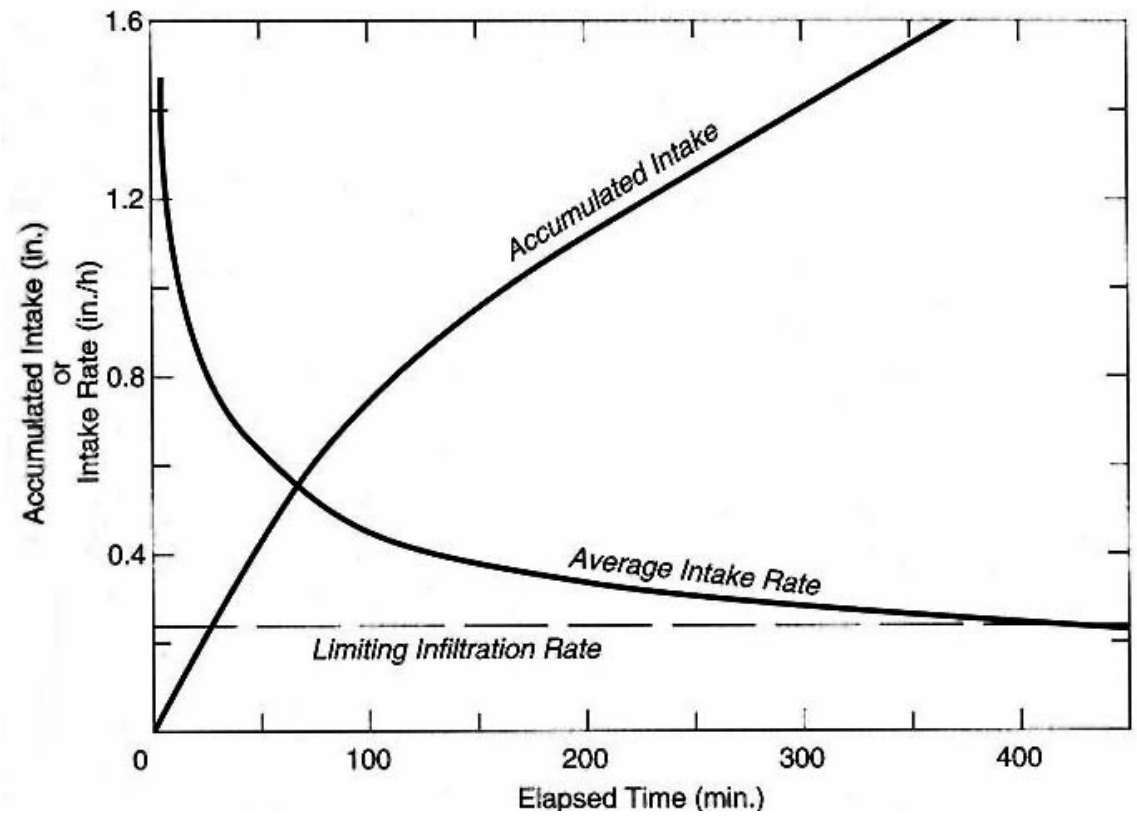


Figure 3-16. Typical Test Results, USACE Infiltration Test.

Appendix B

Outline for Hydrogeologic Report

I. Site location and description

A. Site location (provide maps with minimum scale of 1 inch equals 200 feet and a contour interval of no more than 5 feet)

B. Areal extent of site (acres)

C. Present land use

D. Future land use

II. Description of land-application techniques

A. Degree. of wastewater treatment to be employed prior to land application (i.e. primary, secondary, lagoons, etc.)

1. Wastewater quality before treatment
2. Wastewater quality after treatment

B. Volume of treated wastewater to be discharged (MGD)

C. Land-application techniques employed (i.e. spray irrigation, overland flow, rapid infiltration, well injection, etc.)

III. Geology, soils, and hydrology

A. Geology of site and surrounding groundwater discharge area

1. Rock or sediment types and formations
2. Depths to bedrock and thickness of weathered or unconsolidated material
3. Properties of bedrock and weathered or unconsolidated material
4. Structural features
5. Large-scale maps showing site characteristics
    a. Surficial geology
    b. Depth to bedrock and/or thickness of surficial material expressed in terms of contour lines
    c. Geologic cross-sections
6. Discussion of geologic materials and structural controls on the movement of infiltrating waters and groundwaters and the renovation of applied wastewaters.

B. Soils

1. Description of soil series present
2. List of soil mapping units and a copy of USDA Soil Survey maps
3. Discussion of available soil characterization and Soil Survey data regarding the movement and renovation of infiltrating wastewater.
4. Site-specific information from soil borings, test pits, etc.
    a. Depths of soils
    b. Textures of soils and substratum
    c. Description of water-related soil characteristics
        (1) Mottling
        (2) Perched Water
5. Large-scale maps (1 inch equals 200 feet or larger scale) with locations of all auger borings, test pits, etc. with corresponding logs
6. Discussion of soil-materials control on the movement and renovation of applied wastewaters

C. Hydrology

1. Regional climate
    a. Monthly precipitation
    b. Monthly temperature
    c. Monthly evapotranspiration
2. Surface phenomena
    a. Slope
    b. Vegetational cover type
    c. Description and location on suitable map of surface waters (ponds, lakes, streams, springs, existing water wells, sinkholes, etc.)
    d. Description of erosion present
    e. Water-quality inventory of existing water wells within 1/4 mile of site
3. Permeability of soils
    a. Infiltration capacity of surface soils
    b. Vertical hydraulic conductivity of subsurface soils
4. Type of aquifer(s) present (refer to COMAR **26.08.02.09** Groundwater Quality Standards)
5. Develop hydrologic balance for proposed site considering ultimate fate and disposition of both natural precipitation and wastewater
6. Maps showing highest and lowest depth to water table using both sea-level datum and land-surface datum (include groundwater flow lines on sea-level datum map)
7. Discuss groundwater mounding potential
8. Develop nitrogen balance from discharge site to groundwater table

IV. Plan of operation for facility

A. Application rates (inches per week and inches per hour)

B. Loading rates

1. Wastewater
2. Nitrogen
3. Phosphorus
4. BOD
5. Suspended solids

C. Holding pond specifications

D. Maintenance of land application area

V. Monitoring-surveillance system

A. Observation wells

1. Number
2. Location
3. Method of installation

B. Surface water stations (ponds, lakes, streams)

1. Number
2. Location
3. Method of sampling

VI. General comments

A. Summation of sites advantages and points of concern

B. Overall summation of hydrogeologic report

1. Will it work?
2. For how long?

Appendix C

Calculation of Hydrologic Balance

All hydrologic balances contain parameters which fall into one of two categories, supply or demand. In order for an equation to express accurately a hydrogeologic balance, the sum of the water-supply parameters must equal the sum of the water-demand parameters. The following is an example of a simplified hydrologic balance applicable to a land-application system:

$$P + Lw = ET + GW + SM + RO$$

where:

P = natural precipitation occurring on-site. For design purposes, the wettest year in the last 10 years of record should be used.
Lw = amount of wastewater applied to site.
ET = evapotranspiration losses from site.
GW = amount of water entering groundwater system beneath site.
SM = amount of moisture contained in soil profile on site.
RO = amount of surface runoff flowing from site.

In most land-application systems, surface runoff from the site is not permitted. Consequently, the runoff term (RO) in the previous hydrologic balance is usually omitted. Soil moisture changes, gains and losses, on an annual basis are thought to balance each other out. Consequently, soil moisture (SM) from year to year is considered relatively constant and, therefore, usually omitted from the hydrology equation.

The precipitation and temperature data required for the hydrologic balance can be obtained from regional climatological stations owned and operated by the Weather Bureau, U.S. Department of Commerce. These climatic stations are established throughout the continental U.S., and the data published monthly. The precipitation data (P) is directly used in the equation. The temperature data, along with the precipitation data, is used to calculate the potential evapotranspiration term (ET) in the equation. There are several methods commonly used to calculate potential ET. Most of them can be found in basic hydrology texts.

Estimating the wastewater application rate (hydraulic loading rate) of any land application system is one of the most difficult steps in the design process. The application rate is a function of the physical properties of the soil, depth to groundwater, and the nutrient balance of the site. Traditionally, the application rate for slow-rate systems has been based upon annual precipitation information. In most places of the northeastern U.S., annual precipitation ranges between 35 and 45 inches. Assuming that land application is performed during 9 months of the year, applying wastewater at a rate of 1 inch per week would approximately double the amount of water received by the site under natural conditions; 2 inches per week would approximately triple the amount.

Some scientists and engineers use the permeability of the soils to determine the wastewater application rate. However, this technique can result in over-estimating the ability of the soil to transmit the wastewater. Research has shown that soil permeability decreases when wastewater is used in place of potable water. Soil permeability has also been found to decrease over time, regardless of the water used.

Just how much the permeability decreases over time is still open for discussion and depends upon a great many factors. Some of the more important factors affecting soil permeability are the physical and chemical properties of the soil, the amount and chemical composition of the wastewater, the climatology of the site, the vegetational cover type, and the management practices (e.g. crop harvesting) of the site. Activities affecting any one or more of these factors could result in a change in soil permeability, thus the sites ability to accommodate the applied wastewater.

In the past, the maximum application rate for the most commonly used technique, slow-rate, has been set at 2 inches per week. This rate was used in the research work conducted at Penn State University beginning in 1963 and continuing today. Little information has been collected elsewhere which suggests a relaxation of this maximum. In Maryland, an application rate of 2 inches per week is considered acceptable for soils ranging in texture from silt loams to sands. Application rates less than 2 inches per week are considered necessary for soil ranging in texture from silty clay loams to silty clays.

The actual application rate accepted by the Department of the Environment for any land-treatment system must consider not only the permeability of the soils but also the depth to groundwater and the nutrient balance of the site.

The groundwater term (GW) in the hydrologic balance is dependent upon the magnitudes of the precipitation, wastewater loading rate, and evapotranspiration terms. It is one of the more difficult terms of the balance to measure. Consequently, if it is not predetermined by a management plan, it is calculated using the hydrologic balance in a "check-book" type procedure.

The following example problem has been developed to demonstrate more fully the use of a hydrologic balance in a land-treatment system. The information that is given would be typical of that known about a system in the preliminary planning stages.

Example Problem

A small housing development located in Western Maryland has proposed a slow-rate land application system. The land-application system is to be responsible for handling only the municipal wastewater generated by the development. Several important hydrologic questions that need to be answered are: 1) what weekly application rate (loading rate) should be used, 2) how many acres of land will be required for the spray field, and 3) what is the total amount of water (wastewater plus precipitation) that will enter the underlying groundwater system?

The following information is known about the land-application system:

a) The average daily wastewater flow is 100,000 gallons.

b) The soils occupying the land application site are identified as Calvin channery loam. There are no impermeable layers or fragipans present in the profile, and the permeability of the horizons range from 0.6 to 2.0 inches per hour.

c) The site is and will continue to be used as pastureland.

d) Spray irrigation will begin each year in March and continue through the month of November for a total period of 275 days. Wastewater generated during the 90-day non-spray period will be held in a storage pond. The weekly loading cycle will consist of a one-day spray followed by a six-day rest period.

Question 1:

The soil present on the site is Calvin channery loam. There is neither an impermeable layer present in the soil profile nor any shallow groundwater present. Nutrient loading is not considered to be a problem. In light of these facts, the maximum application rate of 2 inches per week is considered acceptable for the site.

Question 2:

In order to determine the number of acres needed for the land-application system, the following equation was used:

$$A = \frac{Q \times 365 \times (E + F)}{27154 \times (365 - G) \times H}$$

where:

A = area in acres
Q = flow in gallons per day
E+F = loading cycle (loading plus rest periods) in days per week
E = loading period in days per week
F = rest period in days per week
G = storage requirement in days per year
H = application rate (loading rate) in inches per week

Conversion factors:

365 = days per year
27154 = gallons per acre-inch

Substituting the given information into the above equation yields:

$$A = \frac{100{,}000 \text{ gal/day} \times 365 \text{ days/year} \times (1 + 6) \text{ days/week}}{27154 \text{ gal/acre-inch} \times (365 - 90) \text{ days/year} \times 2 \text{ inches/week}}$$

A = 17.11 acres required for spray field (excluding buffers)

Question 3:

The hydrologic balance, previously given, was used to calculate the total amount of water (applied wastewater plus natural precipitation) that will enter the groundwater system beneath the spray field. The average monthly precipitation and temperature data were calculated using the most recent 10 years of data obtained at a nearby Weather Bureau climatic station. The Blaney-Criddle Method was used to estimate potential evapotranspiration for the site:

Calculation of potential evapotranspiration:

Blaney-Criddle Method

PET = KF

where:

PET = Potential ET in inches per unit area,
K = Crop-use coefficient,
F = Consumptive-use factor.

$$F = \frac{tp}{100}$$

where:

t = mean monthly temperature (°F),
p = percent of annual daytime hours occurring during each month of the year (Latitude for example site N 39'', 30').

Month	Ave. Monthly Air Temp. (°F)	Percent Annual Daytime Hours	Veg. Consump. Use Coeff.	(Col 2 x Col 3)/100	Monthly PET (inches)
OCT	50.38	7.76	0.70	3.91	2.74
NOV	40.27	6.75	0.70	2.72	1.90
DEC	31.39	6.55	0.70	2.06	1.44
JAN	27.11	6.78	0.70	1.84	1.29
FEB	27.28	6.74	0.70	1.84	1.29
MAR	35.80	8.30	0.70	2.97	2.08
APR	47.33	8.94	0.70	4.23	2.96
MAY	57.62	9.99	0.70	5.76	4.03
JUN	65.19	10.03	0.70	6.54	4.58
JULY	69.18	10.17	0.70	7.04	4.93
AUG	68.21	8.52	0.70	5.81	4.07
SEPT	61.87	8.39	0.70	5.19	3.63

Calculation of water entering groundwater system:

The equation used to calculate the amount of water entering the groundwater system is as follows:

$P + Lw = ET + GW$

where:

P = natural precipitation, inches (conservatively, assuming 100% precipitation eventually recharging the groundwater flow)
Lw = wastewater loading, inches
ET = potential evapotranspiration, inches
GW = water entering groundwater, inches

Month	Natural Precip. (inches)	Wastewater loading (inches)	Potential ET (inches)	Entering Groundwater (inches)
OCT	2.63	8.67	2.74	3.61
NOV	2.29	8.67	1.90	9.06
DEC	3.04	--	1.44	1.6
JAN	2.57	--	1.29	1.28
FEB	2.10	--	1.29	0.81
MAR	3.08	8.67	2.08	9.67
APR	2.98	8.67	2.96	8.69
MAY	3.76	8.67	4.03	8.40
JUNE	3.01	8.67	4.58	7.10
JULY	345	8.67	4.93	7.39
AUG	3.25	8.67	4.07	7.85
SEPT	3.46	8.67	3.63	8.50
ANNUAL	35.87	78.03	34.94	78.96

The total amount of water entering the groundwater system beneath the spray field was calculated to be 78.96 inches per acre per year. To convert 78.96 inches per acre year to gallons per day, the following calculations are made:

$$\frac{(78.96\,\text{acre-inches/year})\ \text{x}\ (27154\,\text{gallons/acre-inch})}{365\,\text{days/year}} = 5874.2\,\text{gal/day}$$

APPENDIX D

Calculation of Nitrogen Balance

Nitrogen, especially in the nitrate (NO3) form, is considered to be one of the most limiting constituents of municipal wastewater with respect to land application systems. The nitrate ion possesses a negative charge, as do soil particles. Since like charges repel, the nitrate ions tend to leach down through the soil profile. High nitrate concentrations in drinking water pose a health problem, especially in infants. For this reason the Environmental Protection Agency has imposed a maximum concentration of 10 milligrams per liter of nitrate-nitrogen in their Drinking Water Standards.

The nitrogen balance in any soil-water-plant scheme is dependent on several inputs (sources) and outputs (sinks). The major nitrogen inputs of land-application systems are the amount of nitrogen contained in the wastewater that is applied to the site and the amount of nitrogen contained in the natural precipitation that falls on the site. The major nitrogen outputs or sinks of a land-application system are removal by crops (plant uptake), leaching losses, denitrification, and ammonia volatilization. The nitrogen mass balance developed by J.E. Stone (1976) for the above situation can be expressed as follows:

Total N in Wastewater	+	N in Precip.	=	N Removal in crops	+	Leaching Loss	+	Denitri-fication	+	Ammonia Volatilization

The above equation assumes: 1) that any short-term increase in nitrogen storage in the soil has already occurred, and 2) that there are no significant additions of nitrogen through nitrogen fixation by leguminous plants growing on-site.

When the nitrogen mass balance is combined with a simplified water balance (volume of water leaving site equaling precipitation plus wastewater loading minus evapotranspiration) and solved for the wastewater loading, the following equation is derived:

$$W = \frac{4.43C + a(P - ET) - cP}{y - a - y(d + n)}$$

where:

W = wastewater loading (acre-inch/acre-year)
C = removal of nitrogen in crop (lbs/acre-year)
a = allowable nitrogen concentration in percolation or runoff water (mg/L)
P = precipitation (acre-inch/acre-year)
ET = potential evapotranspiration (assumes that P + W will allow potential ET to be realized in all cases) (acre-inch/acre-year)
c = concentration of nitrogen in precipitation (mg/L)
y = concentration of nitrogen in wastewater (mg/L)
d = fraction of nitrogen which is denitrified (% x 10^{-2})
n = fraction of nitrogen which is volatilized as ammonia (% x 10^{-2})

For a more thorough explanation of the development and underlying assumption of the above equations, the reader is referred to Stone (1976).

Example Problem

A community located in the Piedmont region of the State is in the process of developing a spray-irrigation program for their treated municipal wastewater. The average annual precipitation and evapotranspiration values for the area are 40 and 28 inches, respectively. Determine how much wastewater, containing 25 mg/L total nitrogen, can be applied such that the soil leachate realized at the groundwater table will not exceed an average concentration of 10 mg/L total nitrogen (Public Drinking Water Standard). Assume that 275 lbs per acre per year of nitrogen will be taken up by a cover crop of reed canarygrass and removed from the site during harvesting. Natural precipitation contains an average concentration of 0.5 mg/L of nitrate-nitrogen. Since no site specific data are available, losses of nitrogen via denitrification and ammonia volatilization are assumed to be zero.

Substituting the appropriate values into the wastewater loading equation yields the following:

$$W = \frac{4.43(275) + 10(40 - 28) - 0.5(40)}{25 - 10}$$

W = 87.88 acre-inches/acre-year

Assuming the annual irrigation season extends from March through November (a period of approximately 40 weeks), the average weekly wastewater loading rate would be:

$$\frac{87.88\ \text{acre-inches/acre-year}}{40\ \text{weeks/yr}} = 2.20\ \text{acre-inches/acre-week}$$

The above weekly loading rate should be compared with the weekly loading rate calculated from the soil permeability data. The smaller loading rate of the two should be the one at which the system is operated.

For discharging treated wastewater into a groundwater system nearby a surface water body, a more stringent nitrogen concentration in the percolate may be required.
The term “a”, allowable nitrogen concentration in percolation may be 0 mg/l for an impaired surface water body. The wastewater loading rate (W) is reduced according to the following calculations.

$$W = \frac{4.43(275) + 0(40 - 28) - 0.5(40)}{25 - 0}$$

W = 47.93 acre-inches/acre-year

Assuming the annual irrigation season extends from March through November (a period of approximately 40 weeks), the average weekly wastewater loading rate would be:

$$\frac{47.93\ \text{acre-inches/acre-year}}{40\ \text{weeks/yr}} = 1.20\ \text{acre-inches/acre-week}$$

The above weekly loading rate should be compared with the weekly loading rate calculated from the soil permeability data. The smaller loading rate of the two should be the one at which the system is operated.

Appendix D - Historical Sampling Data

MANCHESTER WWTP AND SPRAY IRRIGATION FACILITY

MO. AVE. CONCENTATION (MG/L)

NOTE: BLUE AREA IS PARAMETERS UNDER STREAM DISCHARGE, GREEN IS DURING SPRAY IRRIGATION

	MONTH	BOD5	TSS	PHOS.	ECOLI/FECAL	ORG.N	NO2/NO3	NH3	TOT. N	TKN	ORTHO. P.
	1	7	19	0.83	13.9	0.7	23	2.2	16	1.7	0.31
	2	2	3	0.39	6	0.8	10	0.5	11	1.1	0.19
	3	12	20		6.17		10.2		15.9	8.2	
	4	8	12		0		12		24	11.9	
	5	44	71		1.18		3.86		29.8	26.2	
	6	26	24		101.1		0.45		26	25.7	
	7	34	30		3.8		1.2		29.5	29.25	
	8	18	33		29		0.68		17.2	16.8	
	9	13	32		36.2		6.17		16.5	10.5	
	10	40	17		2.5		9.87		17.8	7.72	
	11	8	17		2.5		12.4		18.4	8.82	
2018	12	3	15	0.92	82.3	0.5	17	0.4	17		0.28
	1	4	17	0.63	28.9	1.1	15	1.1	17		0.06
	2	4	11	0.83	34.9	1.6	15	0.4	17		0.64
	3	12	8		33.7		10.4		13.8	6	
	4	6	19		8.7		3.75		16.1	12.7	
	5	20	34		35.8		6.46		20.4	13.8	
	6	23	24		36		7.27		23.3	17.7	
	7	11	25		11.2		4.9		17.9	13.2	
	8	4	25		2.4		7.9		14.7	7	
	9	6	24		1		5.6		25.3	19.6	
	10	2	13		1		7.44		19	11.54	
	11	2	8		2.3		7.1		19.7	12.7	
2019	12	28	84	2.43	52.3	2	14	10.9	26	12	0.28
	1	3	42	0.9	56	1	13	11.4	27	14	0.77
	2	22	48	1.29	628	3	9	17.3	29	20	0.32
	3	16	22		7.9		4.6		20	13.75	
	4	22	18		4.5		10.52		16.1	10.52	
	5	10	18		4.9		5.05		15.5	10.42	
	6	16	16		1.4		3.1		14.8	11.42	
	7	8	13		3.2		1.27		13.8	12.58	
	8	9	13		1		2.3		15	13.5	
	9	12	18		3.6		4.47		14	10.1	
	10	13	20		1.3		5.66		16.2	10.64	
	11	11	13		1.4		4.35		21.8	17.25	
2020	12	6	10	0.29	58.36	1.4	11	8.2	17	6	0.04
	1	19	18	0.32	66.7	4	11	9.4	28	17	0.05
	2	6	11	0.31	42.29	4	7	11.7	31		0.02
	3	14	15		4.7		2.7		16	13.25	
	4	15	14		6.21		4.6		10.8	2.5	
	5	17	29		1		2.3		15.3	14.1	
	6	27	15		1		1.63		15.8	14	
	7	21	18		1.88		1.4		13.9	12.66	
	8	7	10		1		0.48		17	16.5	
	9	9	16		2.09		3		14.3	11.24	
	10	3	10		3.5		4.1		15.8	12.9	
	11	5	8		1.4		11.3		16.3	5.1	
2021	12	3.5	4.2	0.39	1.4	0.6	19	3.26	22.6	3.6	0.31

Short-Term Sampling			6/9/20	6/10/20	6/11/20	6/12/20	6/13/20	6/14/20	6/15/20	6/16/20	6/17/20	6/18/20	6/19/20	6/20/20	6/21/20	6/22/20
Influent	TSS	mg/L	174	183	158	191	262	33	387	260	36	63	358	213	253	443
	VSS	mg/L	163	173	144	174	240	31	370	250	34	54	323	193	230	417
	Total COD	mg/L	576	211	293	269	202	171	718	602	556	432	515	524	685	425
	Filtered COD	mg/L	159	173	96	138	179	96	155	142	189	278	182	204	208	223
	ffCOD	mg/L	117	112	90	97	108	69	111	96	146	229	140	244	167	183
	Total BOD5	mg/L	220	157	499	161	331	81.6	313	39.4	149	213	296	380	297	398
	Filtered BOD5	mg/L	60.6	70.1	86.6	69.3	68.8	26.7	106	39.4	83	139	75.9	171	129	161
	cBOD5	mg/L	174	112	184	209	213	146	316	164	182	182	145	442	289	496
	Total TKN	mg/L	39.1	40.3	41.1	44.4	54.8	30.4	50.5	43.2	56.8	48.1	50.8	46.1	49.5	43.2
	Filtered TKN	mg/L	41.2	35.1	31.7	33.1	40.4	26	33.7	33.3	43.9	40.9	42.8	38.7	33.8	50.5
	NOx-N	mg/L	0.11	ND	ND	ND	0.76	ND	ND	ND	ND	ND	2.22	ND	ND	ND
	NH_3-N	mg/L	32.4	34.7	29.6	29.2	37.7	25.3	32.4	28.4	41.3	43.8	36.5	34.8	28.5	36.2
	TP	mg/L	5.7	4.7	5.7	5	6.8	3.6	6.8	5.6	7.8	9.1	6.8	6.7	6.5	8.3
	Filtered Ortho-P	mg/L	3.7	3.6	2.7	3.3	3.7	2.3	3.2	2.7	4.8	6.1	4.9	6.4	4.9	5.1
	Alkalinity	mg/L	249	261	239	228	273	199	247	236	290	290	252	245	236	267
Effluent	TSS	mg/L	465	ND	188	138	11		74	44	ND	26	80	170	328	288
	VSS	mg/L														258
	Total COD	mg/L			320		35					38		207	305	195
	Filtered COD	mg/L	37	26	44	32	30		28	24	159	25	24	33	31	16
	ffCOD	mg/L														
	Total BOD5	mg/L														
	Filtered BOD5	mg/L														
	Total TKN	mg/L	33.4	9.1	39.9	10.9	2.2		18.5	5	3.3	12.2	9.8	14.8	23.7	19.5
	Filtered TKN	mg/L	6.3	7.2	9.7	5.6	2		1.9	1.7	1	1.8	42.7	1.7	3.3	4.5
	NOx-N	mg/L	0.86	0.45	0.25	3.72	13.6		7.51	8.92	14.6	18.7	11.2	7.69	5.84	5.16
	NH3-N	mg/L	4.6	5.59	9.29	4.14	0.401		1.18	ND	0.185	ND	0.156	0.57	2.49	4.66
	TP	mg/L	7.7	3	7.5	2.6	4.3		5	4.5	3.8	4.9	5.7	5.6	8.6	4.9
	Filtered Ortho-P	mg/L	2.8	2.6	3.3	1.4	4.1		3.5	3.3	3.2	4.4	3.9	4.4	4.4	3.7
	Alkalinity	mg/L	152	158	243	153	106		122	109	91	76	97	106	124	114

Long-Term Sampling			6/23/20	6/29/20	6/30/20	7/6/20	7/7/20	7/13/20	7/14/20	7/20/20	7/21/20	7/27/20
Influent	TSS	mg/L	Data removed for high variability									
	VSS	mg/L	Data removed for high variability									
	Total COD	mg/L	Data removed for high variability									
	Filtered COD	mg/L	240	240		205		223				
	ffCOD	mg/L										
	Total BOD5	mg/L		463	416	240	583	252	419	337	139	182
	Filtered BOD5	mg/L	149									
	cBOD5	mg/L										
	Total TKN	mg/L	48.9	43.9	72.9	47.5	67.1	18.5	61.5	94.8	40.2	41.5
	Filtered TKN	mg/L										
	NOx-N	mg/L										
	NH_3-N	mg/L	34.8	34.1		32.9		29.7				
	TP	mg/L	10.2	9.4	14.7	5.3	14	6.3	12.1	16.8	6.2	6.1
	Filtered Ortho-P	mg/L	4.9	5.2		4.3		4.3				
	Alkalinity	mg/L										
Effluent	TSS	mg/L	234	188	42	209	182	303	660	114	88	ND
	VSS	mg/L	210	172				286			79	
	Total COD	mg/L	16	131	69	234	52	191	507	47	118	23
	Filtered COD	mg/L	15	120		21		33				
	ffCOD	mg/L										
	Total BOD5	mg/L		209	60.5	102	126	139	285	96.5	73.3	22
	Filtered BOD5	mg/L	6.7									
	Total TKN	mg/L	21.6	16.7	6.9	8.6	7.9	98.6	59.5	15.4	19.8	17.2
	Filtered TKN	mg/L										
	NOx-N	mg/L										
	NH3-N	mg/L	3.28	3.94		0.581		6.09				
	TP	mg/L	4.1	5.8	3.2	4.1	5.0	8.7	13.1	5.6	9.8	2.8
	Filtered Ortho-P	mg/L	2.4	3.5		2.8		4.1				

7/28/20	8/3/20	8/4/20	8/10/20	8/11/20	8/17/20	8/18/20	8/24/20	8/25/20	8/31/20	9/1/20	9/7/20	9/8/20	9/14/20	9/15/20
	204		195								336		247	
169	194	157	361	507	189	474	330	512	455	451	511	517	358	174
41.4	42.1	36.6	40.1	69.1	46.7	49.7	46.2	103	65.7	59.7	51.0	66.8	59.8	42.0
	36.1		39.8								40.3		37.2	
5.0	5.7	4.5	5.7	14.7	6.7	13.6	5.9	15.3	10.2	12.8	12.4	14.1	11.3	5.0
	3.4		7.6								7.9		3.1	
350	318	673	32	300	44	158	ND	246	287	166	290	590	108	ND
	275		30								268		96	
45	472	995	36	143	41	1050	42	393	157	247	368	550	45	30
	49		22								22		23	
147	141	197	150	154	37.1	126	19.1	238	161	135	248	383	74.9	22.3
34.2	45.4	48.5	12.3	26.9	8.9	15.7	25.2	45.9	24.4	15.9	29.7	80.1	3.6	1.7
	19.7		11.7								12.5		0.876	
5.3	9.9	10.2	4.3	12.7	4.5	17.1	5.3	8.9	3.2	6.1	15.0	23.3	3.1	2.9
	3.4		3.6								10.8		1.9	

9/21/20	9/22/20	9/28/20	9/29/20	10/5/20	10/6/20	10/12/20	10/13/20	10/19/20	10/20/20	10/26/20	10/27/20	11/2/20	11/3/20	11/9/20
									267	243	220	210	233	283
												203		263
									785	656	321	606	494	476
				117		210						186		137
				93										
316	387	330	234	251	506	370	229	283	275	297	239	291	336	321
41.6	52.3	56.3	48.4	46.9	60.7	61.3	45.2	52.8	55.0	51.9	53.2	51.5	52.1	53.3
				42.9		43.5						46.1		45.3
4.7	7.2	9.4	7.5	8.3	11.1	10.3	6.5	6.9	6.2	7.2	6.6	6.5	6.6	7.1
				3		3.3						3		3.1
27	44	71	ND	156	ND	180	672	326	32	180	188	153	121	317
				144		166						135		277
24	38	129	20	225	22	121	1170	371	326	302	257	117	101	171
				29		34						39		34
				15										
103	108	92	20.1	129	44.2	144	277	168	87	141	171	130	93.2	225
5.1	5	6.3	3.3	16.4	1.5	26.8	90.9	36.9	21.2	24.3	19.7	20.6	9.3	39.7
				2.33		13.1						7.23		6.93
4.5	4.6	6.1	4.4	9.3	3.3	7.6	13.3	9.3	3.8	5.2	8.0	4.3	2.6	8.9
				3.5		4						0.95		3.8

11/10/20	11/16/20	11/17/20	11/23/20	11/24/20	11/30/20	12/1/20	12/7/20	12/8/20	12/14/20	12/15/20
235	253	230	217	213	248	213	277	390	80	203
							270		74	
446	418	492	435	381	378	395	514	790	424	287
							181		128	
							164			
268	251	230	278	224	236	228	209	372	156	210
51.7	50.2	51.7	26.9	42.7	53.9	42.0	51.4	70.6	43.9	43.6
							47		39.9	
6.9	6.3	6.3	7.1	4.8	6.1	4.4	5.4	7.3	5.5	1.1
							2.9		2.1	
232	303	8	370	347	124	6	23	58	7	12
							22		9	
244	349	46	181	459	24	46	47	45	112	ND
							40		34	
							27			
255	201	11.8	215	229	113	12.9	22.7	29.1	25.6	11
15.1	34.3	10.5	49.2	57.9	18.6	22.6	11.6	7.4	19.1	8.1
							9.14		10.8	
8.1	9.7	2.3	16.0	16.6	2.1	1.4	0.5	0.8	2.8	ND
							ND		0.035	

Manchester Wastewater Treatment Plant
Plant Sampling Results

	General			Aerated Stabilization Tank #1			Final Effluent		
	Temp (F)	Flow Average	Flow	30-Min	MLSS	RAS	BOD5	TSS	TP
1/1/20	34	0.305	0.5						
1/2/20	28	0.294	0.52				2	10	0.49
1/3/20	43	0.273	0.53	87	4500	9100			
1/4/20	50	0.281	0.54						
1/5/20	33	0.32	0.61						
1/6/20	34	0.273	0.51						
1/7/20	30	0.278	0.51	85	4500	8450	2	4	0.82
1/8/20	31	0.284	0.47						
1/9/20	16	0.276	0.46	87	4200	7800	2	3	1.1
1/10/20	33	0.267	0.49	86	4500	8450			
1/11/20	51	0.287	0.46						
1/12/20	58	0.308	0.5						
1/13/20	37	0.284	0.49	85	4500	7800			
1/14/20	41	0.29	0.49	87	4500	8450	2	15	0.37
1/15/20	35	0.263	0.49	88	4500	8450			
1/16/20	48	0.272	0.57	86	4500	8450		3	0.78
1/17/20	23	0.241	0.43	87	4500	8450			
1/18/20	23	0.326	0.52						
1/19/20	37	0.304	0.49						
1/20/20	19	0.313	0.55	94	4500	8450			
1/21/20	20	0.266	0.49				3	8	0.28
1/22/20	17	0.286	0.48						
1/23/20	23	0.261	0.52	94	4500	8450	8	30	0.53
1/24/20	31	0.337	0.6						
1/25/20	40	0.392	0.6						
1/26/20	40	0.355	0.54						
1/27/20	35	0.315	0.52	94	4500	8450			
1/28/20	35	0.341	0.64	94	4500	8450	2	4	0.72
1/29/20	33	0.306	0.51	93	4500	8450			
1/30/20	20	0.276	0.51				2	300	3
1/31/20	31	0.302	0.48						
2/1/20	33	0.267	0.53						
2/2/20	35	0.299	0.52						
2/3/20	45	0.255	0.49	69	3300	5800			
2/4/20	51	0.278	0.56				4	9	0.33
2/5/20	34	0.303	0.74	69	3300	5800			
2/6/20	35	0.311	0.57				6	5	0.23
2/7/20	53	0.304	0.51	68	3300	5800			
2/8/20	27	0.319	0.54						
2/9/20	29	0.314	0.59						
2/10/20	40	0.328	0.7	79	3150	5100			
2/11/20	44	0.297	0.53				9	22	0.79
2/12/20	33	0.292	0.59						
2/13/20	42	0.302	0.53				25	28	0.68
2/14/20	29	0.277	0.58						
2/15/20	16	0.303							
2/16/20	28	0.316	0.53						
2/17/20	35	0.31	0.54						
2/18/20	39	0.267	0.49	83	3150	4775	18	25	0.86
2/19/20	35	0.263	0.53	82	3150	5400			
2/20/20	28	0.274	0.57				27	130	3.2
2/21/20	18	0.237	0.42	30	1100	1850			
2/22/20	26	0.278	0.53						
2/23/20	26	0.288	0.56						
2/24/20	45	0.249	0.61						
2/25/20	43	0.27	0.52	45	4500	1850	63	140	3.2
2/26/20	45	0.264	0.5						
2/27/20	31	0.263	0.5	47	1850	1850	21	26	1
2/28/20	27	0.322	0.52	30	1850	3800			
2/29/20	24	0.277	0.56						
3/1/20	20	0.331	0.54						
3/2/20	33	0.271	0.69						
3/3/20	40	0.293	0.52	58	2500	5100			
3/4/20	42	0.28	0.55	53	2500	5100			
3/5/20	32	0.269	0.49	59	2500	5100			
3/6/20	32	0.292	0.45						
3/7/20	36	0.294	0.55						
3/8/20	45	0.3	0.53						
3/9/20	36	0.261	0.48	55	2150	4500			
3/10/20	53	0.294	0.5						
3/11/20	38	0.305	0.54	47	2150	4500			
3/12/20	43	0.289	0.54						
3/13/20	50	0.251	0.45	31	1850	4500			
3/14/20	39	0.294	0.5						
3/15/20	36	0.311	0.48						
3/16/20	31	0.273	0.57	45	2500	5100			
3/17/20	39	0.272	0.42						
3/18/20	34	0.31	0.51	49	2500	5100			
3/19/20	48	0.289	0.59						
3/20/20	56	0.277	0.49	67	2500	5100			
3/21/20	42	0.288	0.51						
3/22/20	29	0.299	0.48						
3/23/20	34	0.314	0.56						
3/24/20	41	0.276	0.52	90	3300	6400			
3/25/20	41	0.304	0.52						
3/26/20	40	0.313	0.54	85	3150	6400			
3/27/20	47	0.296	0.5	80	2750	5100			
3/28/20	46	0.365	0.63						

3/29/20	46	0.314	0.49						
3/30/20	48	0.254	0.54	51	1850	4500			
3/31/20	42	0.285	0.47						
4/1/20	39	0.277	0.47	58	1850	4500			
4/2/20	37	0.264	0.47						
4/3/20	38	0.24	0.47	50	2150	4500			
4/4/20	45	0.266	0.46						
4/5/20	56	0.276	0.55						
4/6/20	47	0.231	0.4	70	2500	5100			
4/7/20	50	0.307	0.58						
4/8/20	55	0.235	0.42	57	2500	5100			
4/9/20	50	0.257	0.49						
4/10/20	37	0.261	0.4						
4/11/20	37	0.27	0.41						
4/12/20	42	0.327	0.51						
4/13/20	57	0.412	0.63	61	2500	5100			
4/14/20	42	0.3	0.5						
4/15/20	34	0.319	0.57	68	2500	5100			
4/16/20	37	0.268	0.47						
4/17/20	33	0.269	0.49	62	2500	4800			
4/18/20	45	0.3	0.49						
4/19/20	44	0.288	0.48						
4/20/20	48	0.257	0.45						
4/21/20	42	0.273	0.52	65	2500	3800			
4/22/20	35	0.23	0.42						
4/23/20	43	0.287	0.45	67	3150	4500			
4/24/20	46	0.325	0.58						
4/25/20	48	0.29	0.53						
4/26/20	50	0.292	0.6						
4/27/20	38	0.306	0.47	66	2850	4500			
4/28/20	41	0.282	0.4						
4/29/20	46	0.247	0.42						
4/30/20	61	0.453	0.7						
5/1/20	51	0.324	0.55	62	2500	4500			
5/2/20	51	0.3	0.48						
5/3/20		0.322	0.5						
5/4/20	62	0.261	0.53						
5/5/20	47	0.297	0.95	48	1850	4500			
5/6/20	46	0.372	0.53						
5/7/20	44	0.271	0.5	80	1850	4500			
5/8/20	50	0.37	0.7						
5/9/20	33	0.361	0.53						
5/10/20	40	0.321	0.52						
5/11/20	71	0.374	0.5						
5/12/20	41	0.349	0.54						
5/13/20	49	0.305	0.47						
5/14/20	50	0.316	0.55	60	1850	4500			
5/15/20	64	0.255	0.4	56	1850	4500			
5/16/20	68	0.252	0.42						
5/17/20	62	0.291	0.52						
5/18/20	54	0.282	0.5						
5/19/20	55	0.27	0.47	39	1100	5100			
5/20/20	48	0.27	0.41						
5/21/20	56	0.27	0.41	35	1100	6400			
5/22/20	57	0.31	0.45						
5/23/20	62	0.28	0.4						
5/24/20	59	0.275	0.4						
5/25/20	70	0.239	0.5						
5/26/20	64	0.268	0.62						
5/27/20	69	0.219	0.74	35	1100	6400			
5/28/20	69	0.229	0.55	89	1850	3150			
5/29/20	73	0.236	1.05						
5/30/20	55	0.233							
5/31/20	56	0.253	0.64						
6/1/20	53	0.249	0.88	71	1850	3800			
6/2/20	60	0.255	0.73						
6/3/20	75	0.243	0.67						
6/4/20	74	0.307	0.72						
6/5/20	73	0.294	0.71						
6/6/20	68	0.269	0.62						
6/7/20	66	0.272	0.68						
6/8/20	63	0.271	0.72	50	1850	3800			
6/9/20	71	0.273	0.64						
6/10/20	75	0.334	0.68	49	1850	4500			
6/11/20	74	0.297	0.76						
6/12/20	66	0.317	0.64						
6/13/20	62	0.294	0.66						
6/14/20	54	0.285	0.69						
6/15/20	61	0.293	0.69	75	2500	4500			
6/16/20	59	0.242	0.44						
6/17/20	60	0.243	0.42						
6/18/20	64	0.258	0.45						
6/19/20	66	0.227	0.35	60	1850	3800			
6/20/20	66	0.255	0.38						
6/21/20	67	0.264	0.44						
6/22/20	75	0.257	0.46						
6/23/20	68	0.259	0.45	70	1850	4500			
6/24/20	73	0.267	0.59	68	1850	4500			
6/25/20	73	0.247	0.42						
6/26/20	67	0.218	0.4						
6/27/20	75	0.224	0.35						
6/28/20	79	0.24	0.43						
6/29/20	72	0.209	0.36						
6/30/20	72	0.257	0.41						

7/1/20	69	0.22	0.43	69	1850	4500			
7/2/20	72	0.21	0.39						
7/3/20	77	0.204	0.39						
7/4/20	76	0.225	0.42						
7/5/20	84	0.257	0.43						
7/6/20	80	0.274	0.44						
7/7/20	70	0.244	0.52						
7/8/20	75	0.235	0.41	70	1500	3150			
7/9/20	77	0.255	0.4						
7/10/20	73	0.244	0.36						
7/11/20	77	0.253	0.38						
7/12/20	75	0.285	0.53						
7/13/20	68	0.249	0.44						
7/14/20	71	0.223	0.37						
7/15/20	71	0.223	0.4						
7/16/20	70	0.235	0.39						
7/17/20	72	0.222	0.35	68	1850	3150			
7/18/20	69	0.237	0.4						
7/19/20	77	0.25	0.41						
7/20/20	80	0.237	0.55						
7/21/20	70	0.287	0.65						
7/22/20	74	0.276	0.57						
7/23/20	72	0.229	0.41	68	1850	3350			
7/24/20	72	0.237	0.49						
7/25/20	73	0.234	0.43						
7/26/20	77	0.23	0.4						
7/27/20	75	0.222	0.48						
7/28/20	78	0.231	0.39						
7/29/20	71	0.255	0.44	65	2150	3800			
7/30/20	77	0.235	0.42						
7/31/20	71	0.237	0.41						
8/1/20		0.237							
8/2/20		0.243							
8/3/20		0.251							
8/4/20		0.366							
8/5/20		0.244							
8/6/20		0.236							
8/7/20		0.241							
8/8/20		0.235							
8/9/20		0.241							
8/10/20		0.216							
8/11/20		0.249							
8/12/20		0.216							
8/13/20		0.220							
8/14/20		0.211							
8/15/20		0.232							
8/16/20		0.234							
8/17/20		0.220							
8/18/20		0.212							
8/19/20		0.217							
8/20/20		0.211							
8/21/20		0.207							
8/22/20		0.218							
8/23/20		0.226							
8/24/20		0.216							
8/25/20		0.225							
8/26/20		0.231							
8/27/20		0.233							
8/28/20		0.221							
8/29/20		0.250							
8/30/20		0.233							
8/31/20		0.254							
9/1/20		0.255							
9/2/20		0.257							
9/3/20		0.257							
9/4/20		0.233							
9/5/20		0.241							
9/6/20		0.244							
9/7/20		0.312							
9/8/20		0.248							
9/9/20		0.228							
9/10/20		0.254							
9/11/20		0.222							
9/12/20		0.253							
9/13/20		0.256							
9/14/20		0.238							
9/15/20		0.246							
9/16/20		0.253							
9/17/20		0.229							
9/18/20		0.219							
9/19/20		0.243							
9/20/20		0.241							
9/21/20		0.250							
9/22/20		0.235							
9/23/20		0.254							
9/24/20		0.189							
9/25/20		0.231							
9/26/20		0.244							
9/27/20		0.266							
9/28/20		0.227							
9/29/20		0.243							
9/30/20		0.226							
10/1/20		0.229							
10/2/20		0.221							

10/3/20	0.232
10/4/20	0.267
10/5/20	0.243
10/6/20	0.238
10/7/20	0.217
10/8/20	0.258
10/9/20	0.215
10/10/20	0.238
10/11/20	0.298
10/12/20	0.304
10/13/20	0.274
10/14/20	0.265
10/15/20	0.236
10/16/20	0.237
10/17/20	0.251
10/18/20	0.265
10/19/20	0.240
10/20/20	0.240
10/21/20	0.213
10/22/20	0.231
10/23/20	0.217
10/24/20	0.235
10/25/20	0.267
10/26/20	0.253
10/27/20	0.263
10/28/20	0.226
10/29/20	0.342
10/30/20	0.258
10/31/20	0.270
11/1/20	0.286
11/2/20	0.246
11/3/20	0.245
11/4/20	0.268
11/5/20	0.241
11/6/20	0.228
11/7/20	0.250
11/8/20	0.258
11/9/20	0.244
11/10/20	0.239
11/11/20	0.314
11/12/20	0.305
11/13/20	0.239
11/14/20	0.260
11/15/20	0.289
11/16/20	0.246
11/17/20	0.251
11/18/20	0.273
11/19/20	0.254
11/20/20	0.230
11/21/20	0.247
11/22/20	0.278
11/23/20	0.265
11/24/20	0.262
11/25/20	0.236
11/26/20	0.264
11/27/20	0.157
11/28/20	0.243
11/29/20	0.338
11/30/20	0.327
12/1/20	0.254
12/2/20	0.250
12/3/20	0.269
12/4/20	0.321
12/5/20	0.285
12/6/20	0.300
12/7/20	0.255
12/8/20	0.248
12/9/20	0.245
12/10/20	0.269
12/11/20	0.249
12/12/20	0.284
12/13/20	0.298
12/14/20	0.310
12/15/20	0.245
12/16/20	0.288
12/17/20	0.290
12/18/20	0.248
12/19/20	0.272
12/20/20	0.296
12/21/20	0.282
12/22/20	0.291
12/23/20	0.264
12/24/20	0.574
12/25/20	0.369
12/26/20	0.322
12/27/20	0.314
12/28/20	0.280
12/29/20	0.272
12/30/20	0.274
12/31/20	0.281

Appendix E – Existing Manchester WWTP Flows and Loads Analysis

Historical Flow Data

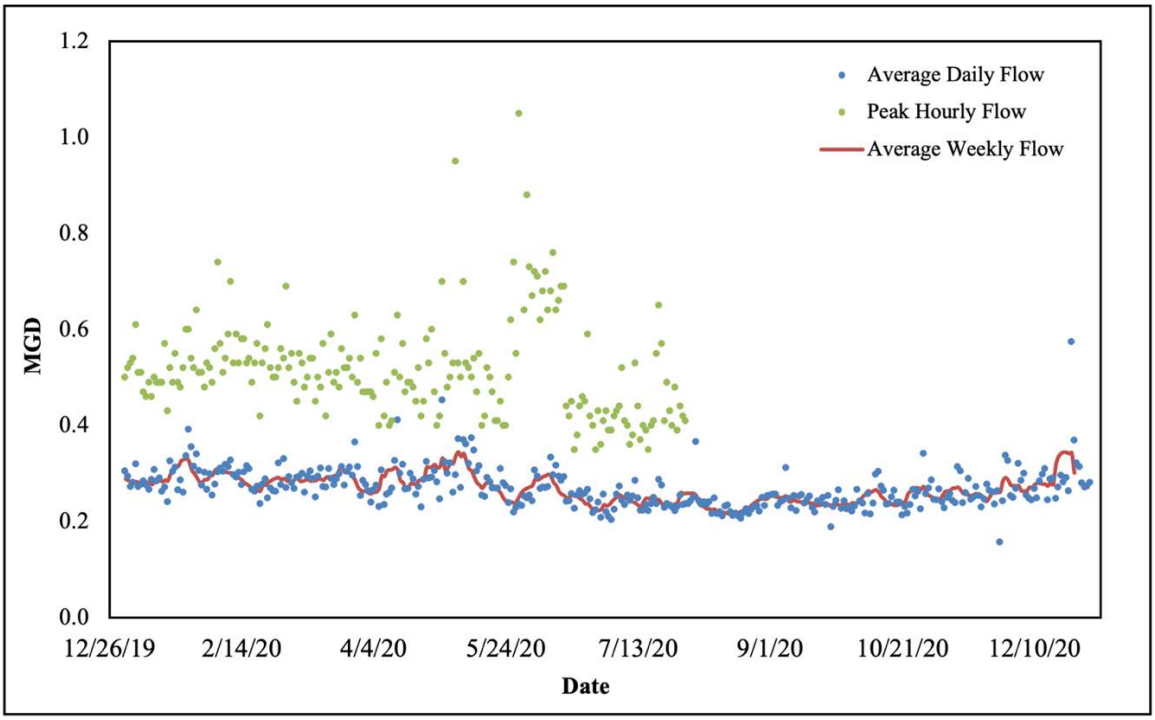


Figure E-1: Average daily, peak hourly, and average weekly flow for Manchester WWTP

Influent Loading

Organic Loading

Organic loading refers to the amount of Total BOD_5 and COD present in the influent. Table E-1 and Table E-2 report BOD_5 and COD influent concentrations and loadings. The existing WWTP manages an average BOD_5 load of 1254 pounds per day.

Table E-1: BOD5 influent concentrations and loading

	Influent Concentration (mg/L)	**Peaking Factor**	**Total Loading (lbs/day)**
Annual Average	300	1.0	1254
Maximum Day	583	1.9	2431
Maximum Month	364	1.2	1519

Table E-2: COD influent concentrations and loading

	Influent Concentration (mg/L)	Peaking Factor	Total Loading (lbs/day)
Annual Average	467	1.0	1947
Maximum Day	790	1.7	3294
Maximum Month	587	1.3	2449

Solids Loading

Solids loading refers to the amount of suspended, non-soluble solids present in the influent. This can refer to TSS or VSS. Table E-3 and E-4 report influent concentrations and loadings. The existing WWTP handles an average TSS load of 946 pounds per day.

Table E-3: TSS influent concentrations and loading

	Influent Concentration (mg/L)	Peaking Factor	Total Loading (lbs/day)
Annual Average	227	1.0	946
Maximum Day	443	2.0	1847
Maximum Month	243	1.1	1015

Table E-4: VSS influent concentrations and loading

	Influent Concentration (mg/L)	Peaking Factor	Total Loading (lbs/day)
Annual Average	200	1.0	835
Maximum Day	417	2.1	1739
Maximum Month	233	1.2	972

Nutrient Loading

Nutrient loading refers to the amount of nitrogen and phosphorus present in the influent. The presence of nitrogen in wastewater is typically represented as TKN, or the sum of organic nitrogen and ammonia nitrogen. TP refers to the total amount of phosphorus in wastewater regardless of form. TKN and TP concentrations are available from sampling data and were used to determine loadings (Table E-5 and E-6). The existing WWTP handles an average TKN load of 212 and an average TP load of 32 pounds per day.

Table E-5: TKN influent concentrations and loading

	Influent Concentration (mg/L)	Peaking Factor	Total Loading (lbs/day)
Annual Average	51	1.0	212
Maximum Day	103	2.0	430
Maximum Month	55	1.1	231

Table E-6: TP influent concentrations and loading

	Influent Concentration (mg/L)	Peaking Factor	Total Loading (lbs/day)
Annual Average	7.8	1.0	32
Maximum Day	16.8	2.2	70
Maximum Month	9.4	1.2	39

Influent Alkalinity

Alkalinity is not a water quality parameter regulated by a NPDES permit, but it is still important to have measurements of this parameter for chemical and biological processes. Table 5 presents influent alkalinity measurements (Table E-7). The influent contains an average daily alkalinity of 250 mg/L as $CaCO_3$.

Table E-7: Influent alkalinity measurements

	Alkalinity (mg/L as $CaCO_3$)
Average Day	250
Maximum Day	290

Effluent Water Quality

The existing WWTP underwent monthly sampling of effluent, the data for which is available from 2018 to 2021. Plant sampling recorded monthly values for the following water quality parameters: Total BOD_5, TSS, Nitrate and Nitrite as N (NO_2/NO_3), Ammonia Nitrogen (NH_3), TN, TKN, TP, and Fecal Coliform

(E. coli). Available effluent water quality data were assessed by outfall and compared to the NPDES permit and Class I and Class III reuse requirements.

BOD_5

Treated effluent contained an average of 9.0 and 15 mg/L BOD_5 for Georges Run and spray irrigation discharges, respectively. Class III reuse requires a monthly average of no more than 10 mg/L BOD_5 (Table E-8)

Table E- 8: Effluent BOD5 concentrations for Outfall 001A (Georges Run) and 002 (Spray Irrigation)

	Outfall 001A BOD_5 (mg/L)	**Outfall 002 BOD_5 (mg/L)**
Minimum Month	2.0	2.0
Average Month	9.0	15
Maximum Month	28	44
Class I Reuse Limit	-	70 (monthly average)
Class III Reuse Limit	-	10 (monthly average)

TSS

Treated effluent contains an average of 23 and 20 mg/L of TSS for Georges Run and spray irrigation discharge, respectively. Class III reuse requires continuous turbidity monitoring in Nephelometric Turbidity Units (NTU) that shall not exceed 5 NTU at any time (Table E-9). NTU and measurements made in mg/L are not convertible. Monitoring for TSS in the new WWTP will be reported in NTU to match Class III reuse guidelines.

Table E-9 Effluent TSS concentrations for Outfalls 001A (Georges Run) and 002 (Spray Irrigation)

	Outfall 001A TSS (mg/L)	**Outfall 002 TSS (mg/L)**
Minimum Month	3.0	8.0
Average Month	24	20
Maximum Month	84	71
Class I Reuse Limit	-	90
Class III Reuse Limit	-	2 NTU (daily average)

Nitrogen

Sampling data for TKN concentrations in both outfalls are available and summarized below (Table E-10)

Table E-10: Effluent TKN concentrations for Outfalls 001A (Georges Run) and 002 (Spray Irrigation)

	Outfall 001A TKN (mg/L)	**Outfall 002 TKN (mg/L)**
Minimum Month	1.1	2.5
Average Month	9.4	13
Maximum Month	20	32
Future NPDES Permit Limit	3.0	-

Phosphorus

The average total phosphorus level in the treated effluent for Outfall 001A (Georges Run) was 0.79 mg/L. The special sampling event did not record any information on total phosphorus concentrations for Outfall 002 (Spray Irrigation) (Table E-11).

Table E-11: Effluent total phosphorus concentrations for Outfall 001A (Georges Run)

	Outfall 001A TP (mg/L)
Minimum Month	0.29
Average Month	0.79
Maximum Month	2.4
Future NPDES Permit Limit	0.3

Fecal Coliform (E.coli)

Treated effluent contains an average of 40 and 10 mg/L of E.coli for Georges Run and spray irrigation discharge, respectively. Class III reuse requires fecal coliform measurements in Most Probable Number (MPN) units per 100 mL, with the monthly mean not to exceed 2.2 MPN (Table E-12). MPN units and measurements made in mg/L are not convertible. Measurements made for E.coli in the new WWTP will be reported in MPN units to match Class III reuse guidelines.

Table E-12: Effluent E.coli concentrations for Outfalls 001A (Georges Run) and 002 (Spray Irrigation)

	Outfall 001A E.coli (mg/L)	**Outfall 002 E.coli (mg/L)**
Minimum Month	1.4	0.0
Average Month	40	10
Maximum Month	82	101
Class III Limit	-	2.2 MPN

Appendix F – Supplementary Qualitative Decision Matrices

Table F-1: Preliminary Treatment Qualitative Matrix

	Footprint	Capital Cost	Operation and Maintenance Cost	Maintenance Demand	Odor Control	Grit Removal	Ability to handle varying flows
Horizontal-Flow Grit Chambers	Highest Footprint	Moderate Cost- due to space requirement	Moderate	Moderate	Not Required	Can be designed to be 95% efficient for particle sizes of 150 um	No
Aerated Grit Chamber	Moderate Footprint	Moderate Cost - energy intensive	Highest	Intensive	Release of Volatile Odors	Can be designed to be 95% efficient for particle sizes of 150 um	Yes
Vortex-Type Grit Chamber	Small Footprint	High Cost - complex design	Low-Moderate	Low	Not Required	Can be designed to be 95% efficient for particle sizes of 75 um and larger	Yes

Table F-2: Nutrient Removal Qualitative Matrix

	Footprint	Capital Cost	Operation and Maintenance Cost	Maintenance Demand	Chemical Addition	Post-Reactor Polishing
4-Stage Bardenpho	High Footprint	Moderate	Moderate	Moderate - Filter Backwash and Cleaning	High	High
4-Stage Bardenpho with MBR	Moderate Footprint	Highest	Highest	Intensive - Constant Upkeep	High	Low
5-Stage Bardenpho	Highest Footprint	High	Moderate	Moderate - Filter Backwash and Cleaning	Lowest	Moderate

Table F-3: Carbon Addition Qualitative Matrix

	Sustainability Score	Operation and Maintenance Cost	C:N	Storage and Handling
Methanol	Manufactured	Moderate	3:1 (less sludge production)	Flammable
Micro-C™ (EOSi)	Natural	High	5:1 (more sludge production)	Less than Methanol

Table F-4: Filter Qualitative Matrix

	Footprint	Capital Cost	Operation and Maintenance Cost	Maintenance Demand	Varying Flow	Effectiveness of Separation
Aqua-Aerobic Cloth Media Filter AquaMiniDisk®	Standard	Higher	Higher - Filter maintenance	Higher - Filter maintenance	Yes 0.5MGD but better	Higher
Continuous Sand Filter ASTRASAND®	Standard	Moderate	Low - Continuous cleaning	Low	Yes 0.5MGD but harder	Moderate

Table F-5: Sludge Digestion Quantitative Matrix

	Footprint	Capital Cost	Operation and Maintenance Cost	Maintenance Demand	Pre-treatment	Volume Reduction	Oxygen Demand
Conventional Aerobic	Small	Lower - can reuse the existing tanks	Moderate	Low	Not Required	Moderate - 35-50% reduction	Moderate
ATAD	Slightly larger	High - need to build new tank	Higher	Highest	Required	Higher - 50% reduction	Higher - Operates at high temperature

Table F-6: Sludge Dewatering Qualitative Matrix

	Footprint	Capital Cost	Operation and Maintenance Cost	Pre-Thickening Requirement	Solids Recovery	Volume Reduction	Maintenance Demand
Volute Press	Smallest	Low	Low	None	High	Moderate	Low - self sufficient
Centrifuge	Largest	Highest	Highest - cleaning	3-6%	Higher - pre-thickening	Higher - pre-thickening	High
Belt Filter Press	Moderate	Moderate	Highest - cleaning	3-6%	Higher - pre-thickening	Higher - pre-thickening	Highest - intensive cleaning

Table F-7: Disinfection Qualitative Matrix

	Footprint	Capital Cost	Operation and Maintenance Cost	Maintenance Demand	Residual Disinfection	Safety and Health
Chlorine Gas	Low	Infrastructure already exists	Highest - Storage Requirements + rebuying	Corrosive - may impact equipment	Highest	Additional training required
Sodium Hypochlorite	Low	Infrastructure already exists	High - Storage Requirements + rebuying	Corrosive - may impact equipment	High	Additional training required
UV Radiation	Moderate (larger structure)	Infrastructure already exists	Low (replace bulbs infrequently)	Does not require much maintenance	None	Low

Table F-8: Water Reuse Qualitative Matrix

	Benefit to Town	Additional Technology Requirement	Additional Monitoring Requirement	Permit Upgrade
Class I	Moderate	None	None	Not Required
Class II	Moderate	Minimal	Minimal	Required
Class III	Highest	Requires BioWIN modeling	Yes - in athletic fields and parks	Required

Appendix G - Equations

Equalization Basin

Tank Sizing

Equation [1] – Volume of Tank

$$V = Q * HRT$$

Where:

V = volume, million gallons

Q = flow, MGD

HRT = hydraulic retention time, day^{-1}

Equation [2] – Air Requirement

$$SCFM = V * 0.015 \frac{m^3 air}{m^3/min}$$

Where:

SCFM = standard cubic feet of air per minute

V = tank volume, m^3

*Note: To maintain aerobic conditions and prevent wastewater from becoming sceptic and odorous, air should be supplied at a rate of 0.01 to 0.015 m^3 airO/m^3*min [1]*

Biological Treatment

Bardenpho Process

Equation [3] – Growth Rate of Ammonia-Oxidizing Bacteria

$$\mu_{AOB} = \mu_{max,AOB} \left(\frac{S_{NH}}{S_{NH}+K_{NH}}\right)\left(\frac{S_O}{S_O+K_{O,AOB}}\right)$$

Where:

μ_{AOB}= specific growth rate of ammonia-oxidizing bacteria (g VSS/g VSS*d)

$\mu_{max,AOB}$= maximum specific growth rate of ammonia-oxidizing bacteria (g VSS/g VSS*d)

S_{NH}= NH_4-N concentration (mg/L)

S_O= DO concentration (mg/L)

K_{NH}= half-velocity coefficient for NH_4-N (mg/L)

$K_{O,AOB}$= half-velocity coefficient for DO for AOB (mg/L)

Equation [4] – Steady State Specific Growth Rate

$$\frac{1}{SRT_{min}} = \mu_A - b_{AOB}$$

Where:

SRT= solids retention time (days)

b_{AOB}= specific endogenous decay rate of ammonia-oxidizing bacteria (g VSS/g VSS*d)

μ_{AOB}= specific growth rate of ammonia-oxidizing bacteria (g VSS/g VSS*d)

Equation [5] – pH Correction for Growth Rate

$$pH\ correction = [1 - 0.833(7.2 - pH)]$$

Equation [6] – Temperature Correction

$$x_T = x_{20}(\theta^{T-20})$$

Where:

x_T= parameter at temperature = T°C

x_{20}= parameter at temperature = 20°C

Equation [7] – SRT Design

$$SRT_{design} = SRT_{min}\ x\ peaking\ factor$$

Equation [8] – Biomass Produced (biological VSS)

$$P_{x\ bio} = \frac{QY_H(S_O - S)}{1 + b_H(SRT)} + \frac{f_d b_H QY_H(S_O - S)(SRT)}{1 + b_H(SRT)} + \frac{QY_n(NO_X)}{1 + b_{AOB}(SRT)}$$

Where:

$P_{x\ bio}$= Biomass production rate

Y_H= heterotrophic bacteria synthesis yield coefficient,

b_H= specific heterotrophic bacteria synthesis rate

f_d= fraction of biomass that remains as cell debris

Y_n= yield of nitrogen

NO_x= nitrogen as NO

Equation [9] – COD Fractions

$$bCOD = 1.6(BOD)$$

$$nbCOD = COD - bCOD$$

$$nbsCOD_e = sCOD - 1.6sBOD$$

$$nbpCOD = TCOD - bCOD - nbsCOD_e$$

$$VSS_{COD} = \frac{TCOD - sCOD}{VSS}$$

$$nbVSS = \frac{nbpCOD}{VSS_{COD}}$$

Where:

BOD= biological oxygen demand

sBOD= soluble BOD

COD= chemical oxygen demand

bCOD= biodegradable COD

nbCOD= nonbiodegradable COD

$nbsCOD_e$= filtered nonbiodegradable soluble COD in sludge effluent

sCOD= soluble COD

nbpCOD= nonbiodegradable particulate COD

TCOD= total COD

nbVSS= nonbiodegradable volatile suspended solids

VSS_{COD}= g COD/g VSS

Equation [10] – Non-Biodegradable volatile suspended solids production rate

$$P_{x\,VSS} = P_{x\,bio} + Q(nbVSS)$$

Where:

$P_{X\,VSS}$= volatile suspended solids production rate

Equation [11] – Volume of Aeration Tank

$$X_{VSS}(V) = P_{x\,VSS}(SRT)$$

Where:

XVSS= volatile suspended solids mass (g/m^3)

V= volume of aeration tank

Oxygen Demand

Equation [12] – Mass of Oxygen

$$M_{O_2} = Q(S_O - S)\left(10^{-3}\frac{kg}{g}\right) - 1.42(P_x)$$

Where:

Q = flow

M_{O2} = mass of oxygen (kg/d)

S_0 = influent bCOD (g/m^3)

S = effluent bCOD (g/m^3)

P_x = Waste Activated Sludge (WAS) produced (kg/d)

Equation [13] – Oxygen Demand for Aeration Tank

$$R_o = M_{O_2} + 4.33Q(NO_x)$$

Where:

R_o = oxygen demand (kg/day)

NO_x = influent NO_x concentration (kg/m^3)

Blower Sizing

Equation [14] – Average dissolved oxygen saturation in aeration tank

$$C_{avg} = C_{s,H,T} * 0.5\left(\frac{P_d}{P_{atm}} + \frac{O_2}{21}\right)$$

Where:

C_{avg} = average dissolved oxygen saturation in aeration tank

$C_{s,H,T}$ = average dissolved oxygen saturation at aeration tank elevation, H, and water temperature, T

P_d = pressure head at air release point

P_{atm} = atmospheric pressure head

O_2 = % of oxygen leaving tank

Equation [15] – Standard Oxygen Transfer Rate (SOTR)

$$SOTR = \frac{AOTR_{req}}{\beta(C_{ave} - C_L)(1.024^{(T-20)}\alpha F)} * C_{s,20}$$

Where:

$AOTR_{req}$ = actual oxygen transfer rate (kgO2/hr):

SOTR = standard oxygen transfer rate

C_{avg} = average dissolved oxygen saturation in clean water in aeration tank

C_L = operating DO mg/L

$C_{s,20}$ = saturation concentration of oxygen in water at 20 °C.

F = fouling factor

T = operating Temperature °C

β = salinity correction

α = clean water correction

Equation [16] – Air requirement in Standard Cubic Feet per Minute (SCFM)

$$SCFM = \frac{SOTR}{1.04 * SOTE}$$

Where:

SCFM = standard cubic feet per minute

SOTE = standard oxygen transfer efficiency

Chemical Addition

Micro C™

Equation [17] – Methanol dosage and Load

$$[Methanol] = 0.9DO + 2.5(NO_3 - N)$$

$$Methanol\ Load = [Methanol] * Q * 8.34$$

Where:

DO = dissolved oxygen concentration entering aeration tank (mg/L)

NO_3–N = Ammonia concentration exiting 4-stage (mg/L)

[Methanol] = Methanol concentration needed (mg/L)

Q = Volumetric flow rate (MGD)

8.34 = Conversion factor

Equation [18] – Methanol to Micro C™ conversion

$$\text{COD per day} = \text{methanol load} * \text{COD}_{\text{Methanol}}$$

Where:

Methanol Load = lbs /day

COD = number of COD per gram of methanol

Equation [19] – Micro C™ 2000 Dose and Load

$$COD\ per\ Micro\ C™\ 2000 = \text{COD}_{\text{Micro}} C * \rho_b$$

Where:

$\text{COD}_{\text{Micro C™}}$ = amount of COD per liter (g/L)

P_b = bulk density of Micro C™ (g/L)

$$Micro\ C™\ \text{load} = \text{COD per day} * \text{COD per Micro C™ 2000}$$

Where:

COD per Micro C™ 2000 = concentration of COD per Micro C™ 2000

Ferric Chloride

Equation [20] – Amount of P removal required by chemical addition

$$(TP\ exiting\ 4\ Stage) - (TP\ required\ into\ filter) = Amount\ of\ P\ removal\ Required$$

Where:

Amount of P removal Required = (mg/L)

Equation [21] – Ferric concentration equivalent to Amount of P removal required

$$Fe^{3+} + PO_4^3 \rightarrow FePO_4$$

$$[FeCl_3] = Amount\ of\ P\ removal\ Required\ /(PO_4 * Iron(III)Cl_3)$$

Where:

PO_4 = molecular weight of phosphate (mg/mmol)

Iron (III)Cl_3 = molecular weight of iron chloride (mg/mmol)

$FeCl_3$ = Concentration of Ferric chloride required (mg/L)

Equation [22] – Ferric chloride Load (lbs/day) assuming 92% purity

$$Load = [FeCl_3] * Q * 8.34$$

Where:

Q = volumetric flow rate (0.5 MGD)

8.34 = conversion factor

Alkalinity

Equation [23] – Soda Ash

$$\frac{[concentration]mgCaCO_3}{L} * \frac{1mmolCaCO_3}{100mg} * \frac{1mmolCO^{-2}}{1mmolCaCO_3} * \frac{1mmolNa_2CO_3}{1mmolCO^{-2}} * \frac{106mg}{1mmolNa_2CO_3} = [concentratiion]\frac{mgNa_2CO_3}{L}$$

Mechanical Mixing

Equation [24] – Power requirement for mechanical mixers

$$P = \mu V_{tank} G^2$$

Where:

P = required input power, W

μ = dynamic viscosity of water at 25°C (design temperature)

G = velocity gradient, s^{-1}

Pump Sizing

Equation [25] – Slope of energy grade line

$$S_f = \frac{10.44 Q^{1.85}}{C^{1.85} D^{4.8566}}$$

Where:

S_f = slope of energy grade line, ft/ft

Q = flow, gpm

C = coefficient of roughness for ductile iron pipe

D = pipe diameter, in

Equation [26] – Pipe friction headloss

$$HL = L * S_f$$

Where:

L = length of pipe, ft

S_f = slope of energy grade line, ft/ft

Equation [27] – Total dynamic head

$$TDH = HL + Elevation$$

Where:

HL = pipe friction headloss, ft

Elevation = elevation difference that water must overcome

Secondary Clarifiers

Equation [28] – Hydraulic Loading Rate

$$OR = \frac{Q}{A}$$

Where:

Q = average daily projected flow, gallons per day

A = surface area, ft^2

OR = overflow rate

Equation [29] – Solids Loading Rate

$$SLR = \frac{Q * X}{A}$$

Where:

Q = average daily projected flow, gallons per day

X = kg of VSS per cubic foot

A = surface are in square feet

SLR = kilograms of TSS a foot per day

Disinfection

Equation [30]– Chlorine Dosage and Load

$$NaOCl + H_2O + 2NH_4 \rightarrow HOCl + NaOH + 8H^+ + N_2$$

$$[Cl_2] = NH_3 - N * MW$$

Where:

Residual $NH3_3$–N : concentration of $NH3_3$–N entering disinfection basin (mg/L)

Molecular Weight Ratio: Ratio N:NH_4

$$Cl_2\ load = [Cl_2] * Q * 8.34$$

Equation [31] – Contact time for 10% of influent not treated (t_{10})

$$t_{10} = \frac{Ct}{C}$$

Where:

C_t = Concentration values for Chlorine to achieve 99.9% Reduction of *Giardia lambia;* this value was chosen based on approximate pH and temperature (mg/L/min)

C = residual free chlorine concentration; this value was estimated based on EPA guidelines for Class III water reuse (mg/L)

Equation [32] – Residence Time

$$t_r = \frac{t_{10}}{0.7}$$

Where:

0.7 = t_{10}/t_r ratio for superior performance of serpentine baffle design

Equation [33] – Required Volume and Dimensions

$$V = Q * t_r$$

Where:

T_r: residence time (min)

$$L = \frac{V}{(W * H)}$$

Where:

V = Required volume (ft)

W = Chosen width (ft)

H= Height equivalent to 3W (ft)

$$Length\ per\ Baffle = \frac{L}{3}$$

Where:

L= Total length (ft); design with three baffles chosen

Sludge

Equation [34] – Sludge density

$$\rho_{sludge}\left(\frac{\text{kg sludge}}{m^3}\right) = \rho_{water} + (\rho_{water} * X_r)$$

Where:

ρ_{water} = water density (kg/m^3)

X_r = percent solids of the sludge (g TSS/100 g sludge)

Equation [35] – Wet sludge mass

$$M_{sludge,in}\left(\frac{\text{kg sludge}}{\text{day}}\right) = P_{x,TSS}/X_r$$

Where:

$P_{x,\,TSS}$ = the dry mass of solids (kg TSS/day)

X_r = percent solids of the sludge within the tank (g TSS/100 g sludge)

Equation [36] – Sludge flow rate

$$Q_{sludge,in}\left(\frac{m^3}{\text{day}}\right) = M_{sludge,in}/\rho_{sludge}$$

Where:

$M_{\text{ sludge, in}}$ = the wet mass of sludge entering the tank (kg sludge/day)

ρ_{sludge} = the sludge density (kg/m^3)

Equation [37] – Solids retention time

$$SRT\ (d) = V_{tank}/Q_{sludge,in}$$

Where:

V_{tank} = the volume of the aerobic digestion tank (m^3 or gallons)

$Q_{\text{ sludge, in}}$ = the volumetric flow rate of sludge entering the tank (m^3/d or gallons/day)

Equation [38] – VSS reduction

$$Mass\ of\ VSS_{reduced}\left(\frac{\text{kg VSS}}{\text{day}}\right) = P_{x,VSS} * \%VSS_{reduced}$$

Where:

$P_{x,\,VSS}$ = the dry mass of volatile suspended solids entering the tank (kg VSS/day)

$\%VSS_{reduced}$ = the percent reduction of VSS in the tank

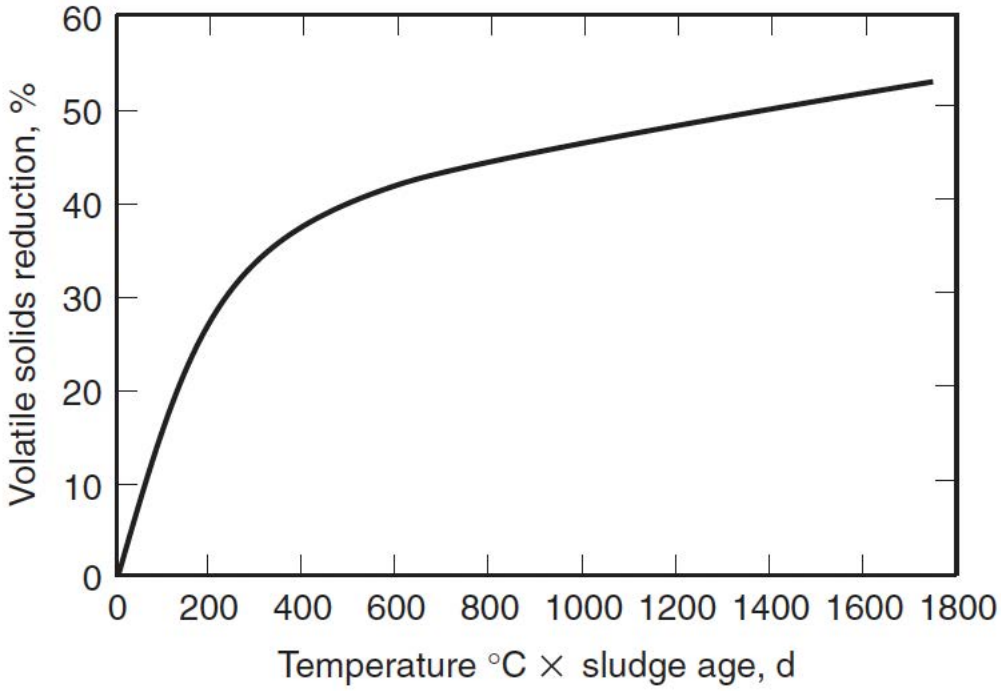


Figure A-1: *Volatile solids reduction in an aerobic digester as a function of sludge temperature and age [1]*

Equation [39] – Dry mass of effluent sludge

$$Dry\ Sludge\ Mass_{effluent}\left(\frac{\text{kg TSS}}{\text{day}}\right) = P_{x,TSS} - \ Mass\ of\ VSS_{reduced}$$

Where:

$P_{x,\,TSS}$ = the dry mass of solids (kg TSS/day)

Mass of $VSS_{reduced}$ = the mass of VSS reduced each day (kg)

Equation [40] – Wet mass of effluent sludge

$$Wet\ Sludge\ Mass_{effluent}\left(\frac{kg\ sludge}{day}\right) = Dry\ Sludge\ Mass_{effluent}/X_r$$

Where:

Dry Sludge Mass $_{effluent}$ = the dry mass of the effluent sludge (kg TSS/day)

X_r = the percent solids in the sludge (g TSS/100 kg sludge)

Equation [41] – Volume of effluent sludge

$$Sludge\ Volume_{effluent}\left(\frac{m^3}{day}\right) = Wet\ Sludge\ Mass_{effluent}/\rho_{sludge}$$

Where:

Wet Sludge Mass $_{effluent}$ = The mass of sludge produced daily

ρ_{sludge} = the sludge density (kg/m^3)

Equation [42] – Oxygen Demand

$$O_2\ demand\ (kg/d) = Mass\ of\ VSS_{reduced} * 2.3$$

Mass of VSS $_{reduced}$ = the mass of VSS reduced each day (kg VSS $_{reduced}$/day)

Equation [43] – Volumetric oxygen demand

$$O_2\ demand\left(\frac{m^3}{d}\right) = \frac{O_2\ demand}{\rho_{air} * \left(\frac{M_{O_2}}{M_{air,total}}\right)}$$

Where:

O_2 demand = the oxygen demand (kg/day)

ρ_{air} = the density of air (kg/m^3)

$\left(\frac{M_{O_2}}{M_{air,total}}\right)$ = the percent oxygen in air (kg O_2/ kg air)

Equation [44] – Solids loading rate

$$SLR\ \left(\frac{kg}{m^2 * d}\right) = \frac{P_{x,TSS}}{A}$$

Where:

$P_{x,\,TSS}$ = the dry mass of solids (kg TSS/day)

A = the surface area of the tank

Equation [45] – Hydraulic loading rate

$$Hydraulic\ Loading\ \left(\frac{m^3}{m^2 * d}\right) = \frac{Q}{A}$$

Where:

Q = the flow rate into the tank (m^3/day)

A = the surface area of the tank (m^2)

Equation [46] – Pressure head at release point

$$P_d = P_{atm} + h_w$$

Where:

P_{atm} = atmospheric pressure head (meters of water)

h_w = depth of water at the discharge point (m)

Appendix H – Biological Treatment Details

Bardenpho Sizing Values

Table H-1: 4-Stage Bardenpho Tank Volumes

	Total System		Per Train	
Anoxic	85,000	gal	42,500	gal
Aerobic	606,000	gal	303,000	gal
Anoxic II	42,000	gal	21,000	gal
Aerobic II	20,000	gal	10,000	gal

Table H-2: 5-Stage Bardenpho Tank Volumes

	Total System		Per Train	
Anaerobic	20,000	gal	10,000	gal
Anoxic	62,500	gal	31,250	gal
Aerobic	606,000	gal	303,000	gal
Anoxic II	42,000	gal	21,000	gal
Aerobic II	20,000	gal	10,000	gal

Selected BioWin Iterations

Table H-3: 4-Stage Bardenpho Modeling at 12°C

Element name	Flow	VSS	TSS	COD - Tot	COD - Filt	Total N	TKN	Filtered TN	N - Ammo	N - Nitrate	P - Total	P - Solubl	BOD - Tot	BOD - Filt	Volume	Temperature	
Influent	1892.71	274.46	319.46	732	295.09	56.5	55.47	45.95	39.74	1.03	9.83	5.21	351.4	156.4	0	12	
Anoxic 1	18847.7	2261.8	3400.09	3345.77	66.53	193.49	192.88	6.03	4.4	0.55	111.87	1.52	773.97	4.2	315	12	
Aeration 1	18847.7	2243.84	3383.3	3310.07	60.86	192.77	188.97	2.31	0.67	3.63	111.87	1.42	750.29	0.93	2296	12	MicroC 270 L/d
Anoxic 2	3706.48	2242.18	3396.38	3382.46	135.78	190.84	188.94	2.29	0.93	1.8	111.85	0.98	806.73	59.25	158	12	Ferric 175 L/d 800%
Aeration 2	3706.48	2255.66	3411.94	3344.83	79.7	190.78	189.74	1.55	0.01	1.03	111.85	0.47	772.79	15.62	79	12	recycle
Secondary Effluent	1813.77	4.61	6.97	86.37	79.7	2.97	1.94	1.55	0.01	1.03	0.7	0.47	17.17	15.62	0	12	
Sludge	79.38	4412.82	6674.91	6467.4	79.7	370.75	369.71	1.55	0.01	1.03	218.37	0.47	1496.89	15.62	0	12	

Table H-4:4-Stage Bardenpho Modeling at 20°C

Element name	Flow	VSS	TSS	COD - Tot	COD - Filt	Total N	TKN	Filtered TN	N - Ammo	N - Nitrate	P - Total	P - Solubl	BOD - Tot	BOD - Filt	Volume	Temperature	
Influent	1892.71	274.46	319.46	732	295.09	56.5	55.47	45.95	39.74	1.03	9.83	5.21	351.4	156.4	0	20	
Anoxic 1	15062.3	2096.23	3221.44	3110.85	66.97	177.11	176.81	6.7	5.09	0.27	108.85	1.71	642.83	4.19	315	20	
Aeration 1	15062.3	2073.09	3199.77	3066.15	60.87	176.23	171.8	1.99	0.34	4.34	108.85	1.6	613.44	0.93	2296	20	MicroC 183 L/d,
Anoxic 2	3706.4	2072.56	3214.15	3110.49	106.14	173.51	171.78	1.87	0.51	1.7	108.84	1.12	647.65	36.14	158	20	ferric 175 L/d, 600%
Aeration 2	3706.4	2080.37	3223.49	3082.28	67.49	173.44	172.42	1.56	0.01	1.02	108.84	0.75	622.81	6.09	79	20	recycle
Secondary Effluent	1813.69	4.25	6.59	73.65	67.49	2.92	1.91	1.56	0.01	1.02	0.97	0.75	7.35	6.09	0	20	
Sludge	79.38	4069.81	6306.09	5965.3	67.49	336.84	335.82	1.56	0.01	1.02	212.21	0.75	1212.58	6.09	0	20	

Table H-5: 5-Stage Bardenpho Modeling at 12°C

Element name	Flow	VSS	TSS	COD - Tot	COD - Filt	Total N	TKN	Filtered TN	N - Ammo	N - Nitrate	P - Total	P - Solubl	BOD - Tot	BOD - Filt	Volume	Temperature	
Influent	15062	2299.96	3245.89	3391.09	63.77	199.53	195.39	2.48	0.69	3.97	114.03	0.35	823.34	0.94	2295	12	
Anaerobic	3706.1	2299.02	3250.7	3473.39	147.6	196.22	195.38	2.38	0.86	0.82	114.02	0.18	887.1	66.06	157.63	12	
Anoxic 1	3706.1	2307.1	3259.77	3446.82	110.29	196.16	195.75	1.73	0.02	0.41	114.02	0	863.42	37.01	78.81	12	
Aeration 1	3705.72	2377.39	3289.41	3614.93	151.12	214.68	214.68	23.89	21.61	0	114.03	10.67	979.56	61.23	78.81	12	MicroC 310 L/d,
Anoxic 2	1892.71	274.46	319.46	732	295.09	56.5	55.47	45.95	39.74	1.03	9.83	5.21	351.4	156.4	0	12	ferric 70 L/d
Aeration 2	15062	2323.65	3259.58	3438.11	70.29	200.44	200.13	7.37	5.76	0.29	114.03	3.52	854.51	4.83	236.44	12	
Secondary Effluent	1813.39	9.43	13.32	123.93	110.29	2.93	2.52	1.73	0.02	0.41	0.47	0	40.39	37.01	0	12	
Sludge	79.7	4508.47	6370.15	6630.46	110.29	381.29	380.88	1.73	0.02	0.41	222.81	0	1651.96	37.01	0	12	

Table H-6: 5-stage Bardenpho Modeling at 20°C

Element name	Flow	VSS	TSS	COD - Tot	COD - Filt	Total N	TKN	Filtered TN	N - Ammo	N - Nitrate	P - Total F	P - Solubl	BOD - Tot	BOD - Filt	Volume	Temperature	
Influent	1892.71	274.46	319.46	732	295.09	56.5	55.47	45.95	39.74	1.03	9.83	5.21	351.4	156.4	0	20	
Anaerobic	3705.73	2194.95	3074.46	3338.55	135.52	196.86	196.85	23.85	21.62	0	112.66	9.5	816.43	49.31	78.81	20	
Anoxic 1	15062	2135.1	3035.92	3165.11	66.71	182.32	181.39	7.06	5.48	0.89	112.66	3.23	696.06	2.59	236.44	20	MicroC 205 L/d, ferric 55 Ld, 600% recycle
Aeration 1	15062	2110.22	3019.27	3119.58	63.13	181.44	176.35	2.1	0.35	5	112.66	0.66	666.27	0.91	2295	20	
Anoxic 2	3705.99	2109.74	3023.52	3169.49	113.93	177.7	176.36	1.97	0.49	1.32	112.65	0.47	704.65	40.34	157.63	20	
Aeration 2	3705.99	2118.1	3033.29	3139.8	73.04	177.63	177.09	1.68	0.01	0.54	112.65	0.13	678.49	8.55	78.81	20	
Secondary Effluent	1813.28	8.66	12.4	85.58	73.04	2.94	2.4	1.68	0.01	0.54	0.59	0.13	11.29	8.55	0	20	
Sludge	79.69	4139.01	5927.41	6065.84	73.04	344.99	344.44	1.68	0.01	0.54	220.01	0.13	1317.69	8.55	0	20	

Appendix I – Manufacturer Data

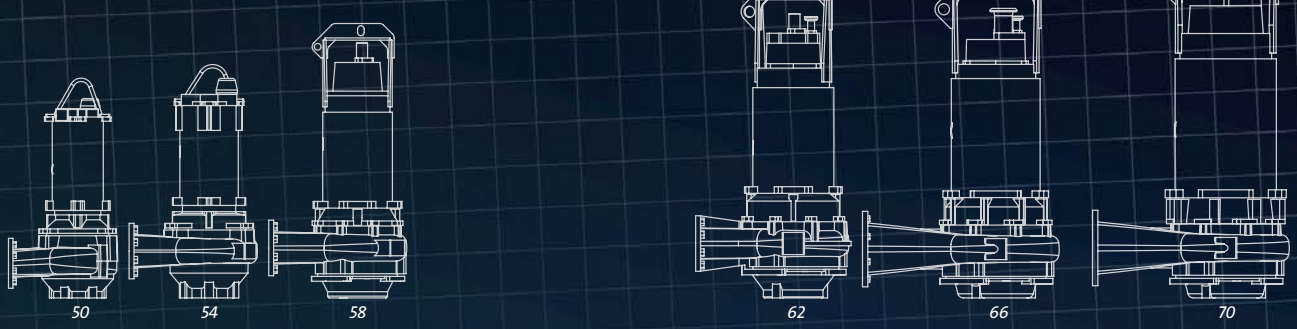
Influent Pumps

PUMPING
ON ANY SCALE



be
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GRUNDFOS



STRENGTH FOR YOUR SYSTEMS

Submersible pumps: from 13 to 700 Hp and 13 frame sizes



The Grundfos S range consists of submersible sewage pumps fitted with a channel or SuperVortex impeller. The number of motor sizes – from 13 to 700 Hp – with a very wide range, including the new updated pumps, provides an easier overview: We have divided the range into 9 frame sizes – each of them available with many different motors.

S pumps form the backbone in many sewage systems. They get chosen for their strength, their durability, and for innovative features such as the SmartTrim impeller clearance adjustment system.

When you design a system, we invite you to draw on our vast experience. Grundfos can help you to ensure the correct system and pump sizing to avoid any potential design errors. Quite often our recommendations can save you substantial monies on design and construction costs. The sooner you call Grundfos, the sooner we can begin to assist you in making our recommendations.

THE S RANGE AT WORK

For unscreened raw sewage and raw water

S pumps are designed to handle unscreened raw sewage or raw water in wastewater/water infrastructure and industrial applications.

The scope of the S range lets it be used for sewage/liquid handling on any scale. Popular applications include sewage pumping stations – both local and main stations – but clean-water systems and industries also find uses for the power of S pumps.

The S-pumps are available with high efficient single-, dual- ,triple or quad-channel impellers or Super Vortex impeller allowing for free passage of solids from 3.5" to 5.7".
Impellers can be delivered in stainless steel for corrosive liquids.

Typical application areas

- Sewage pumping stations
- Wastewater treatment plants
- Raw/potable water intake and distribution
- Industry/corrosive liquids
- Large-scale buildings
- Building facilities
  (car parks, hotel facilities, etc.)

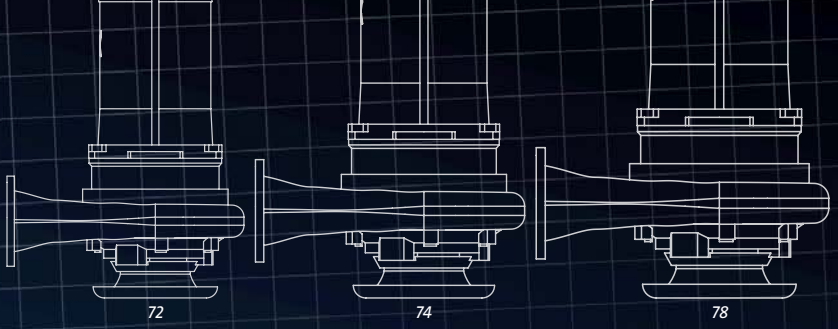
S pumps are suitable in submerged installations for both temporary and permanent use, whereas dry-installed pumps can be installed both vertically and horizontally.



S pumps are often found in large-scale pumping stations.

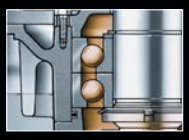


S pumps can be used for dry installation when fitted with cooling jackets.

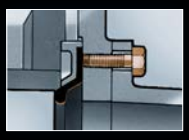


S PUMP FEATURES

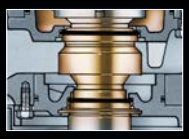
– and what they do for you



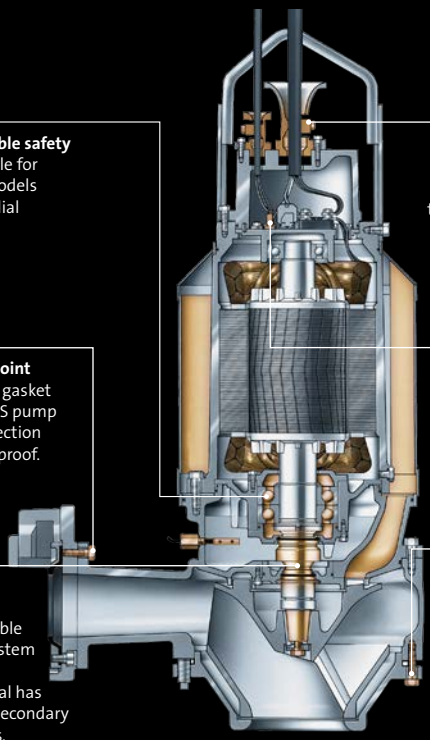
Double bearings for double safety
Lower bearings are double for double safety. Certain models feature an additional radial bearing.

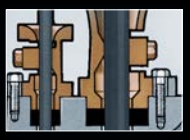


No leaks at connection point
The Grundfos SmartSeal gasket system ensures that the S pump and auto-coupling connection point is completely leak-proof.



No leaks into motor
The liquid is kept away from the motor by a double mechanical shaft seal system in the intermediate oil chamber. The primary seal has SiC/SiC rings, while the secondary seal has SiC/carbon rings.

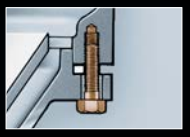




No leaks at cable entry point
The cable entry point is watertight, preventing liquid from entering at this often vulnerable spot. Rounded edges also prevent cable wear.

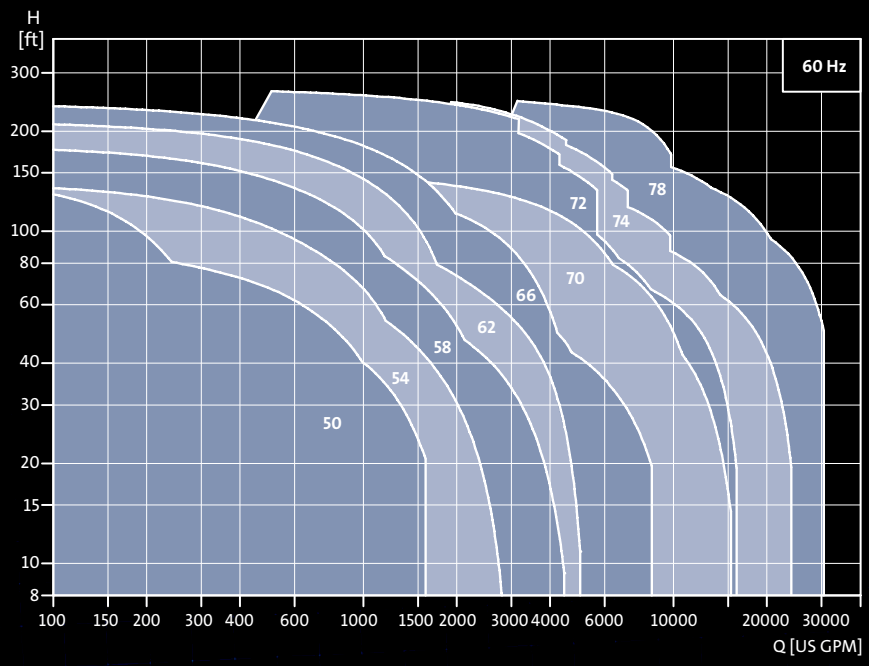


Many sensor options
S models are available w/ integrated vibration sensor, analogue sensors (motor and bearing temperature, water in oil and motor insulation resistance).



Maintain top efficiency with minimum effort
The patented SmartTrim system lets you adjust the impeller clearance by turning a few screws – maximum pump efficiency can be restored in a moment.

Performance overview



SEE THE BIGGER PICTURE

Grundfos is a global leader within water handling technology. Our passion is to bring you all the products you require to create and operate pump systems that combine reliability, cost-efficiency – and innovation. Our products are for use in water supply and wastewater infrastructure on any scale.

Grundfos has a full line of products and systems for the intake, treatment, and distribution of drinking water and for the transport and treatment of wastewater. We also offer expertise and industry insight that can increase reliability and reduce lifecycle costs for water utilities.

Key product areas include:


Submersible pumps


Surface pumps


Sewage pumps


Mixers, flowmakers & recirculation pumps


Pumping stations


Monitoring & controls


Dosing & disinfection


Aeration equipment

Our products are the result of decades of engineering expertise. Supported by a worldwide service network.

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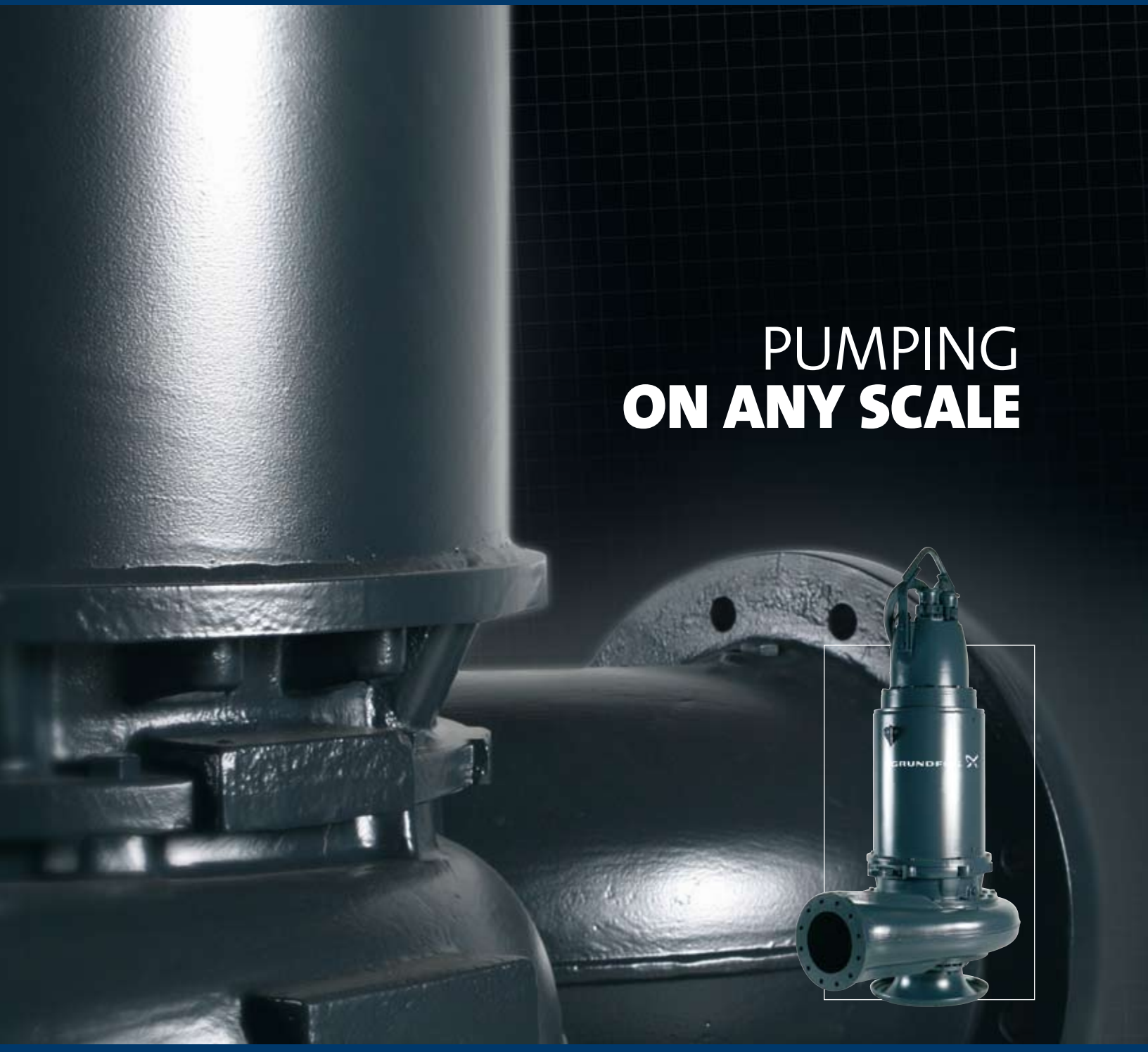
GRUNDFOS
3905 Enterprise Drive, Aurora, IL 60504
USA
PH: 630.236.5500 - FX: 630.236.5511

www.grundfos.us

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GRUNDFOS **S RANGE**

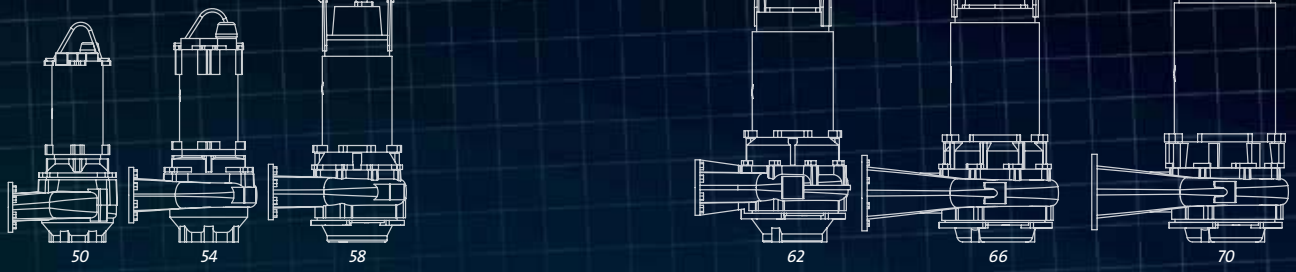
Cast-iron submersible pumps 13-700 Hp
60 Hz North America



PUMPING
ON ANY SCALE

BE › THINK › INNOVATE ›

GRUNDFOS



STRENGTH FOR YOUR SYSTEMS

Submersible pumps: from 13 to 700 Hp and 13 frame sizes



The Grundfos S range consists of submersible sewage pumps fitted with a channel or SuperVortex impeller. The number of motor sizes – from 13 to 700 Hp – with a very wide range, including the new updated pumps, provides an easier overview: We have divided the range into 9 frame sizes – each of them available with many different motors.

S pumps form the backbone in many sewage systems. They get chosen for their strength, their durability, and for innovative features such as the SmartTrim impeller clearance adjustment system.

When you design a system, we invite you to draw on our vast experience. Grundfos can help you to ensure the correct system and pump sizing to avoid any potential design errors. Quite often our recommendations can save you substantial monies on design and construction costs. The sooner you call Grundfos, the sooner we can begin to assist you in making our recommendations.

THE S RANGE AT WORK

For unscreened raw sewage and raw water

S pumps are designed to handle unscreened raw sewage or raw water in wastewater/water infrastructure and industrial applications.

The scope of the S range lets it be used for sewage/liquid handling on any scale. Popular applications include sewage pumping stations – both local and main stations – but clean-water systems and industries also find uses for the power of S pumps.

The S-pumps are available with high efficient single-, dual- ,triple or quad-channel impellers or Super Vortex impeller allowing for free passage of solids from 3.5" to 5.7".
Impellers can be delivered in stainless steel for corrosive liquids.

Typical application areas

- Sewage pumping stations
- Wastewater treatment plants
- Raw/potable water intake and distribution
- Industry/corrosive liquids
- Large-scale buildings
- Building facilities
  (car parks, hotel facilities, etc.)

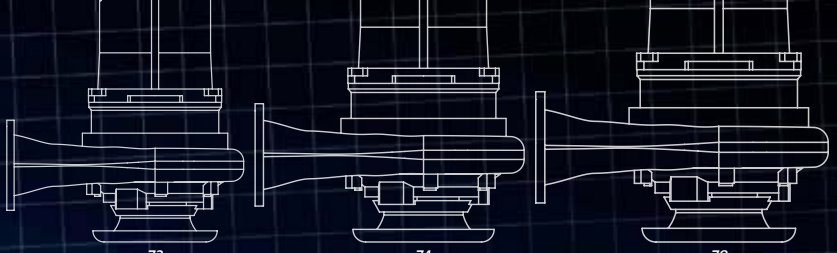
S pumps are suitable in submerged installations for both temporary and permanent use, whereas dry-installed pumps can be installed both vertically and horizontally.



S pumps are often found in large-scale pumping stations.

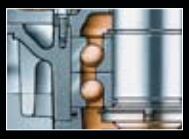


S pumps can be used for dry installation when fitted with cooling jackets.

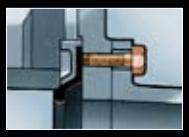


S PUMP FEATURES

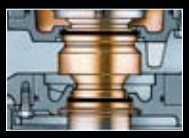
– and what they do for you



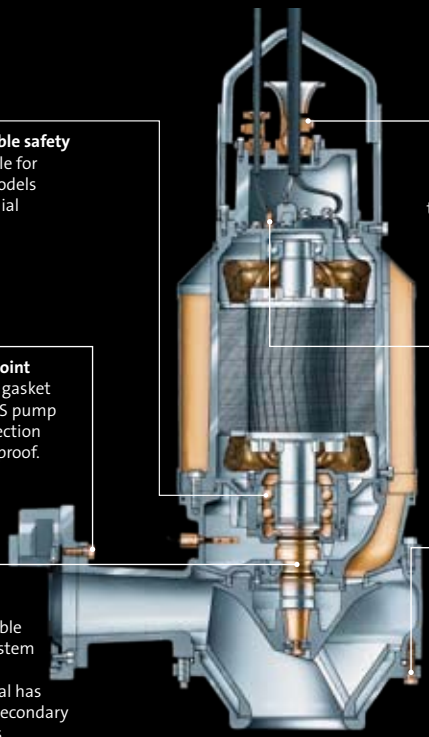
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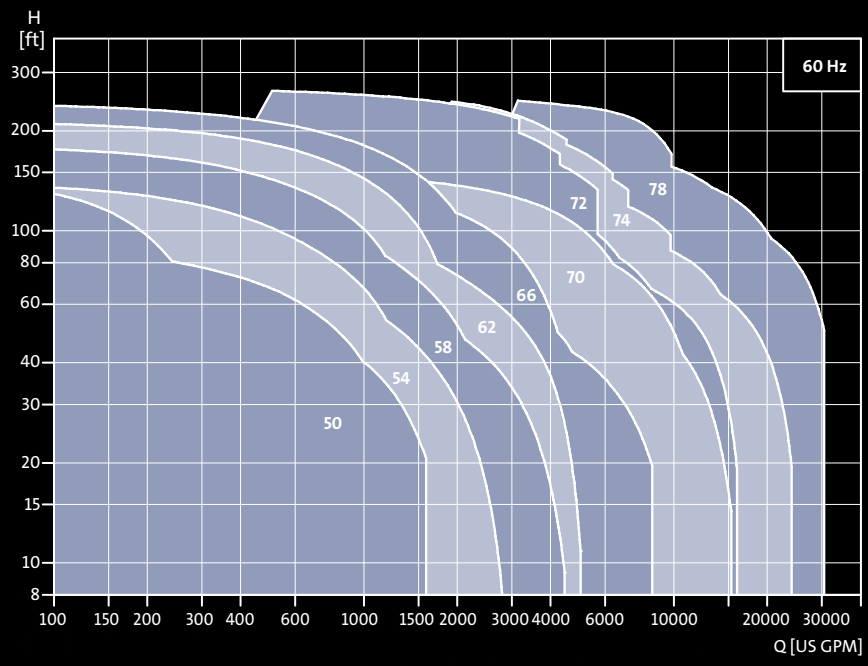
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Maintain top efficiency with minimum effort
The patented SmartTrim system lets you adjust the impeller clearance by turning a few screws – maximum pump efficiency can be restored in a moment.



Performance overview



BE > THINK > INNOVATE >

Being responsible is our foundation
Thinking ahead makes it possible
Innovation is the essence

SEE THE BIGGER PICTURE

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Key product areas include:


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Surface pumps


Sewage pumps


Mixers, flowmakers & recirculation pumps


Pumping stations


Monitoring & controls


Dosing & disinfection


Aeration equipment

Our products are the result of decades of engineering expertise. Supported by a worldwide service network.

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GRUNDFOS

(9567) 97 72 72 15 - 07 10

S pumps, range 62

54 to 79 HP
60 Hz ANSI



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Grundfos GO 61

1. Introduction

Introduction

This data booklet deals with Grundfos heavy-duty sewage pumps, type S, range 62.



TM070218 4517

Fig. 1 S pump, range 62

S pumps, range 62, are a range of free-flow channel impeller pumps specifically designed for pumping sewage and wastewater in a wide range of municipal, private and industrial applications.

The pumps are made of resistant materials, such as cast iron and stainless steel. These materials ensure a proper operation.

The pumps are fitted with motors from 54 to 79 HP (40 to 52 kW). The motors are 4-pole motors.

The free passage in the pumps is 3 to 4 inches (80 to 100 mm).

The pumps are available for these types of installation:

- submerged installation on auto-coupling system
- submerged installation, free-standing
- dry installation, vertical
- dry installation, horizontal

Applications

S pumps are designed for applications such as these:

- raw-water intake
- wastewater treatment plants
- municipal pumping stations
- public buildings
- residential housing
- blocks of apartments
- industries
- parking garages
- underground car parks
- car-wash areas
- restaurants and hotels.

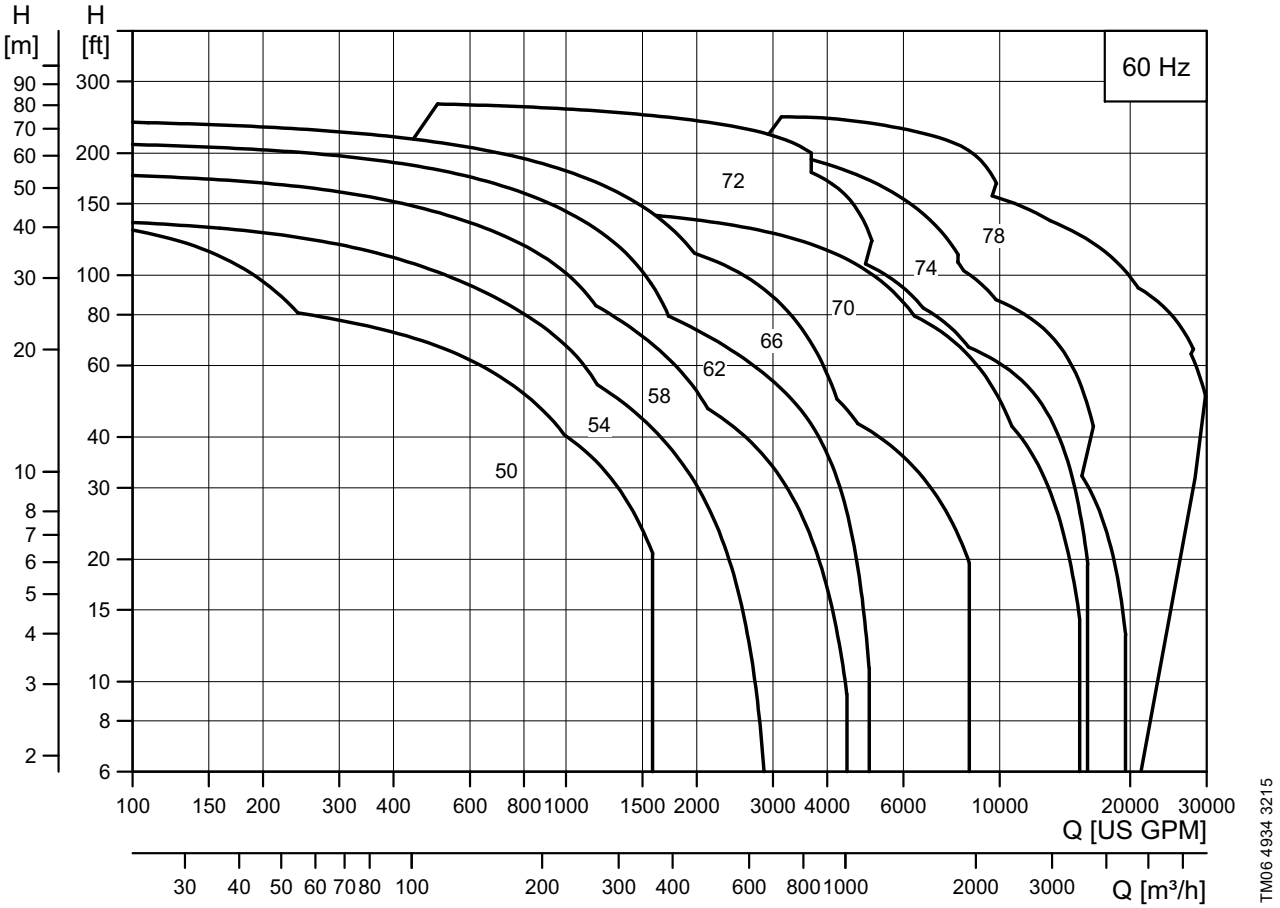
The pumps are suitable for both temporary and permanent installation. The lifting bracket fitted on the pumps facilitates easy transportation as well as installation at the installation site.

Main constructional features

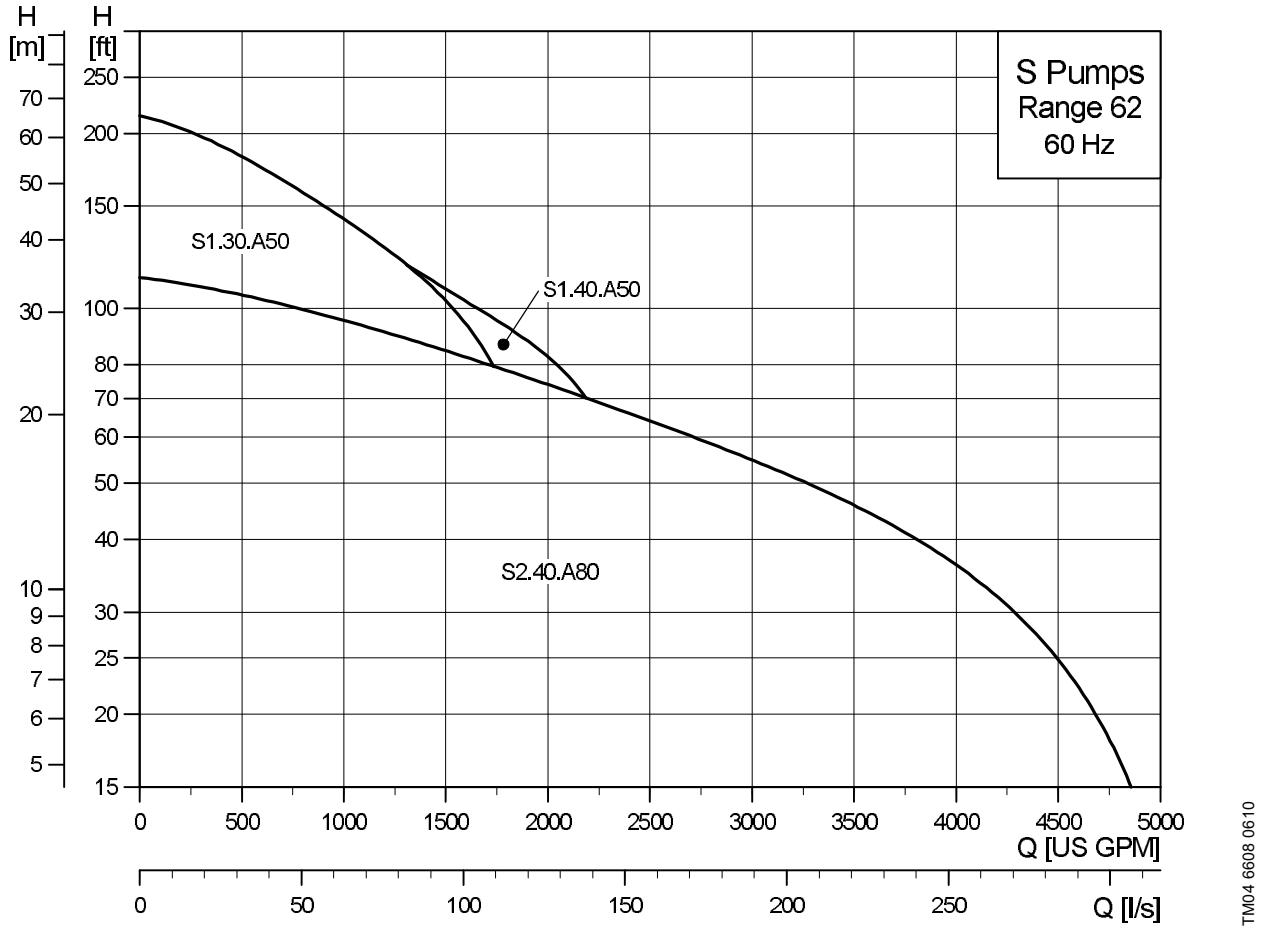
- Leak-proof connections on auto coupling via the Grundfos SmartSeal sealing system
- double mechanical shaft-seal system for reliable sealing between pumped liquid and motor
- watertight cable entry
- moisture switch for continuous monitoring of motor housing and automatic cut-off of power in case of ingress of liquid
- self-cleaning channel impeller with long vanes reducing the risk of jamming or clogging
- SmartTrim system allowing easy adjustment of impeller clearance and maintaining maximum pump efficiency over pump lifetime
- motor in insulation class H [356 °F (180 °C)] with class F [311 °F (155 °C)] temperature increase, enclosure class IP68 with three thermal sensors in stator windings
- shaft seal condition monitoring via water-in-oil sensor (optional)
- explosion-proof motors for applications involving potential risk of explosion
- three stainless steel versions for use in corrosive or aggressive liquids:
  - stainless steel impeller, cast iron pump and motor housing
  - stainless steel pump housing, flange and impeller, cast iron motor housing made entirely of corrosion-resistant stainless steel.

2. Performance range

Performance range overview, S pumps



Performance range, S pumps, range 62



List of pump curves

3 x 460 V

Pump type	Pressure range	Curve chart on page
S2.40.A80.xxx.4	Low	32
S2.40.A80.790.4		34
S1.40.A50.xxx.4	Medium	36
S1.40.A50.790.4		38
S1.30.A50.xxx.4	High	40
S1.30.A50.790.4		42

3. Identification

Type key

Please note that the pump type described in this booklet is not necessarily available in all variants.

Example S1.40.A80.980.4.66H.S.358.G.Ex.D.611.Z

Code	Explanation	Designation
S	Grundfos sewage and wastewater pump	Pump type
ST	Multi-channel impeller pump installed in a column pipe	
1	Single-channel impeller	Impeller type
2	Two-channel impeller	
3	Three-channel impeller	
V	SuperVortex impeller	
40	Maximum solids size = code number from type designation / 10 [inch]	Pump passage [inch]
A80	Nominal diameter of pump outlet port = code number from type designation / 10 [inch]	Pump outlet [inch], S-type
	Nominal diameter of column pipe = code number from type designation / 10 [inch]	Pump outlet [inch], ST-type
980	P2 = code number from type designation / 10 [HP]	Power output [HP][1]
2	2-pole motor	Number of poles
4	4-pole motor	
6	6-pole motor	
8	8-pole motor	
10	10-pole motor	
12	12-pole motor	
50	Range 50	Pump range
54	Range 54	
58	Range 58	
62	Range 62	
66	Range 66	
70	Range 70	
S	Super-high	Pressure version
H	High	
M	Medium	
L	Low	
E	Extra-low	
F	Super-low	
S	Submersible installation without cooling jacket	Installation type
C	Submersible installation with cooling jacket	
D	Dry installation, vertical	
H	Dry installation, horizontal	
358	Impeller diameter	Impeller diameter [mm]
G	Cast-iron impeller, pump housing and stator housing	Material code for impeller, pump housing and stator housing
Q	Stainless-steel impeller, DIN W.-Nr. 1.4408	
N	Non-explosion-proof pump	Pump version
Ex	Pump with explosion-proof motor	
B	S pump with built-in SM 113[2]	Sensor version
C	Not in use	
D	S pump without built-in SM 113	
6	60 Hz	Frequency [Hz]
11	3 x 460 V, Y/D	Voltage code and connection
3A	3 x 460 V, factory wired (dual voltage, 230 V or 460 V)	
3B	3 x 230 V, factory wired (dual voltage, 230 V or 460 V)	
Z	Custom-built products	Customization

[1] The power output (P2) indicated in the type key, which is used to indicate the motor size, can deviate from the actual power output. Please refer to the nameplate or the chapter *Performance curves and technical data* for the exact power output.

[2] PTC sensors are connected directly to IO 113 or another PTC relay.

Pump nameplate

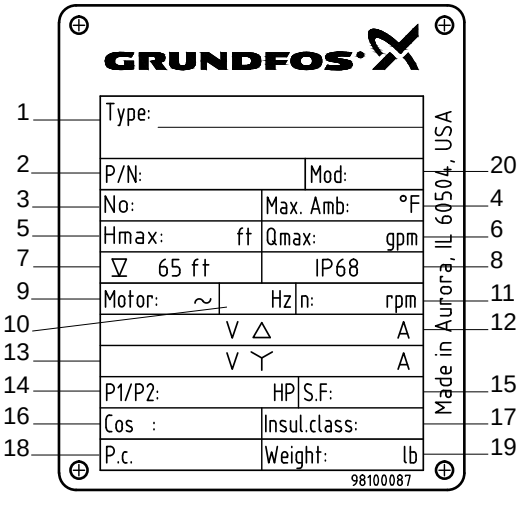


Fig. 2 Pump nameplate

Pos.	Description
1	Type designation
2	Product number
3	Serial number
4	Maximum ambient temperature
5	Maximum head
6	Maximum flow rate
7	Maximum installation depth
8	Enclosure class
9	Number of phases
10	Frequency
11	Rated speed
12	Voltage/current, delta connection
13	Voltage/current, star connection
14	Power input/output (P1/P2)
15	Motor service factor
16	Cos φ, 1/1 load
17	Insulation class
18	Production code, year and week
19	Net weight
20	Generation code

FM approval plate

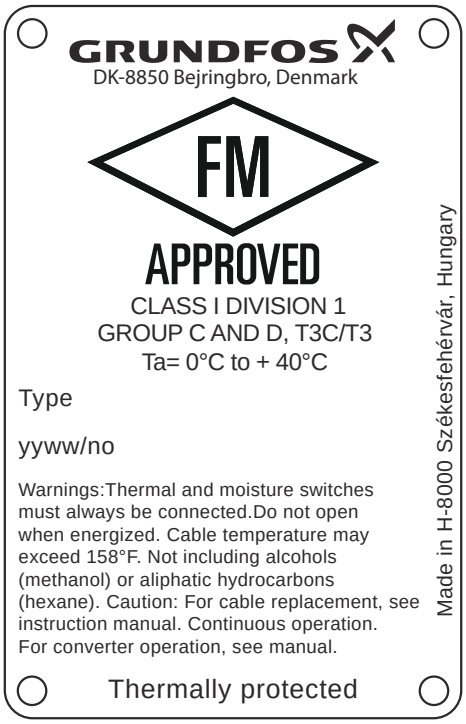


Fig. 3 FM approval plate

The approval plate gives the following details:

FM APPROVED	FM approval symbol
Class I	Permitted for locations where flammable gases or vapors may be present.
Division 1	Permitted for locations where flammable or combustible gases can exist under normal operating conditions or because of repair, breakdown or faulty operation of equipment.
Group C and D	Permitted for specific gases or vapors of Group C and D that will be present.
T3C	Temperature class (T code) Surface temperature max. 320 °F (160 °C)
Type	FM listing code (e.g. S50X13.5/4.60)
yyww/no	Production year, week and serial number (e.g. 1052/123456)

FM certification and classification

Pump	Approval
50-70	Class I Division 1 Group C and D Hazardous (Classified) Locations. Temperature class T3C.

4. Selection of product

Ordering the product

When ordering the product, you need to take the following four aspects into consideration:

1. pump
2. custom-built variation (option)
3. accessories
4. controller.

Pump

Use *Product range* starting on page 9 and *Type key*, page 6 to identify the pump that best fulfils your needs. The list below is a detailed description of the product you get if you order the following pump:

Pump	Product no
S1.30.A50.540.4.62H.S.320.G.Ex.D	97660737

- Pump as specified in the type key
- 50 ft (15 m) cable
- Paint: Black, NCS S9000-N/RAL 9005, gloss 30, thickness 150 µm
- Water-in-oil sensor
- Three thermal switches (Klixon), one in each phase, or three thermal sensors (PTC)
- One moisture switch below the motor top cover and one in the stator housing in the bottom of the motor.
- ANSI-HI centrifugal pump test 11.6:2012, acceptance level 3B.

See *Performance curves and technical data*, page 32 for selection of a standard pump.

Note: Product-specific data for the pump can also be found online in Grundfos Product Center using the product number 97660737.

Custom-built variants

The S pumps can be customized to meet individual requirements. Many pump features and options are available for customization, e.g. versions, various cable lengths or special materials.

Variants can be seen in *List of variants*, page 11. For requirements or designs not included in the list, contact Grundfos.

Accessories

Depending on the installation type, you may need to order accessories. See *Accessories*, page 44 for selection of the correct accessories.

Note: Ordered accessories are not fitted from factory.

Controller

Grundfos Dedicated Controls (DC) is available.



TM06 6501 1515

Fig. 4 Grundfos Dedicated Controls

Grundfos Dedicated Controls is a control system designed for installation in either commercial buildings or network pumping stations with one to six pumps. As standard, the system is supplied with application optimized software and can be configured to meet your specific pumping needs.

For more information about Grundfos Dedicated Controls, see *Level controllers*, page 20.

5. Product range

Explosion-proof pumps - cast iron

All pumps given here can be delivered as non-explosion-proof pumps, if required.

Note: WIO sensor is standard for explosion-proof pumps.

3 x 460 V

Pump type	Cable length [ft (m)]	Pump	Accessories		
			To be ordered separately		
			Horizontal base stand [1]	Vertical base stand	Auto-coupling system
S1.30.A50.540.4.62H.S.320.G.Ex.D	50 (15)	97660708	-	-	97626242
S1.30.A50.540.4.62H.C.320.G.Ex.D	50 (15)	97660709	-	-	97626242
S1.30.A50.540.4.62H.D.320.G.Ex.D	50 (15)	97660710	-	96308238	-
S1.30.A50.540.4.62H.H.320.G.Ex.D	50 (15)	97660731	96787496	-	-
S1.30.A50.700.4.62H.S.334.G.Ex.D	50 (15)	97660736	-	-	97626242
S1.30.A50.700.4.62H.C.334.G.Ex.D	50 (15)	97660737	-	-	97626242
S1.30.A50.700.4.62H.D.334.G.Ex.D	50 (15)	97660738	-	96308238	-
S1.30.A50.700.4.62H.H.334.G.Ex.D	50 (15)	97660739	96787496	-	-
S1.30.A50.790.4.62H.S.351.G.Ex.D	50 (15)	97660760	-	-	97626242
S1.30.A50.790.4.62H.C.351.G.Ex.D	50 (15)	97660761	-	-	97626242
S1.30.A50.790.4.62H.D.351.G.Ex.D	50 (15)	97660762	-	96308238	-
S1.30.A50.790.4.62H.H.351.G.Ex.D	50 (15)	97660763	96787496	-	-
S1.40.A50.540.4.62M.S.292.G.Ex.D	50 (15)	97660732	-	-	97626242
S1.40.A50.540.4.62M.C.292.G.Ex.D	50 (15)	97660733	-	-	97626242
S1.40.A50.540.4.62M.D.292.G.Ex.D	50 (15)	97660734	-	96094523	-
S1.40.A50.540.4.62M.H.292.G.Ex.D	50 (15)	97660735	96787497	-	-
S1.40.A50.700.4.62M.S.308.G.Ex.D	50 (15)	97660748	-	-	97626242
S1.40.A50.700.4.62M.C.308.G.Ex.D	50 (15)	97660749	-	-	97626242
S1.40.A50.700.4.62M.D.308.G.Ex.D	50 (15)	97660750	-	96094523	-
S1.40.A50.700.4.62M.H.308.G.Ex.D	50 (15)	97660751	96787497	-	-
S1.40.A50.790.4.62M.S.326.G.Ex.D	50 (15)	97660752	-	-	97626242
S1.40.A50.790.4.62M.C.326.G.Ex.D	50 (15)	97660753	-	-	97626242
S1.40.A50.790.4.62M.D.326.G.Ex.D	50 (15)	97660754	-	96094523	-
S1.40.A50.790.4.62M.H.326.G.Ex.D	50 (15)	97660755	96787497	-	-
S2.40.A80.540.4.62L.S.245.G.Ex.D	50 (15)	97660740	-	-	97506541
S2.40.A80.540.4.62L.C.245.G.Ex.D	50 (15)	97660741	-	-	97506541
S2.40.A80.540.4.62L.D.245.G.Ex.D	50 (15)	97660742	-	96856263	-
S2.40.A80.540.4.62L.H.245.G.Ex.D	50 (15)	97660743	96857521	-	-
S2.40.A80.700.4.62L.S.256.G.Ex.D	50 (15)	97660744	-	-	97506541
S2.40.A80.700.4.62L.C.256.G.Ex.D	50 (15)	97660745	-	-	97506541
S2.40.A80.700.4.62L.D.256.G.Ex.D	50 (15)	97660746	-	96856263	-
S2.40.A80.700.4.62L.H.256.G.Ex.D	50 (15)	97660747	96857521	-	-
S2.40.A80.790.4.62L.S.272.G.Ex.D	50 (15)	97660756	-	-	97506541
S2.40.A80.790.4.62L.C.272.G.Ex.D	50 (15)	97660757	-	-	97506541
S2.40.A80.790.4.62L.D.272.G.Ex.D	50 (15)	97660758	-	96856263	-
S2.40.A80.790.4.62L.H.272.G.Ex.D	50 (15)	97660759	96857521	-	-

[1] Pumps of installation type H include the standard horizontal stand. Pumps with material code G or Q include a painted-steel stand. If another horizontal stand is required, order a pump of installation type D together with the required stand.

Stainless steel, 3 x 460 V

Pump type	Cable length [ft (m)]	Pump	Accessories		
			Horizontal base stand[1]	To be ordered separately	
				Vertical base stand	Auto-coupling system
S1.30.A50.540.4.62H.S.320.Q.Ex.D.611	50 (15)	97663708	-	-	97626242
S1.30.A50.540.4.62H.C.320.Q.Ex.D.611	50 (15)	97663709	-	-	97626242
S1.30.A50.540.4.62H.D.320.Q.Ex.D.611	50 (15)	97663710	-	96308238	-
S1.30.A50.540.4.62H.H.320.Q.Ex.D.611	50 (15)	97663721	96787496	-	-
S1.30.A50.700.4.62H.S.334.Q.Ex.D.611	50 (15)	97663726	-	-	97626242
S1.30.A50.700.4.62H.C.334.Q.Ex.D.611	50 (15)	97663727	-	-	97626242
S1.30.A50.700.4.62H.D.334.Q.Ex.D.611	50 (15)	97663728	-	96308238	-
S1.30.A50.700.4.62H.H.334.Q.Ex.D.611	50 (15)	99974208	96787496	-	-
S1.30.A50.790.4.62H.S.351.Q.Ex.D.611	50 (15)	97663761	-	-	97626242
S1.30.A50.790.4.62H.C.351.Q.Ex.D.611	50 (15)	97663762	-	-	97626242
S1.30.A50.790.4.62H.D.351.Q.Ex.D.611	50 (15)	97663763	-	96308238	-
S1.30.A50.790.4.62H.H.351.Q.Ex.D.611	50 (15)	99974209	96787496	-	-
S1.40.A50.540.4.62M.S.292.Q.Ex.D.611	50 (15)	97663722	-	-	97626242
S1.40.A50.540.4.62M.C.292.Q.Ex.D.611	50 (15)	97663723	-	-	97626242
S1.40.A50.540.4.62M.D.292.Q.Ex.D.611	50 (15)	97663724	-	96094523	-
S1.40.A50.540.4.62M.H.292.Q.Ex.D.611	50 (15)	97663725	96787497	-	-
S1.40.A50.700.4.62M.S.308.Q.Ex.D.611	50 (15)	97663749	-	-	97626242
S1.40.A50.700.4.62M.C.308.Q.Ex.D.611	50 (15)	97663750	-	-	97626242
S1.40.A50.700.4.62M.D.308.Q.Ex.D.611	50 (15)	97663751	-	96094523	-
S1.40.A50.700.4.62M.H.308.Q.Ex.D.611	50 (15)	97663752	96787497	-	-
S1.40.A50.790.4.62M.S.326.Q.Ex.D.611	50 (15)	97663753	-	-	97626242
S1.40.A50.790.4.62M.C.326.Q.Ex.D.611	50 (15)	97663754	-	-	97626242
S1.40.A50.790.4.62M.D.326.Q.Ex.D.611	50 (15)	97663755	-	96094523	-
S1.40.A50.790.4.62M.H.326.Q.Ex.D.611	50 (15)	97663756	96787497	-	-
S2.40.A80.540.4.62L.S.245.Q.Ex.D.611	50 (15)	97663730	-	-	97506541
S2.40.A80.540.4.62L.C.245.Q.Ex.D.611	50 (15)	97663741	-	-	97506541
S2.40.A80.540.4.62L.D.245.Q.Ex.D.611	50 (15)	97663742	-	96856263	-
S2.40.A80.540.4.62L.H.245.Q.Ex.D.611	50 (15)	97663743	96857521	-	-
S2.40.A80.700.4.62L.S.256.Q.Ex.D.611	50 (15)	97663744	-	-	97506541
S2.40.A80.700.4.62L.C.256.Q.Ex.D.611	50 (15)	97663745	-	-	97506541
S2.40.A80.700.4.62L.D.256.Q.Ex.D.611	50 (15)	97663747	-	96856263	-
S2.40.A80.700.4.62L.H.256.Q.Ex.D.611	50 (15)	97663748	96857521	-	-
S2.40.A80.790.4.62L.S.272.Q.Ex.D.611	50 (15)	97663757	-	-	97506541
S2.40.A80.790.4.62L.C.272.Q.Ex.D.611	50 (15)	97663758	-	-	97506541
S2.40.A80.790.4.62L.D.272.Q.Ex.D.611	50 (15)	97663759	-	96856263	-
S2.40.A80.790.4.62L.H.272.Q.Ex.D.611	50 (15)	97663760	96857521	-	-

[1] Pumps of installation type H include the standard horizontal stand. Pumps with material code G or Q include a painted-steel stand. If another horizontal stand is required, order a pump of installation type D together with the required stand.

6. Variants

List of variants

Motor		
Various cable lengths		82 ft (25 m)
		165 ft (50 m)
EMC power cables	Screened power cables for variable-speed drives	33 ft (10 m)
		50 ft (15 m)
		82 ft (25 m)
		165 ft (50 m)
Special motor		Special voltage
PTC thermistors in windings		
Special oil	Non-toxic Shell Ondina X420[1]	
Motor protection		
PTC + moisture switch		FPV1
Klixon + moisture switch + WIO [2]		FPV2a
PTC + moisture switch + WIO [2]		FPV2b
Klixon + moisture switch + WIO [2] + Pt100 at lower and upper bearing		FPV4a
PTC + moisture switch + WIO [2] + Pt100 at lower and upper bearing		FPV4b
Materials		
Stainless steel lifting bracket	AISI 316	
Stainless steel impeller	Duplex and 316 stainless steel	Variant Q
Ceramic coatings for pump housing and impellers	Belzona 1321	
Tests		
Test at specified duty on standard impeller curve		
Trimmed impeller for specified duty test		
Additional test of entire QH curve (including report)	5-10 points on pump performance curve	
Different test standard	Efficiency guaranteed by Grundfos	HI 11.6:2012 grade 1B/1U tolerances
		HI 11.6:2012 grade 2B/2U tolerances
Vibration test (including report)	According to Grundfos factory quality standard	
Performance test on dry test stand	Not yet available	
ANSIHr test	Not yet available	
String test	Contact Grundfos	
Witness test	Contact Grundfos	
Miscellaneous		
Special packaging	Contact Grundfos	
Special nameplate	Contact Grundfos	
Other variants	Contact Grundfos	

1 For pumps with WIO sensor, Shell Ondina is not an option.

2 WIO sensor is standard for explosion-proof pumps.

7. Construction

Sectional drawings, motors

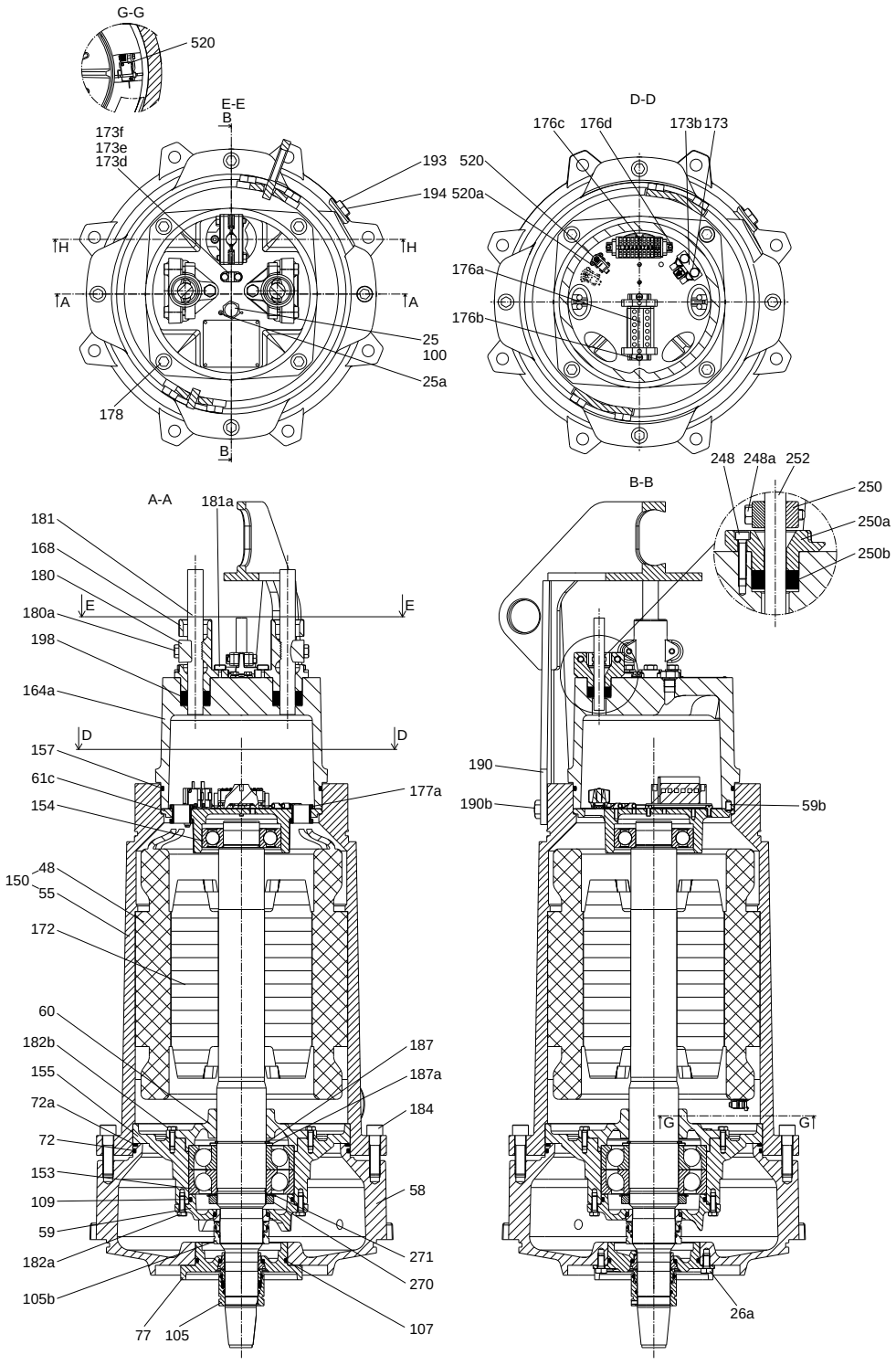


Fig. 5 Explosion-proof motor without cooling jacket (installation type S)

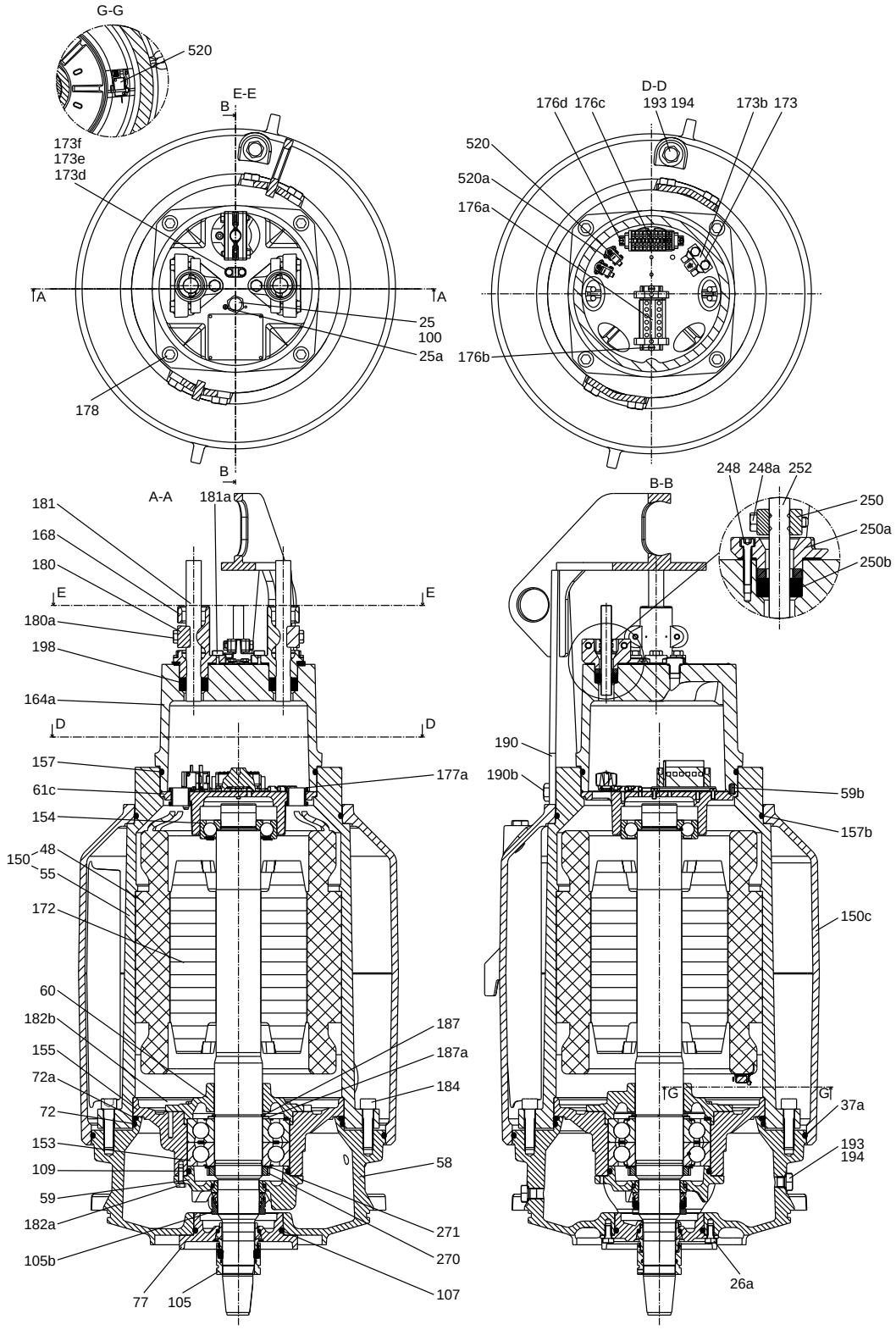


Fig. 6 Explosion-proof motor with cooling jacket (installation types C, D and H)

Sectional drawings, pumps

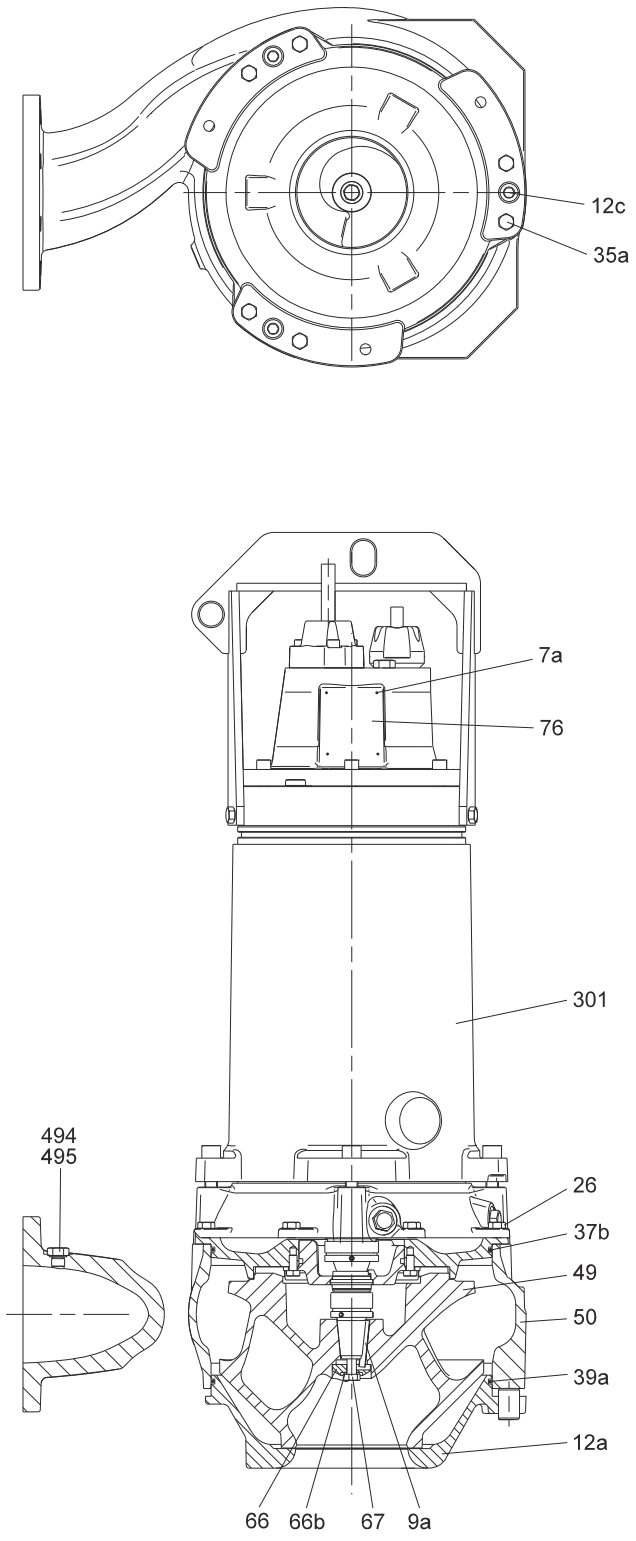


Fig. 7 Basic pump, installation types S and C

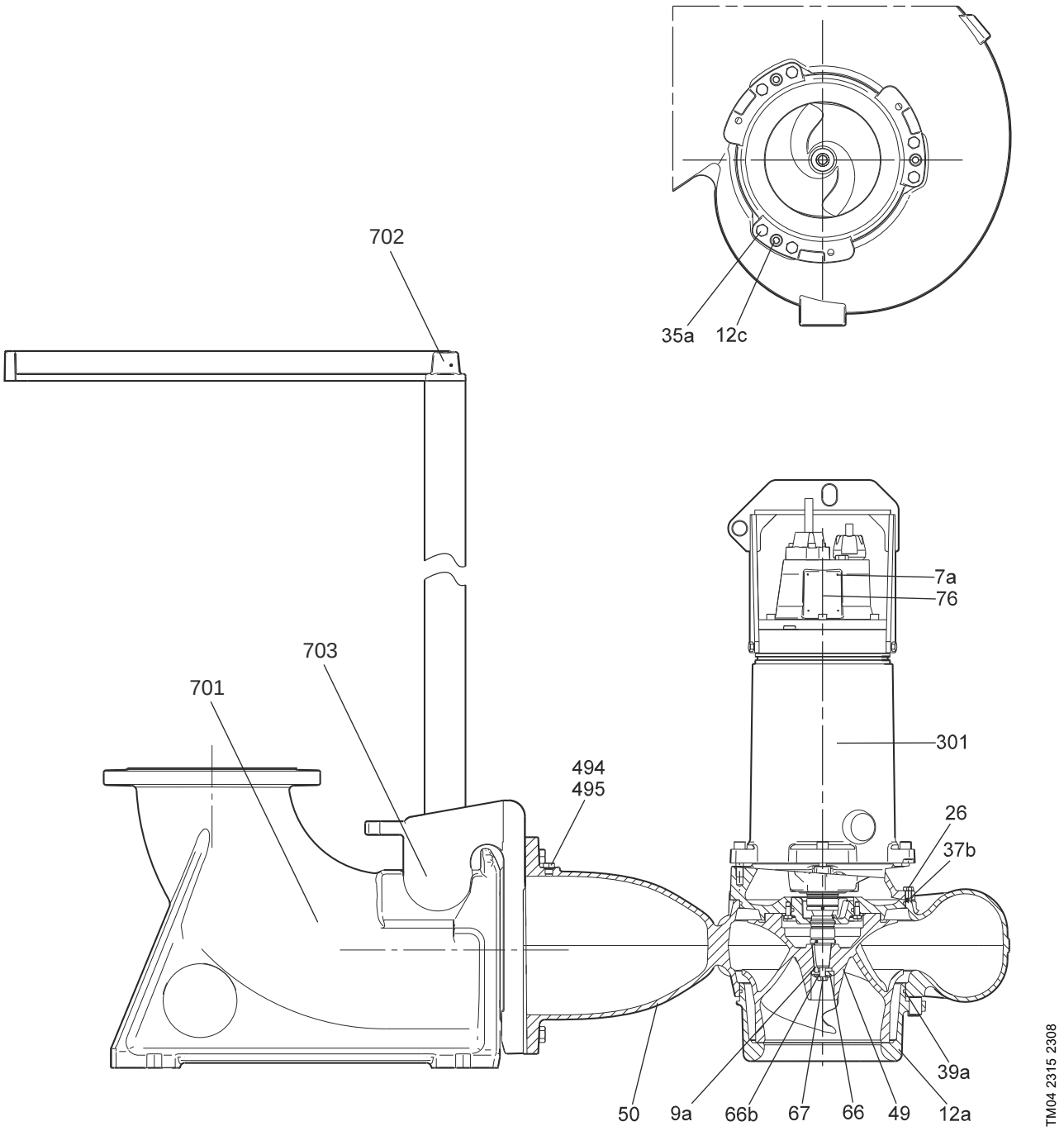
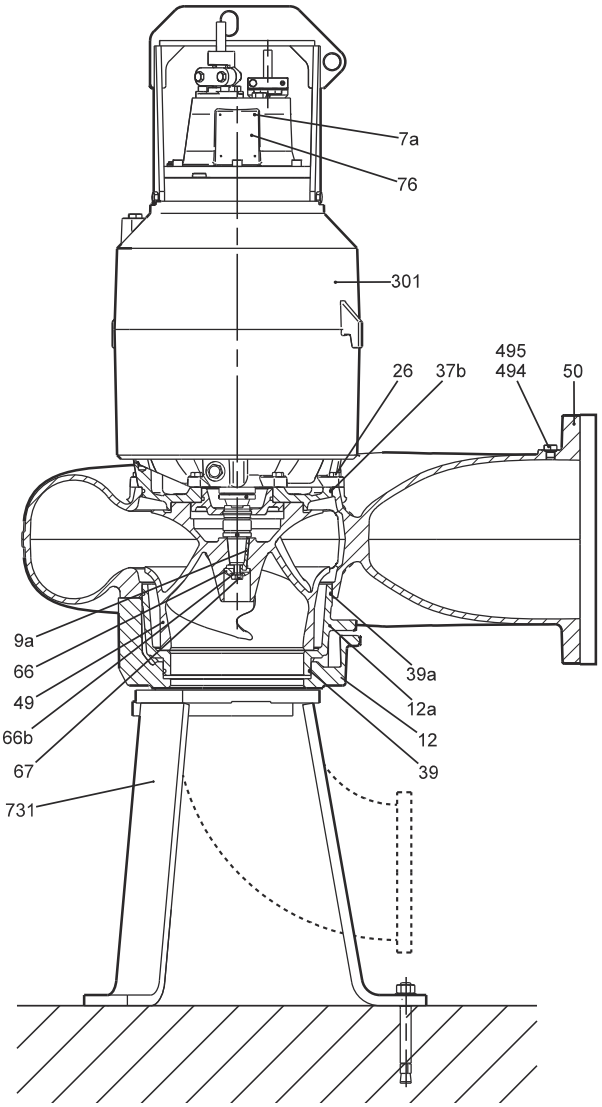
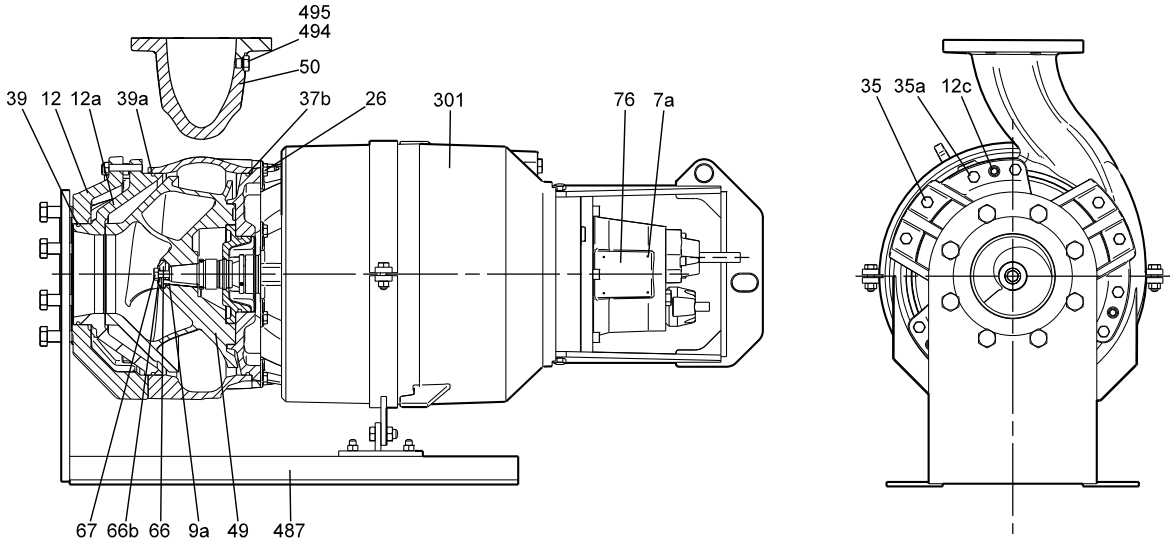


Fig. 8 Installation types S and C pump on auto coupling



TM04 2316 2308

Fig. 9 Installation type D, dry, vertical pump on base stand



TM04 2313 2308

Fig. 10 Installation type H, dry, horizontal pump on base stand

Components and material specification

Motor

Pos.	Component	Material	DIN W.Nr./ EN standard	AISI/ ASTM
25	Pressure test plug	Stainless steel	1.4436	316
25a	Screw	Stainless steel	1.4436	316
26a	Screw	Stainless steel	1.4436	316
37a	O-ring	Stainless steel	1.4436	316
48	Stator lamination			
55	Stator housing	Cast iron[1]	EN-GJL-250	A48 class 30
58	Seal housing	Cast iron		
59	Lower bearing bracket cover			
59b	Pin			
60	Bearing bracket cover	Cast iron		
61c	Upper bearing bracket	Cast iron		
72a	O-ring	NBR rubber		
72	O-ring	NBR rubber		
77	Seal housing cover			
100	O-ring	NBR rubber		
105	Mechanical seal	SiC/SiC or SiC/ carbon		
105b	Mechanical seal	SiC/SiC or SiC/ carbon		
107	O-ring	NBR rubber		
109	O-ring	NBR rubber		
150	Stator complete			
150c	Cooling jacket	Galvanized steel		
153	Ball bearing	Stainless steel		
154	Ball bearing	Stainless steel		
155	Lower bearing bracket	Cast iron [1]		
157	O-ring	NBR rubber		
157b	O-ring	NBR rubber		
164a	Motor top cover	Cast iron		
168	Cable entry	Cast iron		
172	Shaft with rotor	Stainless steel	1.4462	329
173	Screw	Stainless steel	1.4436	316
173b	Earth terminal			
173c	Ground washer	Stainless steel	1.4436	316
173d	Washer			
173e	Screw	Stainless steel	1.4436	316
173f	Spring washer	Stainless steel	1.4436	316
173g	Earth connector			
176a	Terminal block			
176b	Screw	Stainless steel	1.4436	316
176c	Terminal block			
176d	Terminal block			
177a	Protection sleeve			
178	Screw	Stainless steel	1.4436	316
180	Cable clamp	PA or cast iron		
180a	Screw			
181	Cable	ATON		
182a	Screw			
182b	Screw	Stainless steel	1.4436	316
184	Screw	Stainless steel	1.4436	316
187	Circlip			
187a	Washer	Stainless steel	1.4436	316
190	Lifting bracket	Galvanized steel		
190b	Screw			
193	Plug	Stainless steel	1.4436	316
194	O-ring	NBR rubber		
198	Rubber seal			
248	Screw	Stainless steel	1.4436	316
248a	Screw			
250	Cable clamp	PA or cast iron		
250a	Cable entry	PA or cast iron		
250b	Rubber seal			
250e	Moisture switch			
252	Cable	ATON		
270	Lock nut			
271	Lock Washer			
520	Moisture switch[2]			
520a	Screw	Stainless steel	1.4436	316

[1] Available in stainless steel (custom-built option).

[2] FM versions have three moisture switches.

Pump

Pos.	Component	Material	DIN W.Nr./ EN standard	AISI/ ASTM
7a	Rivet	Stainless steel	1.4436	316
7b	O-ring	NBR rubber		
9a	Key (for keyway)	Stainless steel	1.4436	316
12	Flange	Cast iron		
12a	Inlet cover	Cast iron		
12c	Adjusting screw	Stainless steel	1.4436	316
26	Screw	Stainless steel	1.4436	316
26c	Screw	Stainless steel		
35	Screw	Stainless steel		
35a	Screw	Stainless steel		
37	O-ring	NBR rubber		
37b	O-ring	NBR rubber		
39	O-ring	NBR rubber		
39a	O-ring	NBR rubber		
49	Impeller	Cast iron[1]	EN-GJL-250	A48 class 30
50	Pump housing	Cast iron[1]	EN-GJL-250	A48 class 30
66	Cap	Cast iron or stainless steel		
66b	Washer			
67	Impeller screw	Stainless steel	1.4436	316
76	Nameplate			
76a	Approval plate			
301	Motor housing			
478	Base stand, horizontal	Cast iron or steel		
494	Plug	Stainless steel	1.4436	316
495	O-ring	NBR rubber		

[1] Available in stainless steel (custom-built option).

Accessories

Pos.	Component	Material
487	Base stand, horizontal[1]	Galvanized steel
701	Auto-coupling base unit	Cast iron[2]
702	Upper guide rail bracket	Cast iron[2]
703	Guide claw	Cast iron [2]
762	Base stand, vertical	Cast ironor steel

[1] Pumps of installation type H include the standard horizontal stand. Pumps with material code G or Q include a painted-steel stand. If another horizontal stand is required, order a pump of installation type D together with the required stand.

[2] Available in stainless steel (custom-built option).

8. Product description

Features

SmartTrim

On conventional pumps, maintaining factory-set impeller clearance is a time-consuming and costly task. The pumps need to be disconnected from the pipes and to be totally dismantled, and new parts need to be mounted in order to maintain full pumping efficiency. Not so with Grundfos SmartTrim!

All Grundfos heavy-duty channel-impeller pumps, whether for submerged or dry installation, are equipped with the unique SmartTrim impeller clearance adjustment system. This enables you to easily restore factory-set impeller clearance and maintain peak pumping efficiency. All you need to do is to tighten the adjustment screws on the exterior of the impeller housing. This can be done on site, quickly and easily, without dismantling the pump and without using special tools.

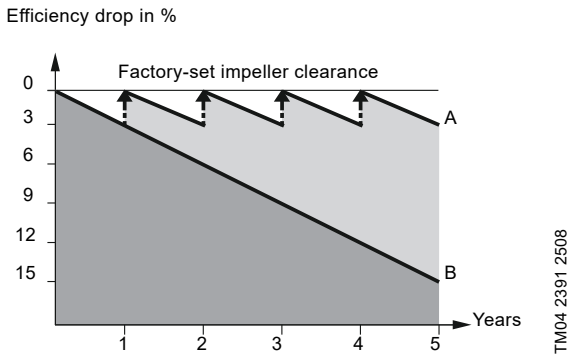


Fig. 11 Impeller clearance adjustment cycle

A: With Grundfos SmartTrim impeller clearance adjustment system

B: Without impeller clearance adjustment system

SmartSeal

The Grundfos SmartSeal auto-coupling sealing mounted on the pump outlet flange provides a completely leak-proof connection between the pump and the base unit of the auto-coupling system. This optimizes the efficiency of the entire pumping system and keeps operating costs at a minimum.

Bearings

The bearings are greased for life.

Main bearings: Double-row angular contact ball bearing. Single or pair-mounted angular contact ball bearings for axial forces and cylindrical roller bearing for radial forces.

Support bearings: Single-row deep-groove ball bearing.

Shaft seals

The pumps have a separate primary and a secondary shaft seal.

The material combination of the primary shaft seal of all pump types is silicon carbide/silicon carbide. For the secondary shaft seal, the material combination is silicon carbide/carbon.

The shaft seals are placed in the oil chamber of the pump. The oil chamber provides reliable sealing between the pumped liquid and the motor.

The shaft seals have no springs or other parts in direct contact with the pumped liquid. This prevents rags and fibres from getting caught. The shaft seals are bidirectional, meaning that they can operate in either direction, thus allowing for opposite rotation caused by back-flow of liquid through the pump.

Motor

The motor is a watertight, totally encapsulated motor with:

- insulation class H [356 °F (180 °C)]
- temperature rise class F [189 °F (105 °K)]
- enclosure class IP68.

For motor protection and sensors, see *Sensors*, page 19.

Cables

The pumps have H07RN-F AT power cable as standard or screened ATON EMC VSCCB cables on request.

The pumps have H07RN-F 450/750 V control cables as standard or screened ATON VSCB 450/750 V control cables on request.

The cables are 50 ft (15 m) long as standard. Other cable lengths are available on request. See *List of variants*, page 11.

The number and dimension of cables depend on the motor size and number of poles.

Motor power [HP (kW)]	Voltage	Cable size [power + control]
54 (40)	3 x 460 V	2 x 4 x 10 mm^2 + 1 x 10 x 1.5 mm^2
70 (52)		
79 (59)		2 x 4 x 16 mm^2 + 1 x 10 x 1.5 mm^2

Power cable

Cable type [mm²]	Outer cable diameter [inch (mm)]	Weight [lb/ft (kg/m)]	Bending radius [inch (mm)]
4 x 10	0.82 - 0.92 (20.9 - 23.4)	0.26 (0.38)	5.5 (140)
4 x 16	0.94 - 1.04 (23.8 - 26.3)	0.85 (1.26)	6.3 (160)

Control cable

Cable type [mm²]	Outer cable diameter [inch (mm)]	Weight [lb/ft (kg/m)]	Bending radius [inch (mm)]
10 x 1.5	0.71 - 0.79 (18.0 - 20.0)	0.34 (0.5)	6 x D

Cable entry

Watertight cast iron cable entry with soft shape and sealing rings to prevent damage of the cable or leaks.

Sensors

An explosion-proof pump is equipped with these switches and sensors:

- three thermal switches (Klixon) or three thermal protectors in the stator housing
- one moisture switch under the motor top cover and one in the stator housing in the dry end of the motor.

Customized sensor options

1. WIO (water-in-oil) sensor
   The WIO sensor measures the water content in the oil and converts the value into an analog current signal. The two sensor conductors are for power supply as well as for carrying the signal to the measuring device or controller. The sensor measures the water content from 0 to 20 %. It also sends a signal if the water content is outside the normal range (warning), or if there is air in the oil chamber (alarm). The sensor is fitted in a stainless steel tube for mechanical protection.
   The sensor is either built-in with the motor (FM) or installed as an accessory. If the sensor is installed externally, it is fitted in a plastic hose for mechanical protection. The WIO sensor is connected to Grundfos IO 113.
2. PVS3 (pump vibration sensor)
   The vibration sensor monitors the vibration level of the pump by using measurements of three axes and combining them into a single measurement outputted in an analog current signal. The sensor acts only as a general indicator of changes in the vibration levels. PVS3 is to be connected to the Grundfos IO 113 and SM 113 modules. A substantial increase in vibration will trigger a warning or an alarm.
   An increase in vibrations can be caused by a clogged impeller, worn bearings, closed force main valves, etc. indicating that service inspection should be carried out quickly in order to protect the pump or the pipe system from being damaged.
3. Bearing temperature sensor
   PT 100 bearing temperature sensor installed within the motor housing. Sensors to be connected using an SM 113 and IO 113.

Testing

All pumps are tested before leaving the factory. The factory test report is based on ANSI-HI centrifugal pump test 11.6:2012, acceptance level 3B. Test reports can be ordered directly with the pump or can be ordered separately based on the pump serial number. Other tests or third-party inspection certificates are available on request. See *List of variants*, page 11.

Operating conditions

Pumps without cooling jacket in submerged installation:

- Continuous operation when the pump is fully submerged to the top of the motor.
- Intermittent operation with maximum 20 starts per hour when the pump is submerged to the middle of the motor and with short periods of operation down to the top of the pump housing.
  Warning: A motor protection device must be used to cut off power supply in case of overheating.

Note: Explosion-proof pumps must always be fully submerged.

Pumps with cooling jacket in submerged and dry installation:

- Continuous and intermittent operation with maximum 15 starts per hour with water level down to the top of the pump housing.

Pumped liquids

pH value: 4-10

Liquid temperature: 32-104 °F (0-40 °C)

When pumping liquids with a density and/or a kinematic viscosity higher than that of water, use motors with correspondingly higher outputs.

Sound pressure

The sound pressure level of the pump is lower than the limiting values stated in EC Council directive 2006/42/EC relating to machinery (the EC Machinery Directive).

Motor range

Motor power [HP (kW)]	Number of poles
54 (40)	4
70 (52)	
79 (59)	

Explosion-proof pumps

Use explosion-proof pumps in potentially explosive environments.

Note: All installations must be approved by the local authorities.

Relevant standards/regulations

- FM 3600
- FM 3615
- FM 3615.80
- ANSI/UL 1004-1
- ANSI/UL 1004-3

Explosion protection classification (FMus)

~~Class I, Division 1, Groups C and D, T3C~~Class I, Division 1, Groups C and D, T3 or T3C

Operation with frequency converter

~~Not allowed~~Only temperature class T3

Notified body

FM Approvals

Level controllers

Grundfos offers dedicated pump controllers for monitoring liquid levels in the wastewater collecting tanks to ensure correct operation and protection of the pumps.

Grundfos pump controllers are ideally suited to Grundfos S pumps, and include:

- Grundfos Dedicated Controls (DC)
- Grundfos LC controllers

Grundfos DC Controllers



Gr-1016086

Fig. 12 Grundfos Dedicated Controls control cabinet

Grundfos Dedicated Controls (DC) is a control system designed for installation in municipal wastewater transportation, commercial buildings or network pumping stations with up to six wastewater pumps and an optional mixer or a flush valve.

Advanced control and data communication are also possible with the Grundfos Dedicated Controls system. The control cabinets are delivered with a built-in main switch and thermal magnetic circuit breaker.

Features and benefits:

- Advanced Flow Calculation
- Automatic energy optimization
- Easy installation and configuration
- Configuration wizard
- Electrical overview
- Advanced data communication
- Advanced alarm and warning priority
- Supports several languages
- Daily emptying
- Mixer control or flush valve
- User-defined functions
- Anti-blocking
- Start level variation
- Advanced pump alternation with pump groups
- SMS scheduling
- Communication to SCADA, BMS, GRM or cell phone.

Dedicated Controls is ordered either with or without a built-in communication interface module (CIM).

The communication module enables the possibility for fieldbus protocol (e.g. PROFIBUS DP, Modbus RTU and PROFINET IO/Modbus TCP) and the communication line.

For further information about Grundfos Dedicated Controls, please see Grundfos Product Center:

- Grundfos Dedicated Controls, brochure http://net.grundfos.com/qr/i/96925597
- Grundfos iSolutions, brochure http://net.grundfos.com/qr/i/99249771
- Grundfos Controls Guide, product guide http://net.grundfos.com/qr/i/97954965

Additional features, CUE or VFD

The CUE/VFD (optional), which is either a Grundfos variable frequency drive or a general variable frequency drive, offers better pump protection and a more steady flow through the pipe system.

In addition, Grundfos CUE,VFD offers these features and benefits:

- Anti-blocking
- Automatic energy optimization
- Specific-energy test
- Output frequency
- Monitoring of:
  - voltage*
  - current*
  - phase sequence*
  - power*
  - energy*
  - torque*
- Reverse start**
- Run flushing
- Stop flushing
- PID control.

* These functions are only available with a Grundfos CUE.

** We do not recommend reversing at full speed at any time. When reduced reverse operation settings are set, make sure constant torque is enabled in Variable Frequency Drive (VFD) (i.e. Grundfos CUE, Siemens Simatic, ABB, Schneider Electric etc.) to have maximum torque available when reversing.

Grundfos LC controllers

The LC 231 pump controller is designed for level control, monitoring and protection of Grundfos pumping stations featuring one pump or two pumps, starting direct-on-line. The LC 231 controller is integrated in a polymer cabinet.

The LC 241 is a modular pump controller that has a metal or polymer cabinet and can be customized according to your needs.

It is designed for level control, monitoring and protection of Grundfos pumping stations featuring one pump or two pumps, starting direct-on-line with 0-23 A, star-delta with 0-59 A or soft starter with 0-72 A.

IO 113

The IO 113 module is a protection module for Grundfos wastewater pumps.

IO 113 has inputs for digital and analog pump sensors and can stop the pump if a sensor indicates a pump fault.

IO 113 can be connected to the Grundfos Dedicated Controls system and allows advanced monitoring functions:

- motor temperature
- moisture in motor
- water in oil
- insulation resistance.

SM 113

The SM 113 module is used for collection and transfer of sensor data in pumps and includes a large number of sensors.

SM 113 can be placed either inside the pump (allowing fewer sensor conductors out of the pump) or in the control cabinet next to the pump installation.

SM 113 works together with IO 113 through a power-line communication using the Grundfos GENIbus protocol.

SM 113 can collect data from:

- 3 current sensors, 4-20 mA
- 3 Pt100 thermal sensors or 3 Pt1000 thermal sensors
- 1 PTC thermal sensor
- 1 digital input.

MP 204

The MP 204 control cabinet can be used as a standalone motor protector. MP 204 may also be incorporated in a Grundfos Dedicated Controls system in which it functions as a motor protector. The pump is protected secondarily by measuring the temperature with a Pt100 sensor and a PTC sensor or thermal switch.

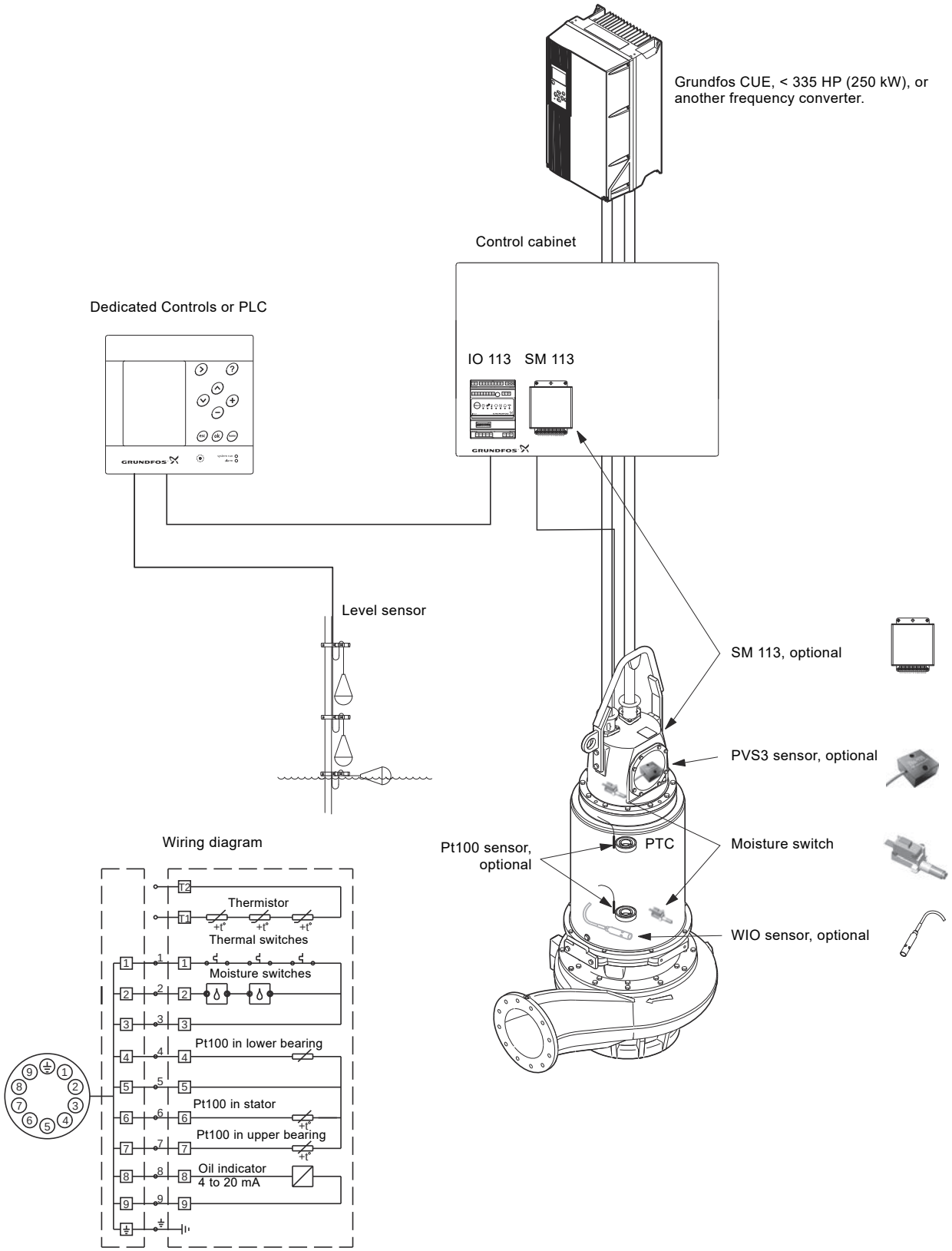


Fig. 13 Pumps with frequency converter operation

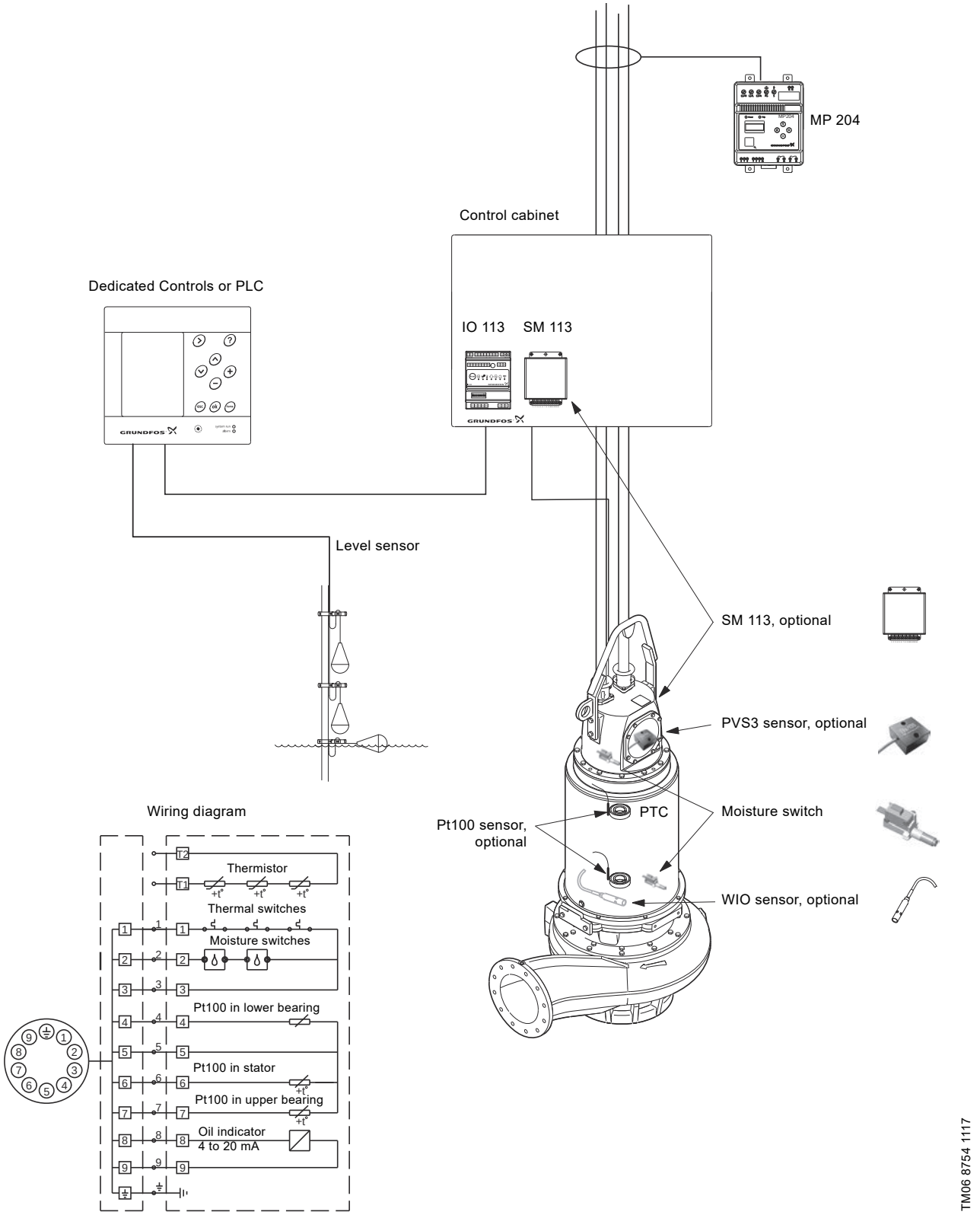


Fig. 14 Pump with MP 204 motor protector

Wiring diagrams

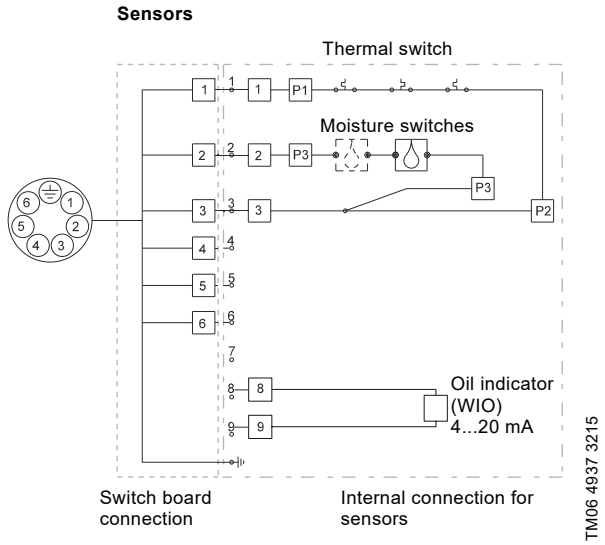


Fig. 15 Wiring diagram for standard sensors

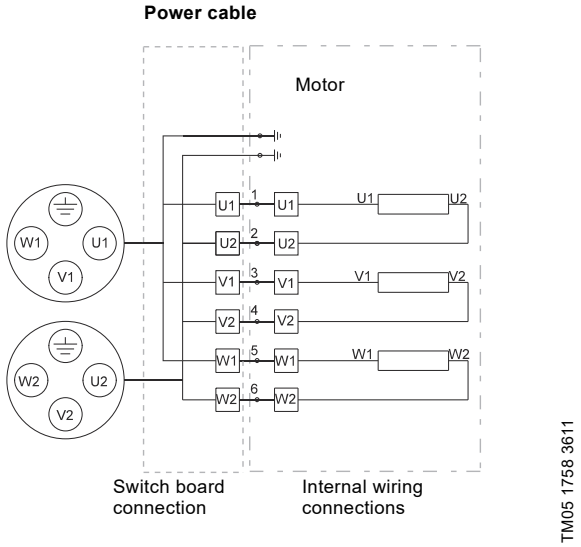


Fig. 17 Wiring diagram for 460 volt

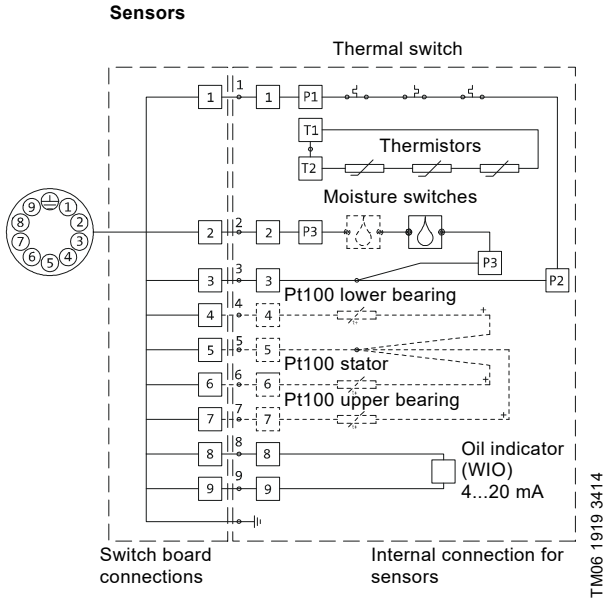


Fig. 16 Wiring diagrams for full sensor model

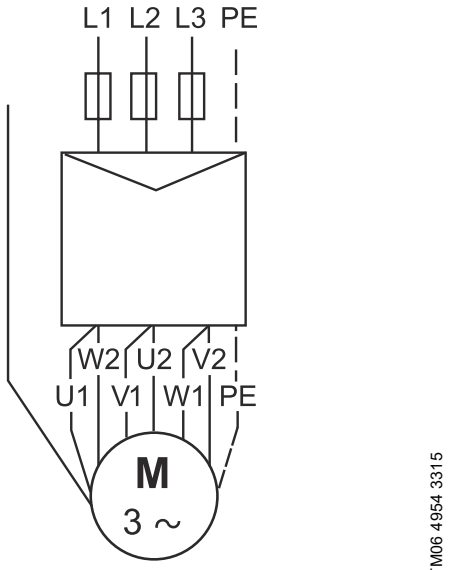
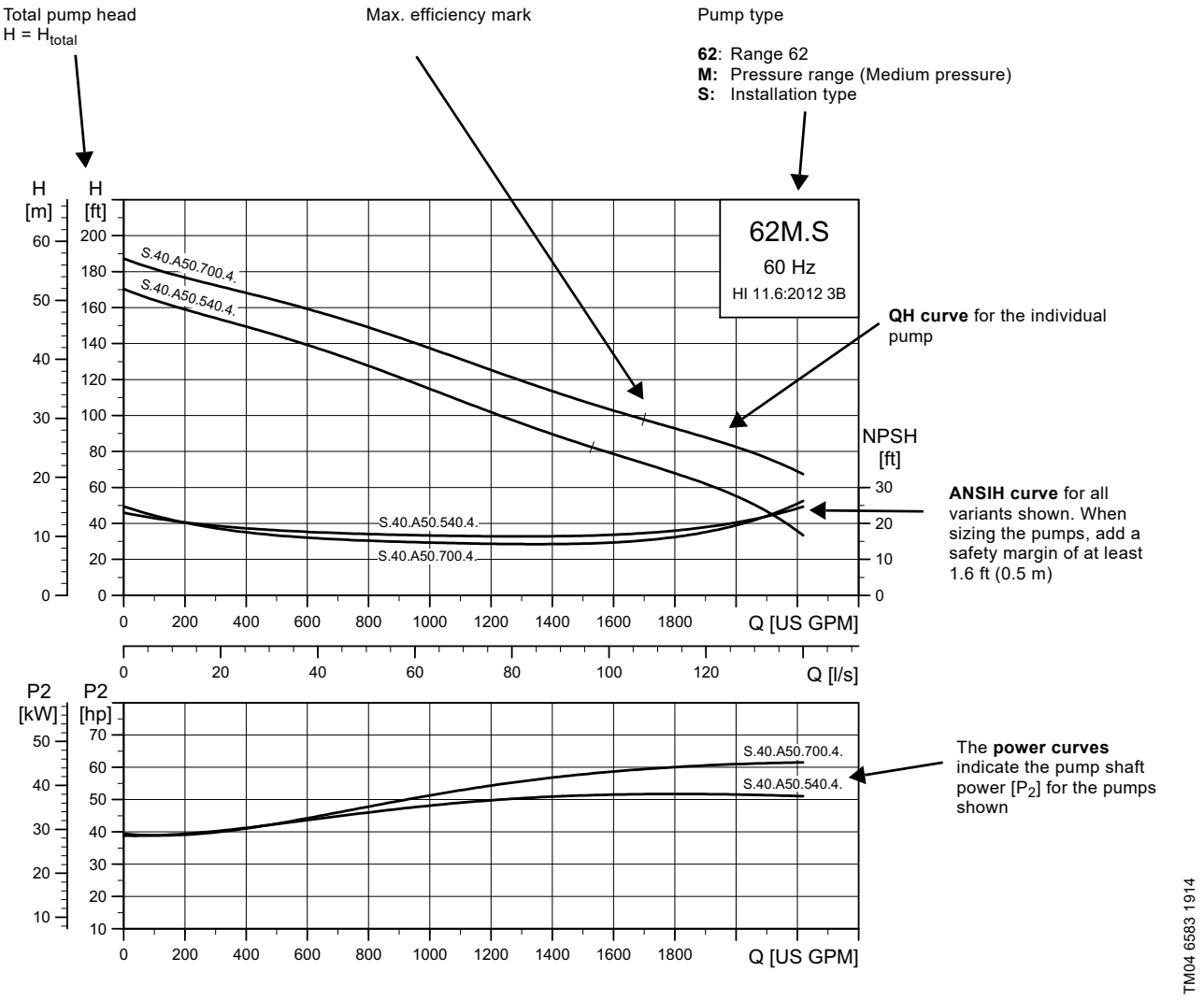


Fig. 18 Wiring diagram for frame size 62

9. Curve charts and technical data

The following many pages are divided into sections.
On pages 26 to 27 you will find a brief explanation of how to read the curve charts, the curve conditions, etc.

How to read the curve charts



Note: The pumps are tested according to ANSI HI 11.6:2012 grade 3B tolerance. Testing equipment and measuring instruments are designed and calibrated according to the standards mentioned. The pumps are approved according to tolerances for entire curves, specified in grade 3B.

Curve conditions

The guidelines below apply to the curves shown in the performance charts on pages 32-41.

- ANSI-HI centrifugal pump test 11.6:2012, Acceptance level 3B.
- The curves show pump performance with different impeller diameters at rated speed.
- The curves apply to the pumping of airless water at a temperature of 68 °F (20 °C) and a kinematic viscosity of 1 cSt (1 mm^2/s).
- **ANSIH:** The curves show average values measured under the same conditions as the performance curves.
  When sizing the pump, add a safety margin of at least 1.6 ft (0.5 m).
- In case of densities other than 133.5 ounces/gallon (1000 kg/m^3), the outlet pressure is proportional to the density.
- When pumping liquids with a density higher than 133.5 ounces/gallon (1000 kg/m^3), motors with correspondingly higher outputs must be used.

Calculation of total head

The total pump head consists of the height difference between the measuring points + the differential head + the dynamic head.

$$H_{total} = H_{geo} + H_{stat} + H_{dyn}$$

H_{geo}: Height difference between measuring points.
H_{stat}: Differential head between inlet and the outlet side of the pump.
H_{dyn}: Calculated values based on the velocity of the pumped liquid on the inlet and the outlet side of the pump.

Pump performance tests

S pump testers are all capable of performing hydraulic performance tests according to ANSI HI 11.6:2012 requirements.

ANSI HI 11.6:2012 sets standards for "rotodynamic pumps, Hydraulic performance acceptance tests, Grades 1, 2 and 3".

Performance acceptance grades

Six-pump-performance-test acceptance grades, 3B, 2B, 2U, 1B and 1U are defined in ANSI HI 11.6:2012.

Acceptance grade	Mandatory measurements		Optional measurements	
	Q	H	P1	Eta-tot
3B	± 9 %	± 7 %	+9 %	-7 %
2B	± 8 %	± 5 %	+8 %	-5 %
2U	+16 %	+10 %	+16 %	
1B	± 5 %	± 3 %	+4 %	-3 %
1U	+10 %	+6 %	+10 %	≥ 0 %

These tolerance grades can be used in the contract between the pump manufacturer and the customer, or they can be used in a default tolerance factor which will apply if no specific tolerance grade has been agreed between the manufacturer and the customer.

The performance acceptance grades are explained in *Specifying acceptance grades*, page 31, showing the performance grades related to an ordinary pump curve.

The guarantee point

According to ANSI HI 11.6:2012, the acceptance-grade tolerance applies to one guarantee point.

A guarantee point is defined by a guaranteed flow rate and a guaranteed head.

In addition, either minimum total efficiency or maximum total input power may be guaranteed at the specified conditions.

This means that the standard sets guidelines for a duty point guaranteed for the following:

– Q and H, or
– Q, H and total efficiency (Eta-total), or
– Q, H and total consumed power (P1).

The guarantee point is defined by a minimum of five measured test points.

Example of a duty point test living up to ANSI HI 11.6:2012 requirements

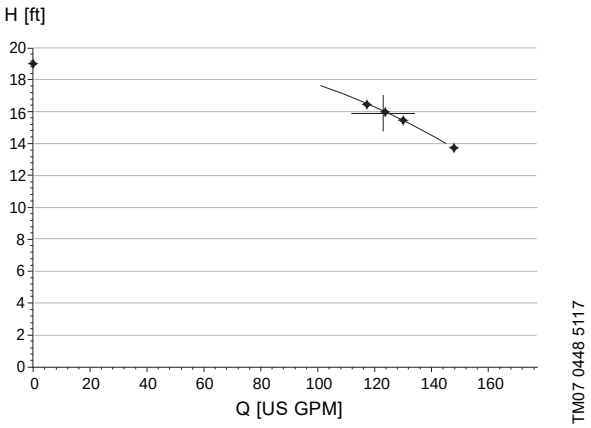


Fig. 19 Five measured test points are used to verify one guarantee point

Evaluation of performance

The test must show that the measured pump curve touches or passes through a tolerance surrounding the guarantee point, as defined by the selected acceptance grade.

Guarantee-point evaluation must be made at the rated speed, which for S pumps means 50 Hz or 60 Hz.

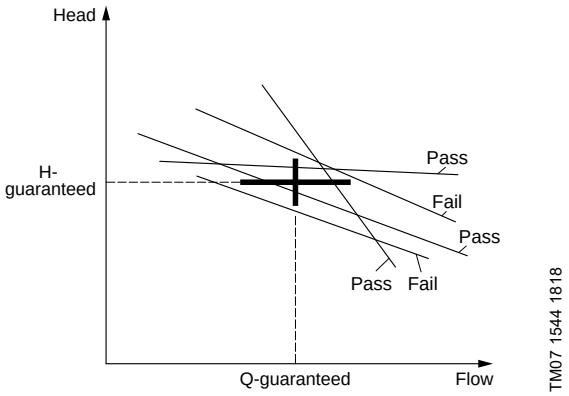


Fig. 20 Pump curves that either pass or fail to cross the tolerance cross of the guarantee point

Performance-test types for end-suction pumps

Two types of performance tests are available for S pumps:

- duty-point-verification test
- curve test.

Tests carried out on S pumps

– Tests are saved for at least five years and can be traced using the pump's unique serial number.

– It is not possible to change acceptance grade on an already tested and supplied pump; if required, a re-test of the pump is made

– Witness testing can be arranged.

Duty-point-verification test, Grades 3B, 2B, 2U, 1B and 1U

This test method offers the possibility to perform a duty-point verification of the following:

– Q and H; or

– Q, H and total efficiency (Eta-tot); or

– Q, H and total consumed power (P1).

Acceptance grade	Mandatory measurements		Optional measurements	
	Q	H	P1	Eta-tot
3B	Standard		On request	
2B	On request		On request	
2U				
1B	On request		On request	
1U				

What Grundfos is able to guarantee for the different acceptance grades will be evaluated on a case-by-case basis. Contact your local sales company on this.

Grundfos makes duty-point verification according to ANSI HI 11.6:2012 for one guarantee point at full speed, 50 or 60 Hz. The customer must tell Grundfos which duty point to verify.

The requested duty point is verified by five measured points.

Grade 1U duty-point verification

The following example illustrates performance testing according to Grade 1U.

Flow rate and head are mandatory, and efficiency or power consumption, P1, is optional.

Tolerances for a Grade 1U test are as follows:

– Flow rate: 10 %

– Head: 6 %

– Efficiency: 0 %, only equal to or better than the guaranteed value

– P1: 10 %

1. Q, H and Eta-tot are tested and verified.

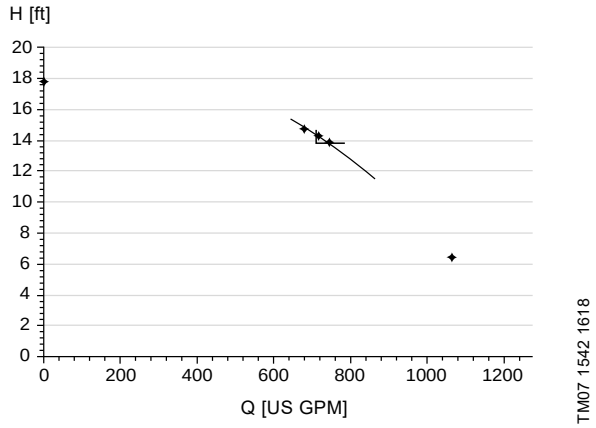


Fig. 21 Measured values for flow rate and head

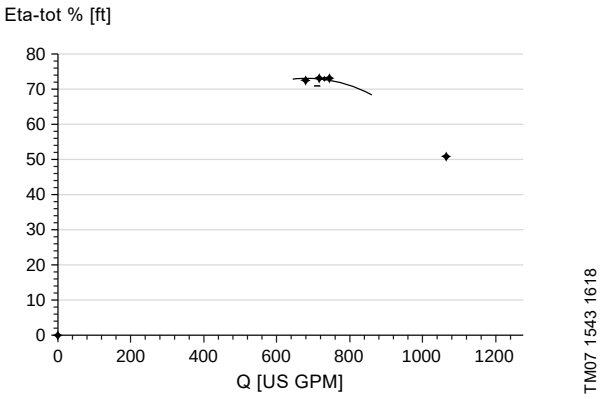


Fig. 22 Measured values for total efficiency

2. Q, H and P1 tested and verified

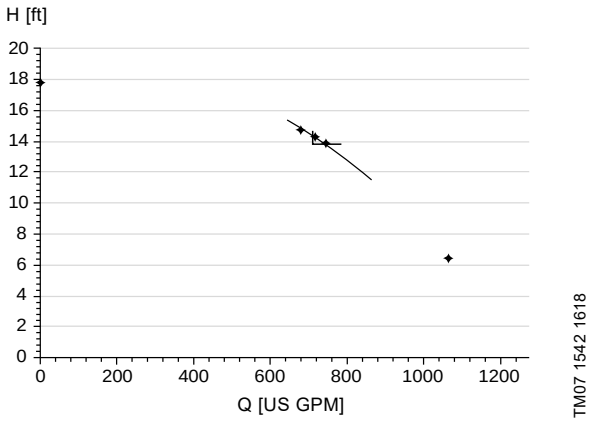


Fig. 23 Measured values for flow rate and head

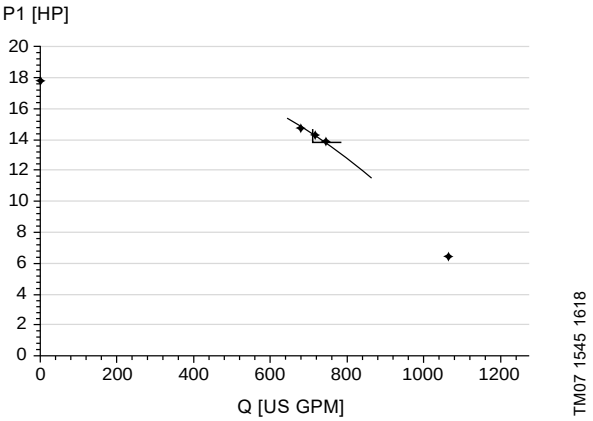


Fig. 24 performance range

Note that other points than the guarantee point can be measured and displayed in a curve test report according to Grade 3B tolerances.

Curve test, Grade 3B

This test method is developed by Grundfos and is based on ANSI HI 11.6:2012 performance acceptance grade 3B tolerances: Q = ± 9 %, H = ± 7 %.

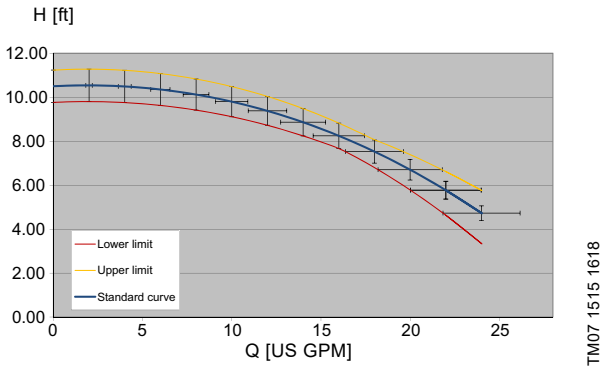


Fig. 25 Q-H curve with tolerance crosses on complete performance range

In fig. 25, tolerance crosses according to Grade 3B have been distributed across the complete performance range of a pump. We generate the upper and lower limit of the performance curve by drawing two curves at the outlines of these crosses.

When the pump is tested, and the measured point is located within the range between the upper and lower limit, it meets the ANSI HI 11.6:2012 Grade 3B tolerances. This way of qualifying the pump performance is stricter than a duty-point-verification test for Grade 3B.

How does Grundfos make curve testing for S pumps?

Grundfos applies two types of curve tests:

- a reference curve test
- a performance curve test.

Reference curve test, Grade 3B

A reference curve test is made when no curve test report is specified with the order. Three or four test points are measured depending on production site, and no curve test report is supplied with the pump.

Measurements are made to maintain and observe continuous quality and to ensure that the supplied pump is within test grade tolerances. Test grade tolerances are set as for Grade 3B but without certification.

Example of a reference curve test

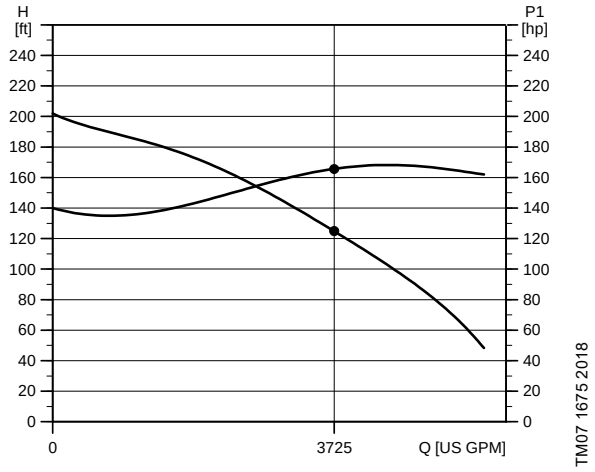


Fig. 26 Measured values for tested pump

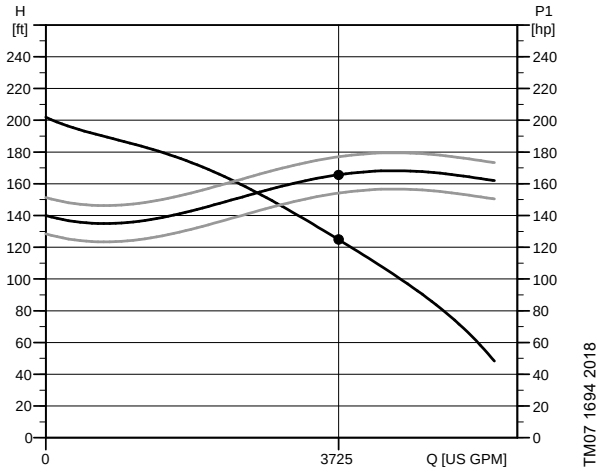


Fig. 27 The values in fig. 26 calculated to reference speed for comparison to a reference performance curve

If a pump performance report is requested at a later stage, only reference test data are available.

Performance curve test, grade 3B

A performance curve test is carried out when a curve test report is specified with the order.

The pump is tested at pre-specified flow rates and test grade tolerances are set as for Grade 3B but without certification.

Example of an S pump curve test

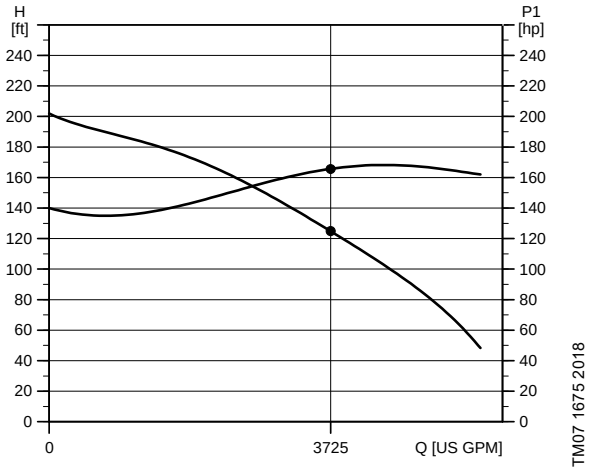


Fig. 28 Measured values for tested pump

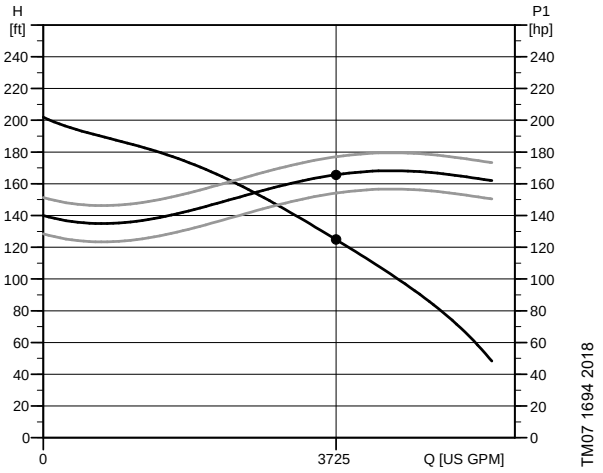


Fig. 29 The values in fig. 28 calculated to a reference speed for comparison to a reference performance

If the customer requires more points on the curve to be checked, individual measurements must be made, which is not part of the performance curve test.

Static high pressure test

All produced pumps undergo a static high pressure test of 1.5 x PN (nominal pressure of the pump).

Specifying acceptance grades

The graphs in the table on page 31 show the tolerances as stated in the standard, related to an ordinary pump curve. The graphs also show which pump performance to expect if the customer, having the same pump to start with, orders a pump with the same guarantee point for different tolerances (B or U) within the acceptance grades.

In some cases, it will not be possible to fulfil the same guarantee point for a unilateral tolerance as it will for a bilateral tolerance. This is indicated by the lower curve for 'U' grades.

If the requested guarantee point is the same for a Grade U pump as for a Grade B pump, the consequence of the production tolerances could be that a larger pump being is required to obtain the requested duty point.

What Grundfos is able to guarantee for the different acceptance grades will be evaluated on a case-by-case basis. Contact your local sales company on this.

Acceptance grades and tolerances

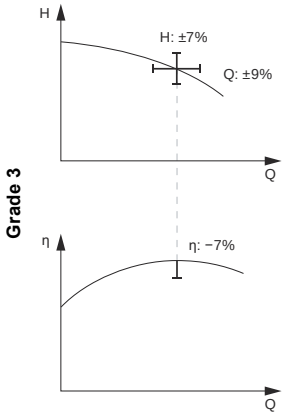
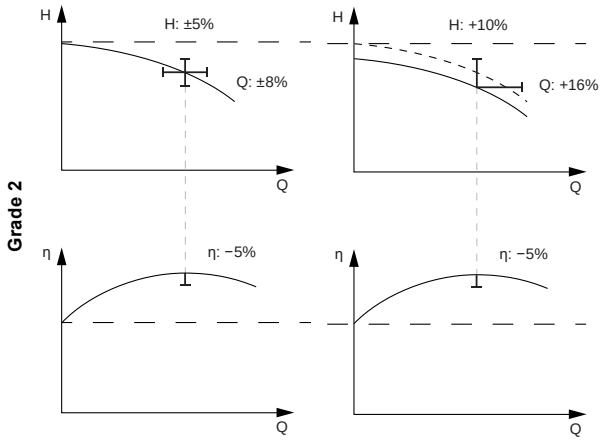
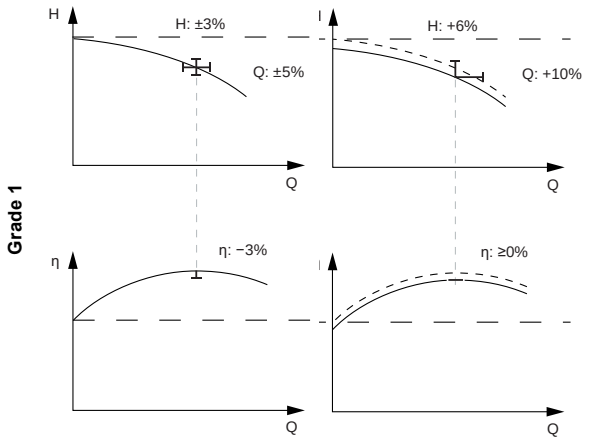
Acceptance grade B

This acceptance grade refers to grades with a bilateral tolerance on flow rate and head and with a tolerance on efficiency.

Acceptance grade U

This acceptance grade refers to a grade with a unilateral tolerance on flow rate and head. For the 2U grade there is a tolerance on efficiency. For the 1U grade there is no tolerance on efficiency.

Note that if the acceptance grade changes from Grade 1B to 1U, the customer does not necessarily get a better pump with a higher efficiency. More likely, he gets a pump where the performance is always to the positive side of the guarantee point.

	Acceptance grade	
	B	U
Grade 3		
Grade 2		
Grade 1		

Certificates

Certificates have to be confirmed for every order and are available on request as follows:

- certificate of compliance with the order (EN 10204 - 2.1)
- pump test sheet.

Witness test

When the pumps are being tested or are tested with a certification, it is possible for the customer to witness the testing procedure according to HI 11.6:2012.

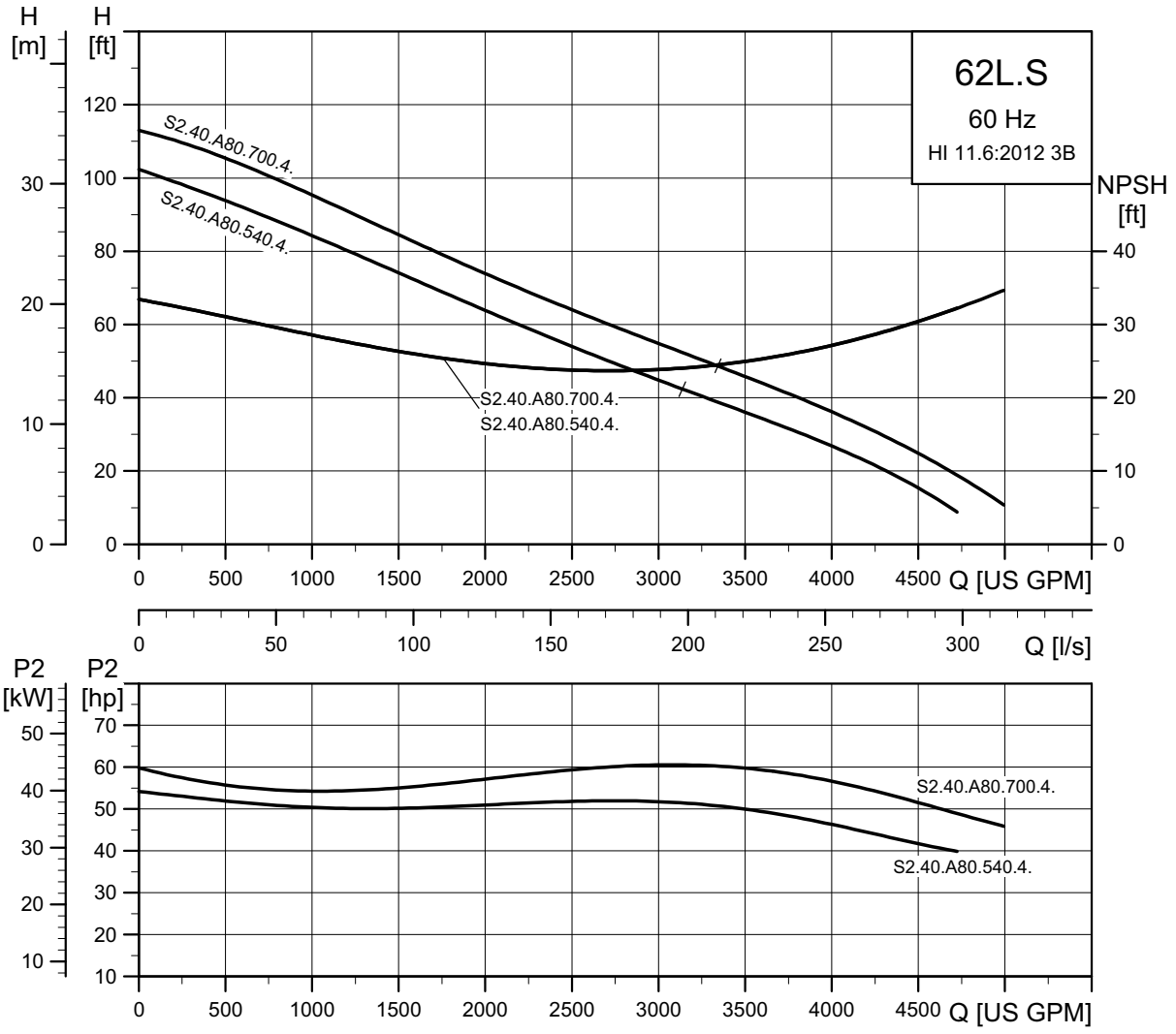
The witness test is not a certificate and will not result in a written statement from Grundfos. The witness itself is the only guarantee that everything is carried out as prescribed in the testing procedure.

If the customer wants to witness the test, place this request on the order.

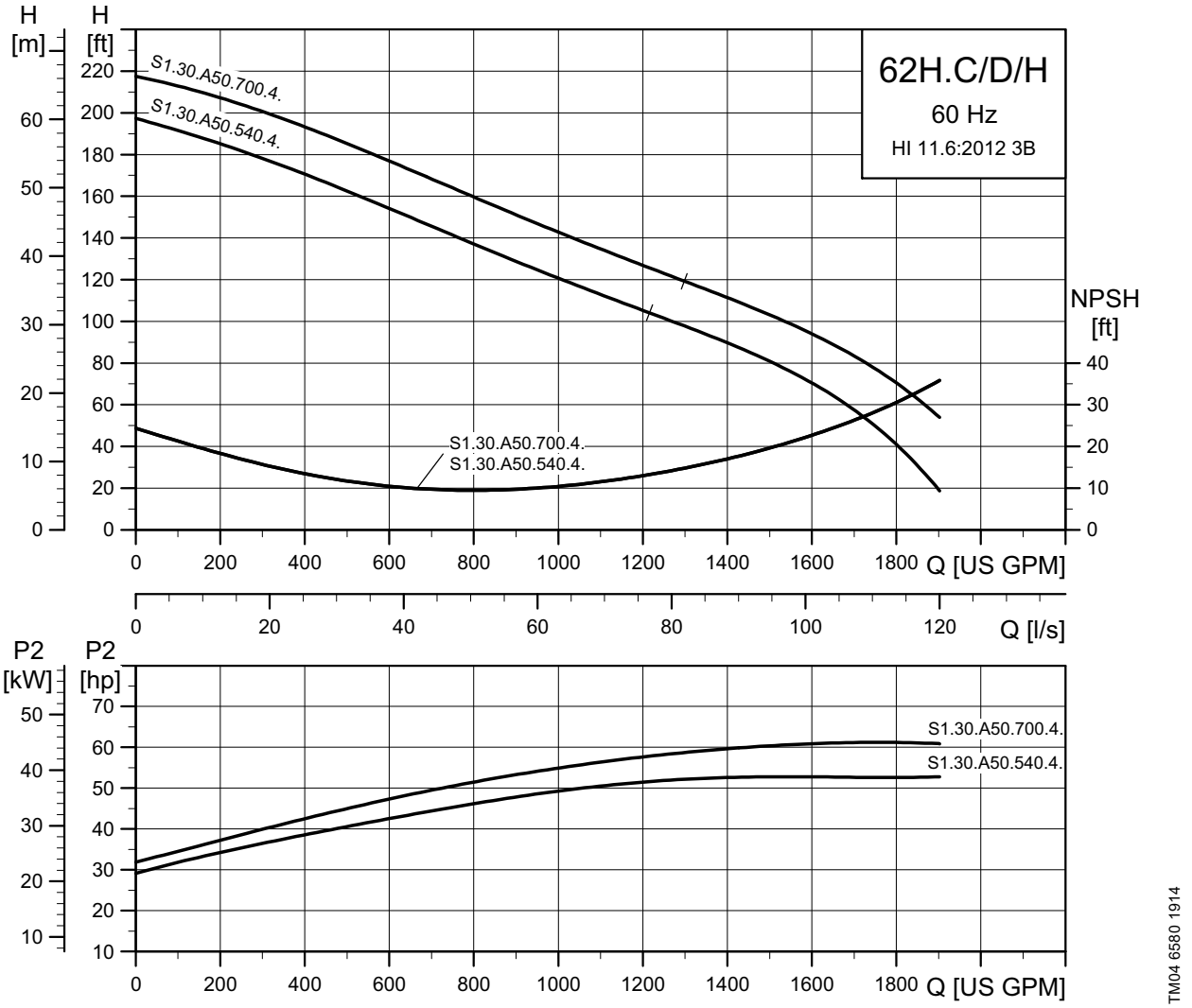
10. Performance curves and technical data

Low pressure - 3 x 460 V

S2.40.A80.540.4 and S2.40.A80.700.4



TM04 6581 1914



Motor data

Pump type	P1	P2	Poles	RPM	Starting method	I_N	I_{start}	η_{motor} [%]			Cos φ			Moment of inertia	Breakdown torque M_{max}
	[HP (kW)]					[A]	[A]	1/2	3/4	1/1	1/2	3/4	1/1	[lbft^2 (kgm^2)]	[lbf*ft (Nm)]
S2.40.A80.540.4.62L.S...	59 (44)	54 (40)	4	1770	Y/D	73	571	87	89	90	0.60	0.70	0.77	7.12 (0.3)	438.8 (595)
S2.40.A80.540.4.62L.C/D/H...	62 (46)	56 (42)	4	1774	Y/D	76	571	87	90	90	0.61	0.71	0.78	7.12 (0.3)	438.8 (595)
S2.40.A80.700.4.62L.S...	71 (53)	64 (48)	4	1764	Y/D	85	571	88	90	90	0.65	0.75	0.79	7.12 (0.3)	438.8 (595)
S2.40.A80.700.4.62L.C/D/H...	78 (58)	70 (52)	4	1758	Y/D	91	571	89	90	90	0.67	0.76	0.80	7.12 (0.3)	438.8 (595)

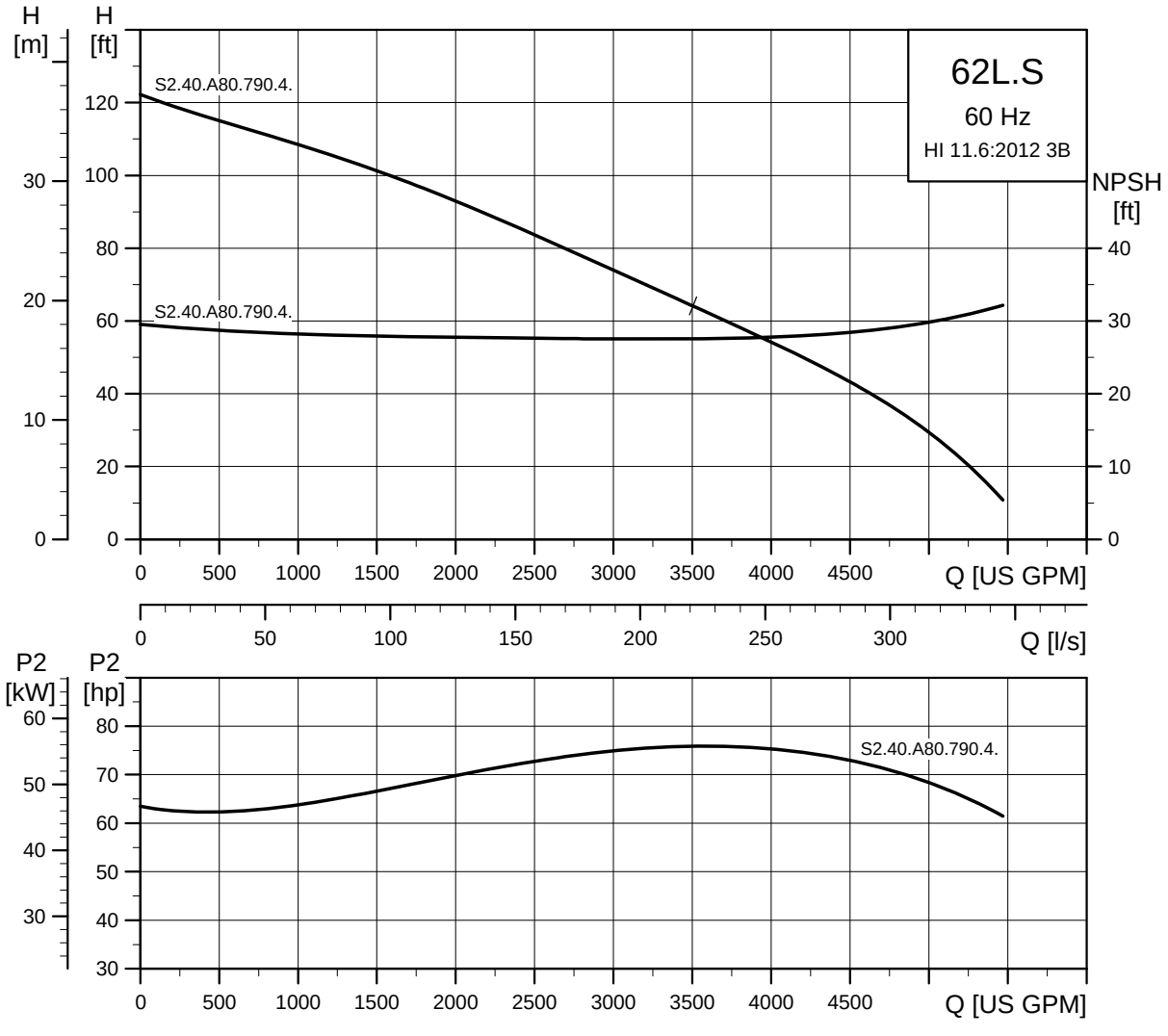
Note: Enclosure class: IP68

Pump data

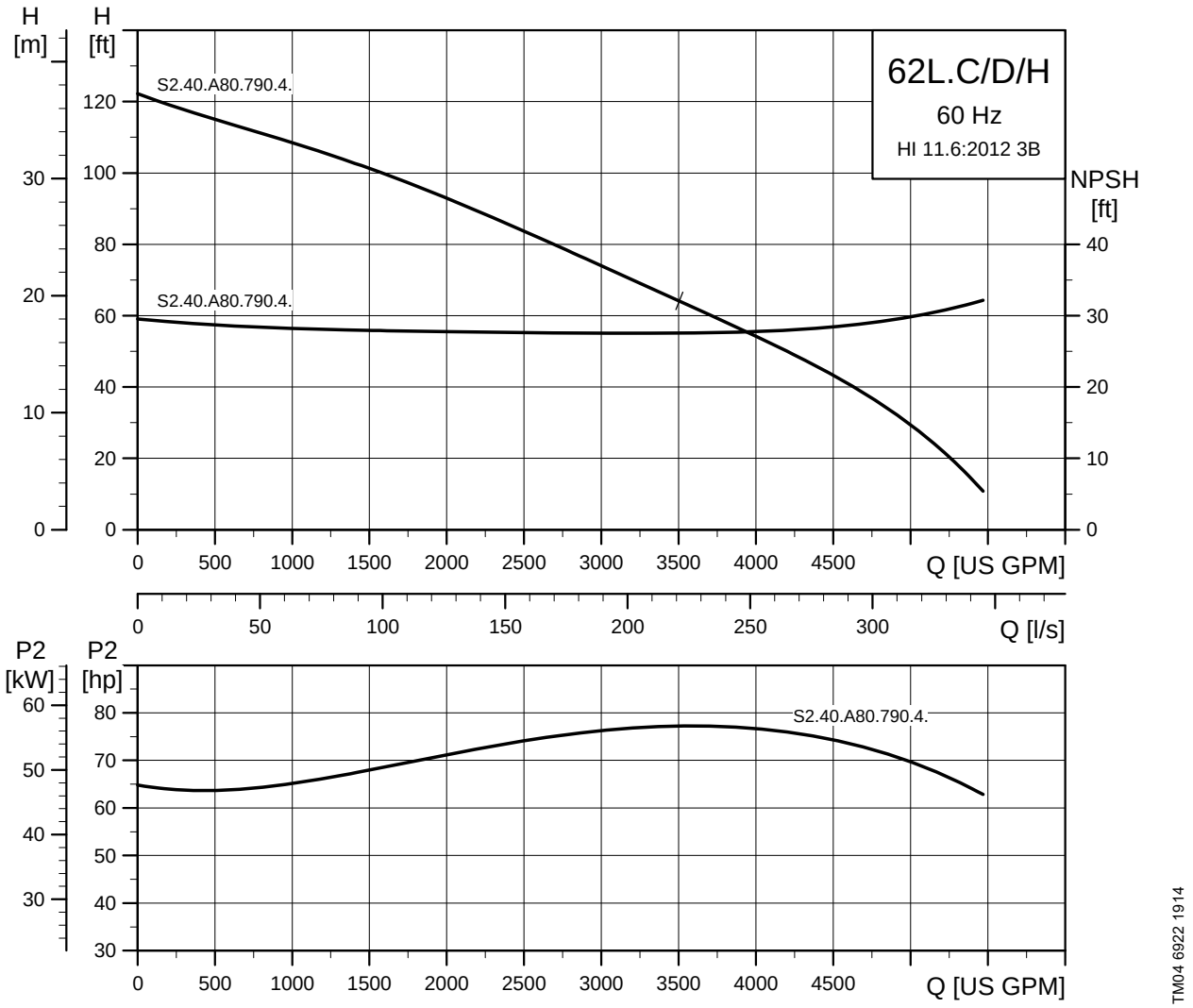
Pump type	Impeller diameter	Maximum solids size	Pump housing pressure	Maximum installation depth	Moment of inertia*
	[inch (mm)]	[inch (mm)]	[PSI (PN)]	[ft (m)]	[lbft^2 (kgm^2)]
S2.40.A80.540.4.62L.S/C/D/H.245...	9.6 (245)	4 (100)	145 (10)	66 (20)	7.84 (0.33)
S2.40.A80.700.4.62L.S/C/D/H.256...	10.0 (256)				10.97 (0.462)

* Applies to material code G (see Type key). For other material codes, please contact Grundfos.

S2.40.A80.790.4



TM04 6838 1914



Motor data

Pump type	P1	P2	Poles	RPM	Starting method	I_N	I_{start}	η_{motor} [%]			Cos φ			Moment of inertia	Breakdown torque M_{max}
	[HP (kW)]					[A]	[A]	1/2	3/4	1/1	1/2	3/4	1/1	[lbft^2 (kgm^2)]	[lbf*ft (Nm)]
S2.40.A80.790.4.62L...	88 (66)	79 (59)	4	1768	Y/D	105	579	88	90	90	0.61	0.72	0.79	9.0 (0.38)	476.5 (646)

Note: Enclosure class: IP68

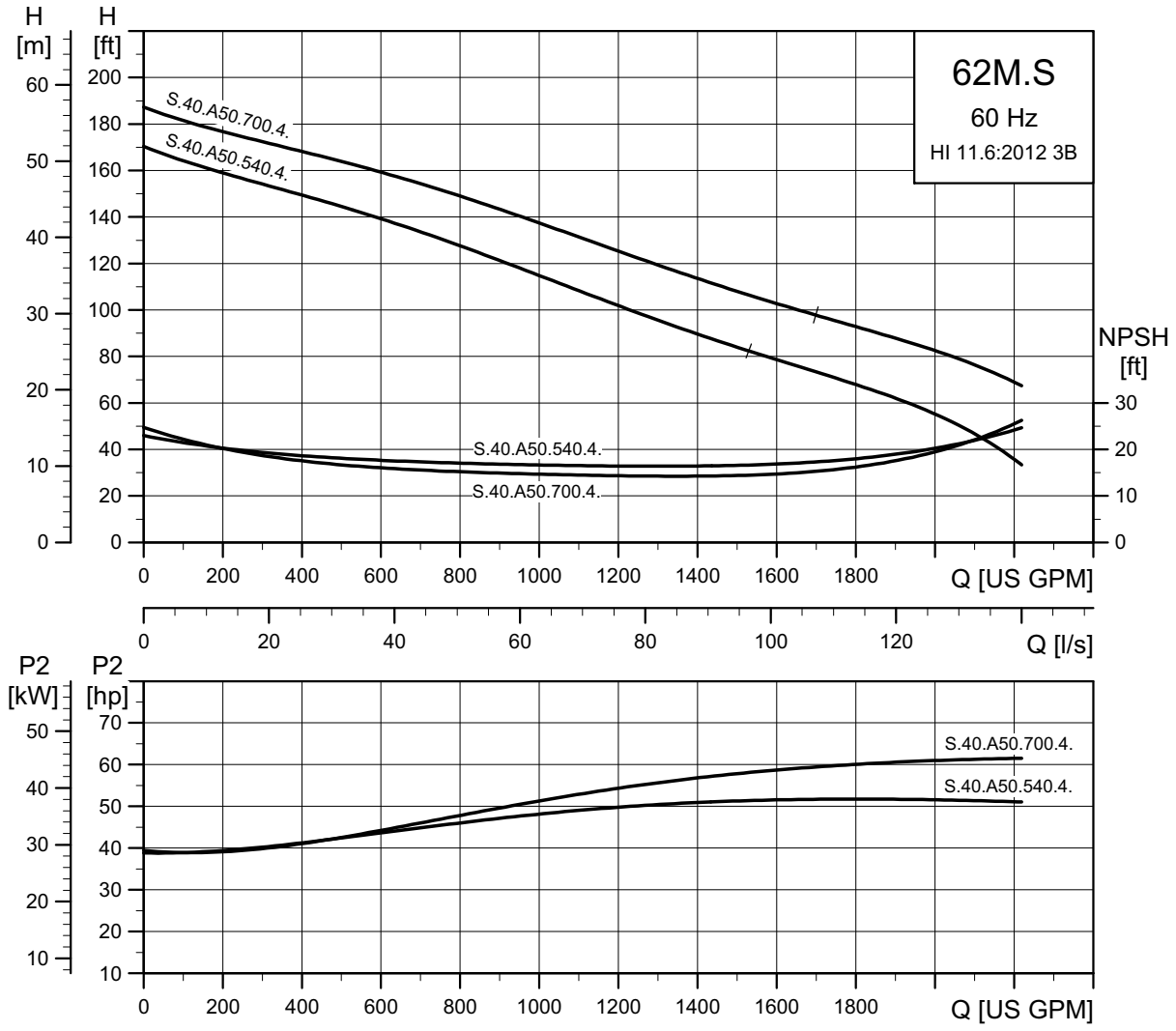
Pump data

Pump type	Impeller diameter	Maximum solids size	Pump housing pressure	Maximum installation depth	Moment of inertia*
	[inch (mm)]	[inch (mm)]	[PSI (PN)]	[ft (m)]	[lbft^2 (kgm^2)]
S2.40.A80.790.4.62L.S/C/D/H.272...	10.7 (272)	4 (100)	145 (10)	66 (20)	9.3 (0.392)

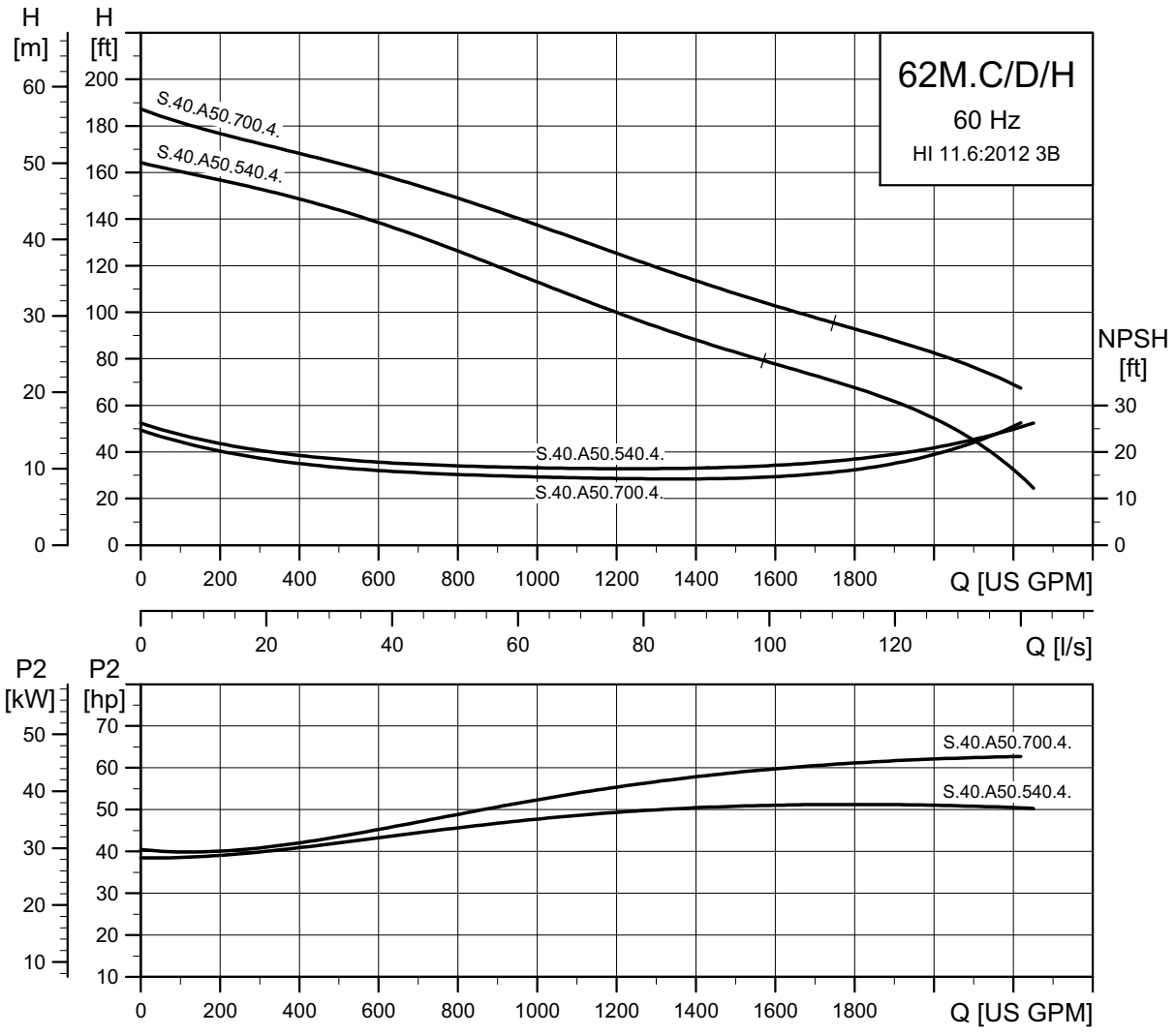
* Applies to material code G (see Type key). For other material codes, please contact Grundfos.

Medium pressure - 3 x 460 V

S1.40.A50.540.4 and S1.40.A50.700.4



TM04 6583 1914



Motor data

Pump type	P1	P2	Poles	RPM	Starting method	I_N	I_{start}	η_{motor} [%]			Cos φ			Moment of inertia	Breakdown torque M_{max}
	[HP (kW)]					[A]	[A]	1/2	3/4	1/1	1/2	3/4	1/1	[lbft^2 (kgm^2)]	[lbf*ft (Nm)]
S1.40.A50.540.4.62M.S...	59 (44)	54 (40)	4	1770	Y/D	73	571	87	89	90	0.60	0.70	0.77	7.12 (0.3)	438.8 (595)
S1.40.A50.540.4.62M.C/D/H...	62 (46)	56 (42)	4	1774	Y/D	76	571	87	90	90	0.61	0.71	0.78	7.12 (0.3)	438.8 (595)
S1.40.A50.700.4.62M.S...	71 (53)	64 (48)	4	1764	Y/D	85	571	88	90	90	0.65	0.75	0.79	7.12 (0.3)	438.8 (595)
S1.40.A50.700.4.62M.C/D/H...	78 (58)	70 (52)	4	1758	Y/D	91	571	89	90	90	0.67	0.76	0.80	7.12 (0.3)	438.8 (595)

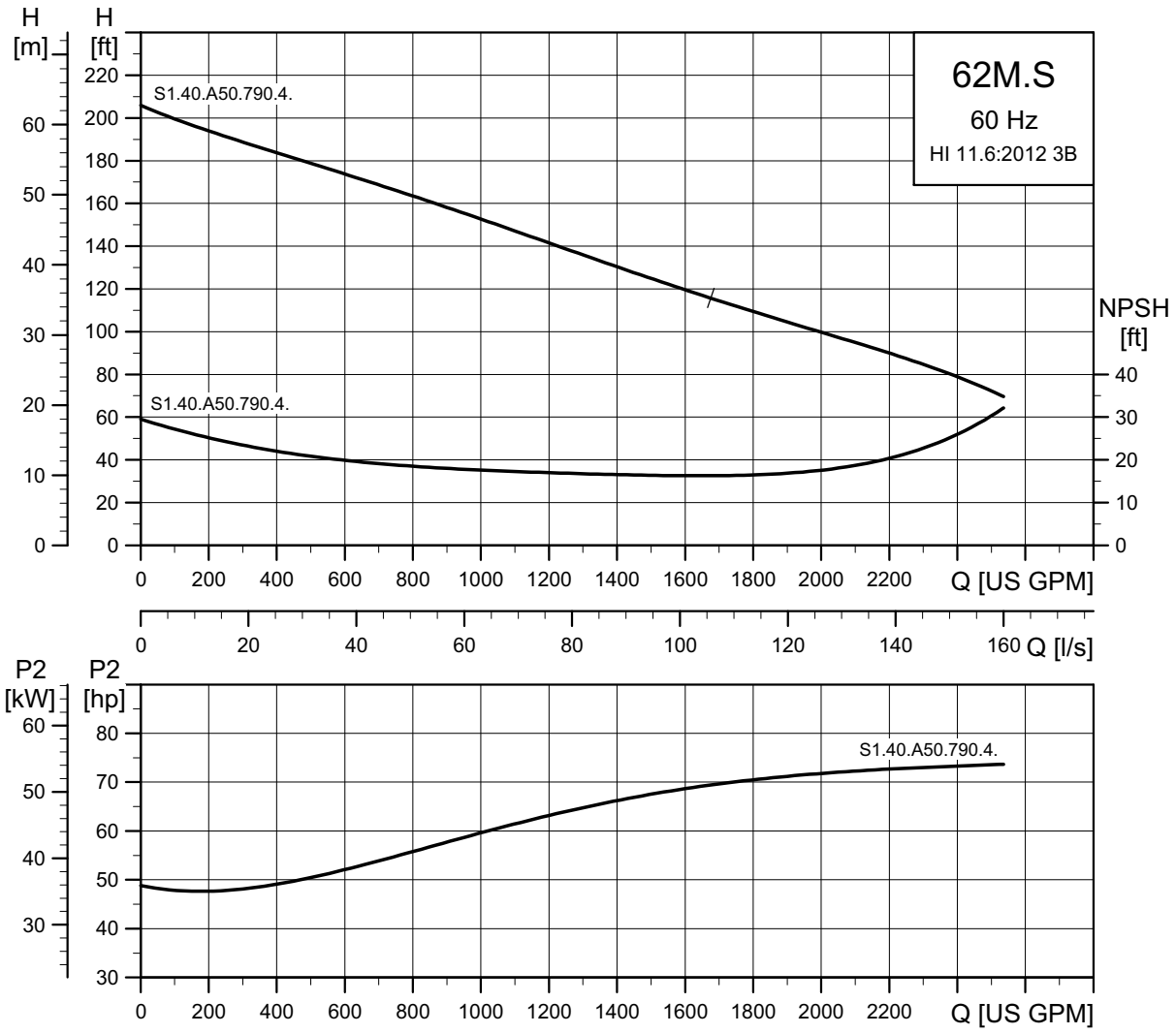
Note: Enclosure class: IP68

Pump data

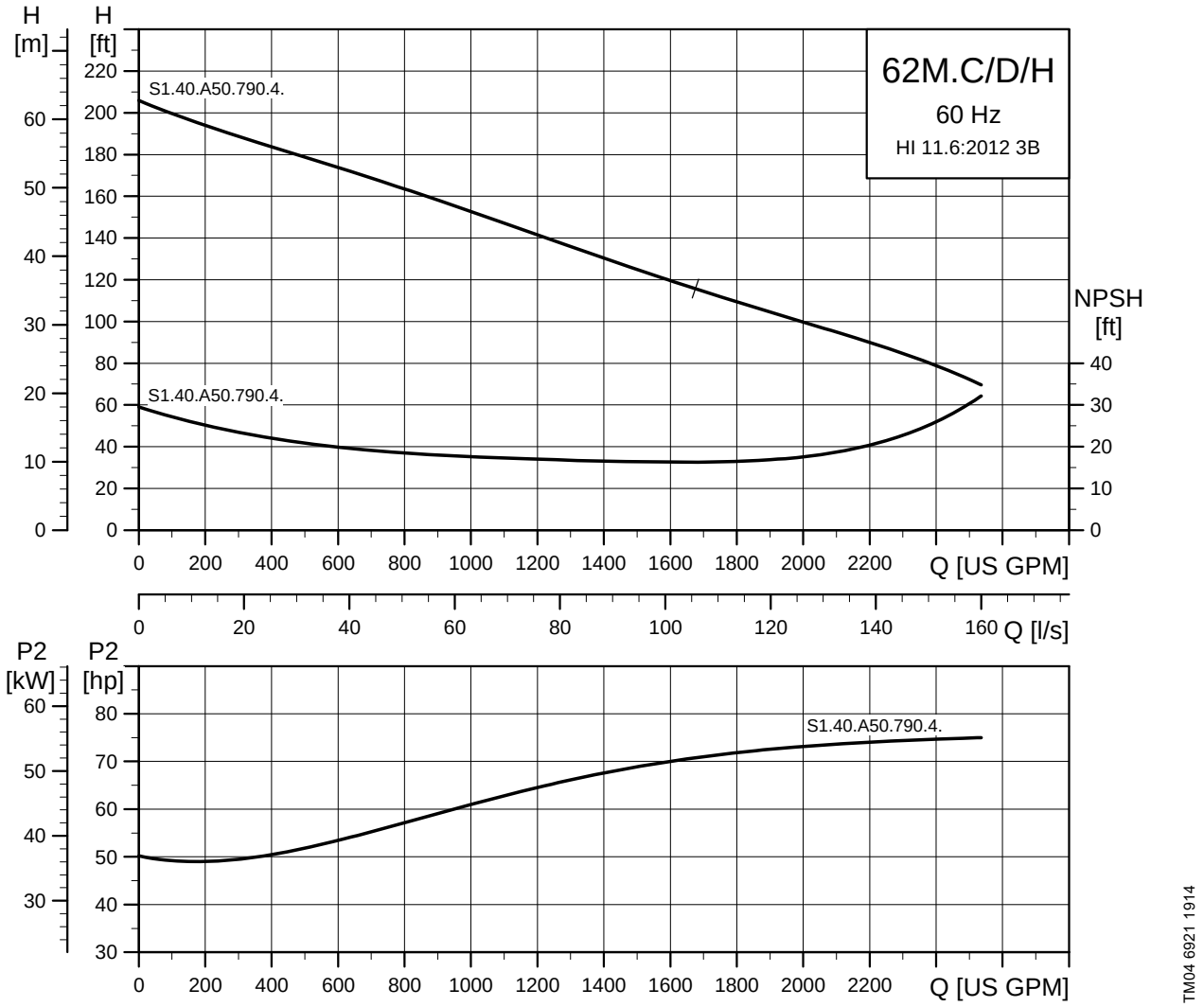
Pump type	Impeller diameter	Maximum solids size	Pump housing pressure	Maximum installation depth	Moment of inertia*
	[inch (mm)]	[inch (mm)]	[PSI (PN)]	[ft (m)]	[lbft^2 (kgm^2)]
S1.40.A50.540.4.62M.S/C/D/H.292...	11.5 (292)	4 (100)	145 (10)	66 (20)	10.36 (0.437)
S1.40.A50.700.4.62M.S/C/D/H.308...	12.1 (308)				11.63 (0.49)

* Applies to material code G (see Type key). For other material codes, please contact Grundfos.

S1.40.A50.790.4



TM04 6837 1914



Motor data

Pump type	P1	P2	Poles	RPM	Starting method	I_N	I_{start}	η_{motor} [%]			Cos φ			Moment of inertia	Breakdown torque M_{max}
	[HP	(kW)]				[A]	[A]	1/2	3/4	1/1	1/2	3/4	1/1	[lbft^2 (kgm^2)]	[lbf*ft (Nm)]
S1.40.A50.790.4.62M...	88 (66)	79 (59)	4	1768	Y/D	105	579	88	90	90	0.61	0.72	0.79	9.0 (0.38)	476.5 (646)

Note: Enclosure class: IP68

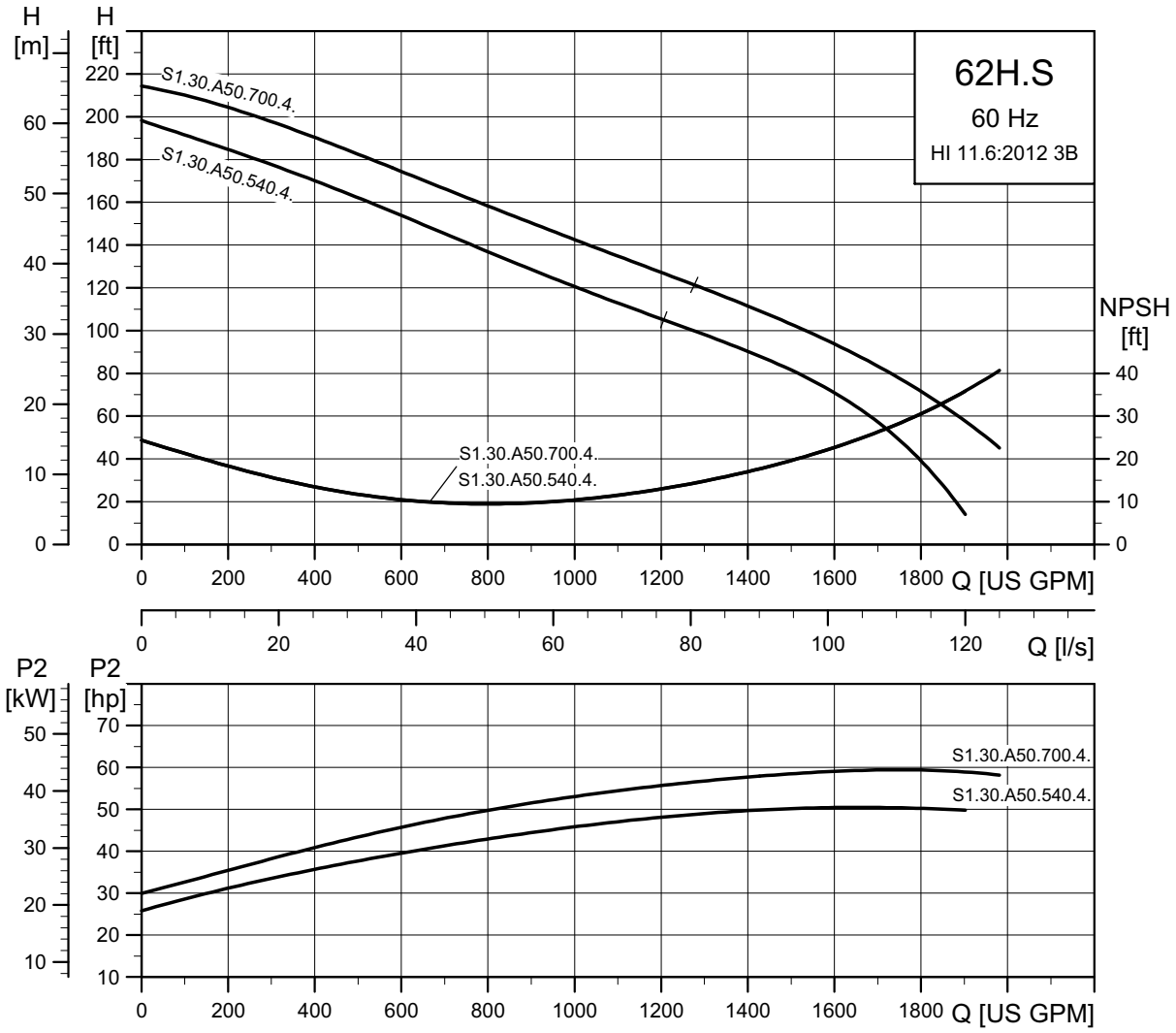
Pump data

Pump type	Impeller diameter	Maximum solids size	Pump housing pressure	Maximum installation depth	Moment of inertia*
	[inch (mm)]	[inch (mm)]	[PSI (PN)]	[ft (m)]	[lbft^2 (kgm^2)]
S1.40.A50.790.4.62M.S/C/D/H.326...	12.8 (326)	4 (100)	145 (10)	66 (20)	13.24 (0.558)

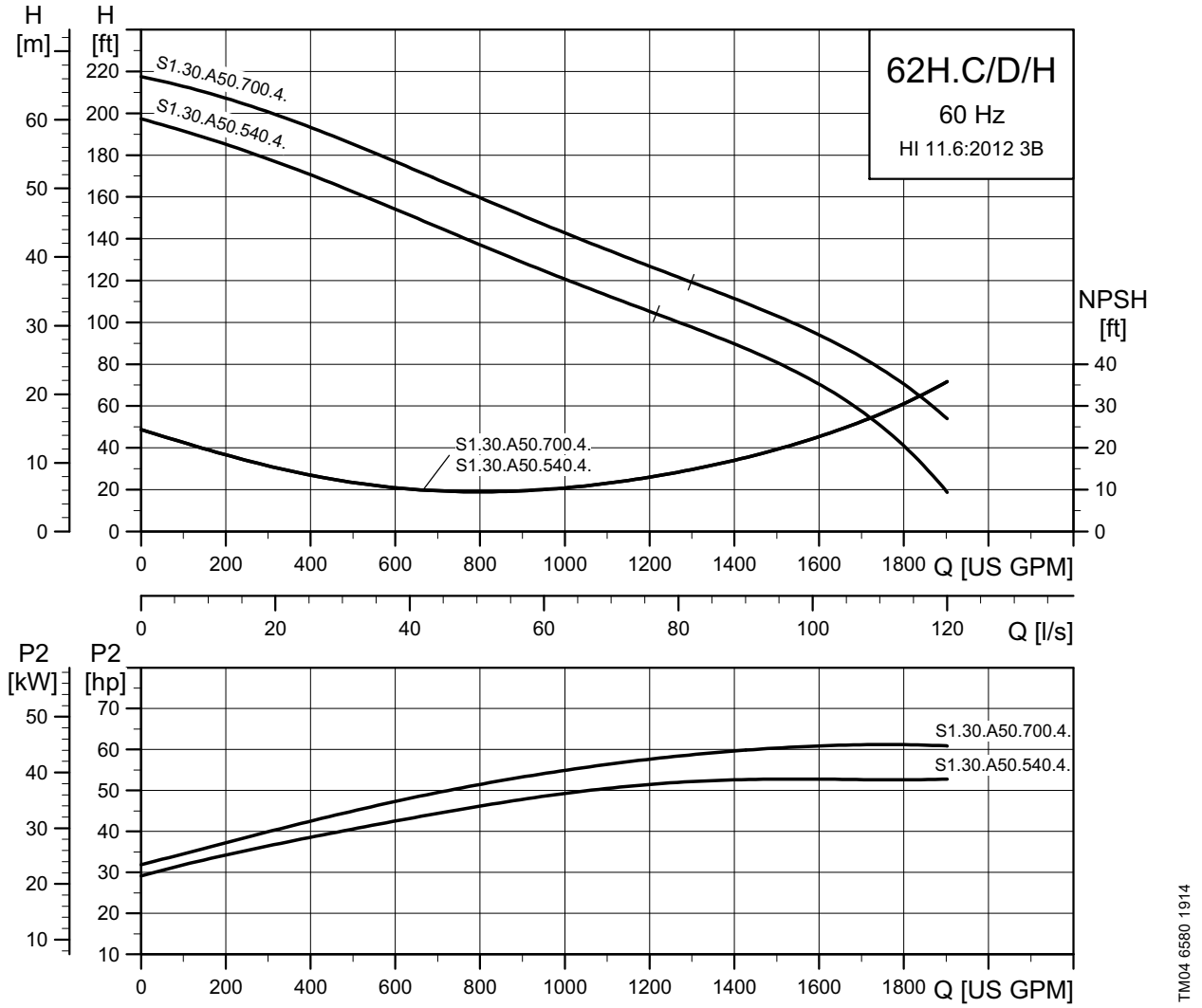
* Applies to material code G (see Type key). For other material codes, please contact Grundfos.

High pressure - 3 x 460 V

S1.30.A50.540.4 and S1.30.A50.700.4



TM04 6579 1914



Motor data

Pump type	P1	P2	Poles	RPM	Starting method	I_N	I_{start}	η_{motor} [%]			Cos φ			Moment of inertia	Breakdown torque M_{max}
	[HP (kW)]					[A]	[A]	1/2	3/4	1/1	1/2	3/4	1/1	[lbft^2 (kgm^2)]	[lbf*ft (Nm)]
S1.30.A50.540.4.62H.S...	59 (44)	54 (40)	4	1770	Y/D	73	571	87	89	90	0.60	0.70	0.77	7.12 (0.3)	438.8 (595)
S1.30.A50.540.4.62H.C/D/H...	62 (46)	56 (42)	4	1774	Y/D	76	571	87	90	90	0.61	0.71	0.78	7.12 (0.3)	438.8 (595)
S1.30.A50.700.4.62H.S...	71 (53)	65 (48)	4	1764	Y/D	85	571	88	90	90	0.65	0.75	0.79	7.12 (0.3)	438.8 (595)
S1.30.A50.700.4.62H.C/D/H...	78 (58)	70 (52)	4	1758	Y/D	91	571	89	90	90	0.67	0.76	0.80	7.12 (0.3)	438.8 (595)

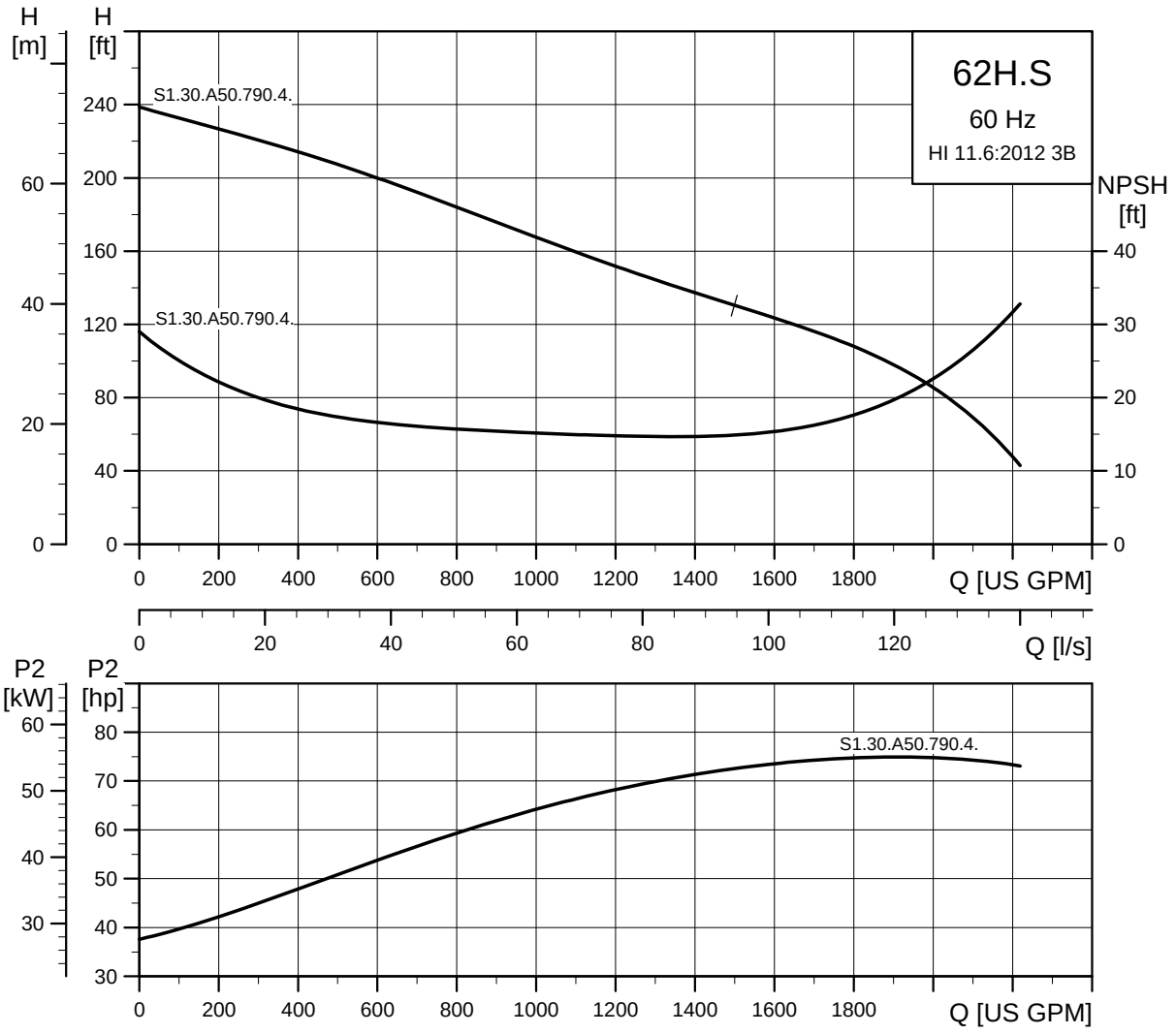
Note: Enclosure class: IP68

Pump data

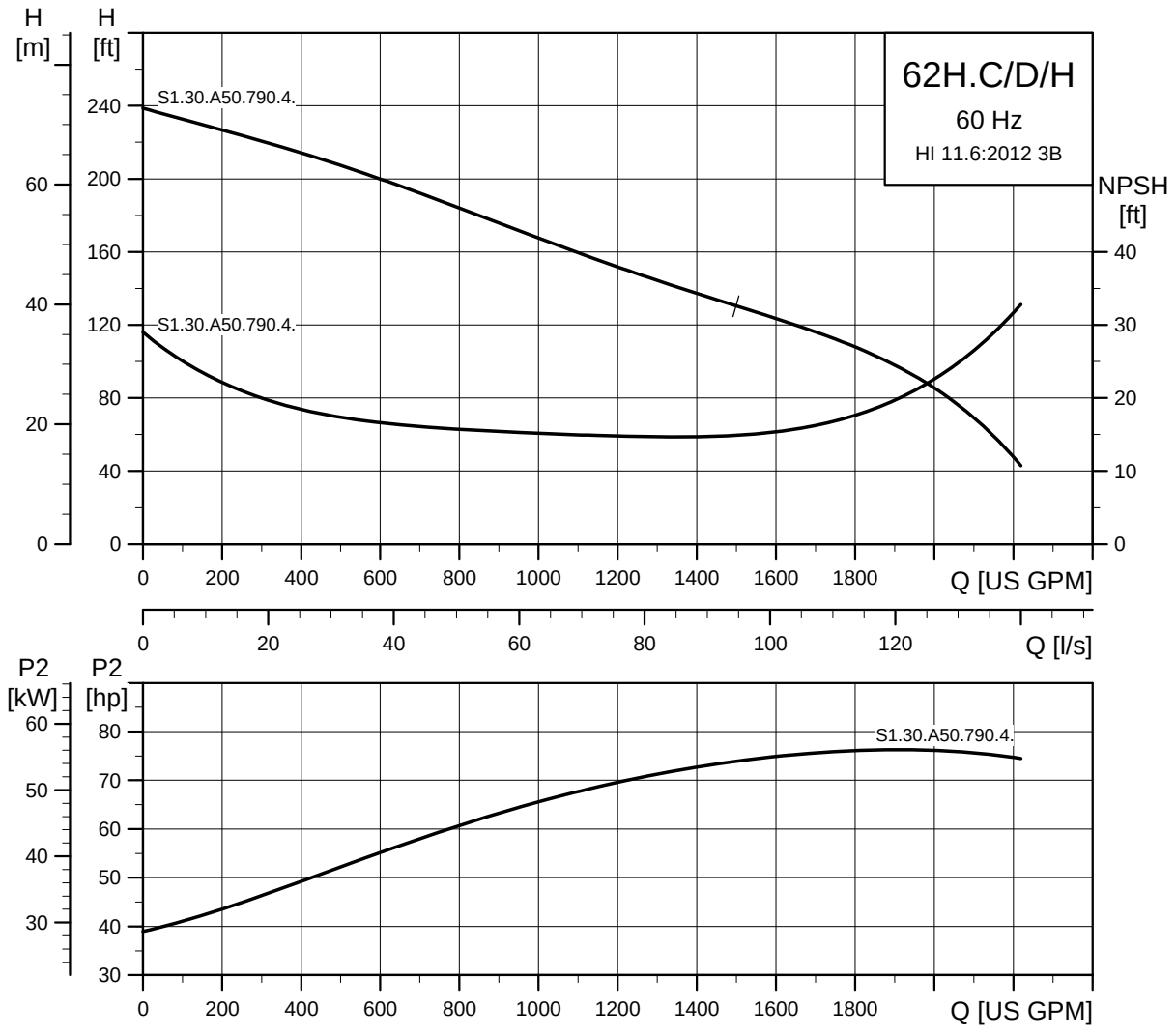
Pump type	Impeller diameter	Maximum solids size	Pump housing pressure	Maximum installation depth	Moment of inertia*
	[inch (mm)]	[inch (mm)]	[PSI (PN)]	[ft (m)]	[lbft^2 (kgm^2)]
S1.30.A50.540.4.62H.S/C/D/H.320...	12.6 (320)	4 (100)	145 (10)	66 (20)	13.32 (0.561)
S1.30.A50.700.4.62H.S/C/D/H.334...	13.1 (334)				15.06 (0.635)

* Applies to material code G (see Type key). For other material codes, please contact Grundfos.

S1.30.A50.790.4



TM04 6839 1914



Motor data

Pump type	P1	P2	Poles	RPM	Starting method	I_N	I_{start}	η_{motor} [%]			Cos φ			Moment of inertia	Breakdown torque M_{max}
	[HP (kW)]					[A]	[A]	1/2	3/4	1/1	1/2	3/4	1/1	[lbft^2 (kgm^2)]	[lbf*ft (Nm)]
S1.30.A50.790.4.62H...	88 (66)	79 (59)	4	1768	Y/D	105	579	88	90	90	0.61	0.72	0.79	9.0 (0.38)	476.5 (646)

Note: Enclosure class: IP68

Pump data

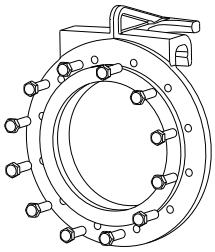
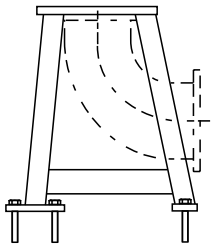
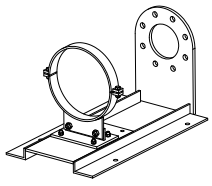
Pump type	Impeller diameter	Maximum solids size	Pump housing pressure	Maximum installation depth	Moment of inertia*
	[inch (mm)]	[inch (mm)]	[PSI (PN)]	[ft (m)]	[lbft^2 (kgm^2)]
S1.30.A50.790.4.62H.S/C/D/H.351...	13.8 (351)	4 (100)	145 (10)	66 (20)	17.47 (0.736)

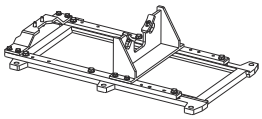
* Applies to material code G (see Type key). For other material codes, please contact Grundfos.

11. Accessories

Accessories (for installation)

Pump type	Installation accessories
Range 50-70 S and C	ANSI 3"-8" (DN 80-DN 200) without guide claw (guide claw included in auto-coupling kit)
Range 50-70 S and C	ANSI 10"-24" (DN 250-DN 600) with guide claw mounted on the pump
Range 50-70 D	Pump without installation accessories (available as separate kit)
Range 50-70 H	Base stand for horizontal, dry installation supplied together with the pump. Pumps of installation type H include the standard horizontal stand. Pumps with material code G or Q include a painted-steel stand. If another horizontal stand is required, order a pump of installation type D together with the required stand.

Pictures	Description		Size	Weight [lb (kg)]	PSI (PN)	Product number
 TM06 9868 3417	Cast-iron, epoxy-coated auto-coupling system complete with: • guide claw • base unit • upper guide rail bracket • gaskets and bolts	Outlet flange	ANSI 5"/ANSI 6" (DN 125/DN 150)	229 (104)	145 (10)	97626242
			ANSI 8" (DN 200)	551 (250)		97506541
Intermediate guide rail bracket	For guide rails longer than 19.5 ft (6 m)		ANSI 5"/ANSI 6" (DN 125/DN 150)	6.6 (3)		96829331
			ANSI 8"-ANSI 24" (DN 200-DN 600)	17.6 (8)		96255842
Guide rails	Standard pipes. Not supplied by Grundfos					
 TM06 9923 3617	Adaptor for Flygt auto coupling with: • flange seal • rubber seal • bolts		ANSI 6" (DN 150)	41.9 (19)		98061107
 TM04 4035 0509	Vertical base stand (without bend)	Inlet flange	ANSI 6" (DN150)	211 (96)		96308238
			ANSI 8" (DN 200)	222 (101)	145 (10)	96094523
			ANSI 10" (DN 250)	-		96856263
 TM04 4156 0909	Steel base stand for horizontal, dry installation with: • screws • nuts		ANSI 6" (DN150)	79 (36)		96787496
			ANSI 8" (DN 200)	108 (49)	145 (10)	96787497
			ANSI 10" (DN 250)	-		96857521

Pictures	Description	Size	Weight [lb (kg)]	PSI (PN)	Product number
 TM06 4971 3415	Special base stand for horizontal, dry installation with customized height.				Contact Grundfos.

Other accessories

Pictures	Description	Size	Product number
 TM02 6126 5102	Galvanized lifting chain with lifting link and safety hook. Certified. Maximum lifting capacity 4409 lb (2000 kg).	13 ft (4 m)	98425784
		20 ft (6 m)	98425785
		26 ft (8 m)	98425786
		33 ft (10 m)	98425787
	Stainless steel lifting chain with lifting link and safety hook. Certified. Maximum lifting capacity 4409 lb (2000 kg).	13 ft (4 m)	98425801
		20 ft (6 m)	98425802
		26 ft (8 m)	98425803
		33 ft (10 m)	98425804

12. Dimensions

Recommendation for pump foundations

Note: This applies only to pumps above 15 HP (15 kW).

All rotating equipment generates vibrations as a mass, such as an impeller or rotor, is turning at high speeds. Proper installation and anchorage of Grundfos pumps and installation accessories is critical to limit vibrations and achieve reliable, trouble-free installation. It is important to note that all mechanically connected pipes, fittings and supports of the pump are part of a single system.

The rotating mass of the entire pump, together with the forces from the motor and hydraulics, will generate disturbances related to the speed of the motor. Unbalance and blade pass in hydraulics are the two most important frequencies affecting vibration. When these frequencies coincide with the natural frequency of the entire mechanical system, the vibration level will increase substantially.

Pumps from Grundfos are designed and produced according to the highest quality standards. The method and grade of balancing is specified by the manufacturer in order to achieve acceptable vibration levels. Although the pump itself can withstand rather high vibration levels under operating conditions without considerable lifetime reduction, the pipes and supportive structure might suffer and crack if vibration levels are too high. Furthermore, noticeable noise levels might be generated.

The likelihood of high vibration levels occurring is increased in variable-speed applications where the pump is operated over a range of speeds rather than at a single constant speed. Most variable-speed drives provide the possibility to exclude certain frequency ranges to avoid operating areas with high vibrations. To ensure acceptable vibration levels in the field, all parts of the system must be sufficiently stiff and firmly anchored to minimize vibrations:

- The foundation and concrete must be of adequate strength to support the weight of the pump including accessories, the weight of the liquid passing through the pump and the forces generated by the pump.
- As a rule of thumb, the mass of the concrete foundation must be a minimum of three to five times the mass of the supported equipment and must have sufficient rigidity to withstand the axial, transverse and torsional loadings generated by the equipment.
- The foundation must be 6 inches (15 cm) wider than the base plate for pumps up to 470 HP (350 kW) and 10 inches (25 cm) wider for larger pumps.
- The concrete used in the foundation must have a minimum tensile strength of 362.6 PSI (250 N/cm^2). Epoxy grout must always be used to secure the pump base plate to the foundation.

Pull-out strengths for anchor bolts

Submerged installation on auto coupling (type S and C):

Auto-coupling base unit	Anchor bolts	Pull-out strength [kip (kN)]
ANSI 4" (DN 100)	4 x 5/8" (4 x M16)	1.1 (5)
ANSI 5"/NPS 6" (DN 125/DN 150)[1]		1.8 (8)
ANSI 8" (DN 200)	4 x 1" (4 x M24)	3.6 (16)
ANSI 10" (DN 250)		6.8 (30)
ANSI 12" (DN 300)		9.0 (40)
ANSI 20" (DN 500)	6 x 1 1/4" (6 x M30)	
ANSI 24" (DN 600)		
ANSI 32" (DN 800)		4.5 (20)

[1] Pump outlet ANSI 5" (DN 125) and base plate outlet ANSI 6" (DN 150).

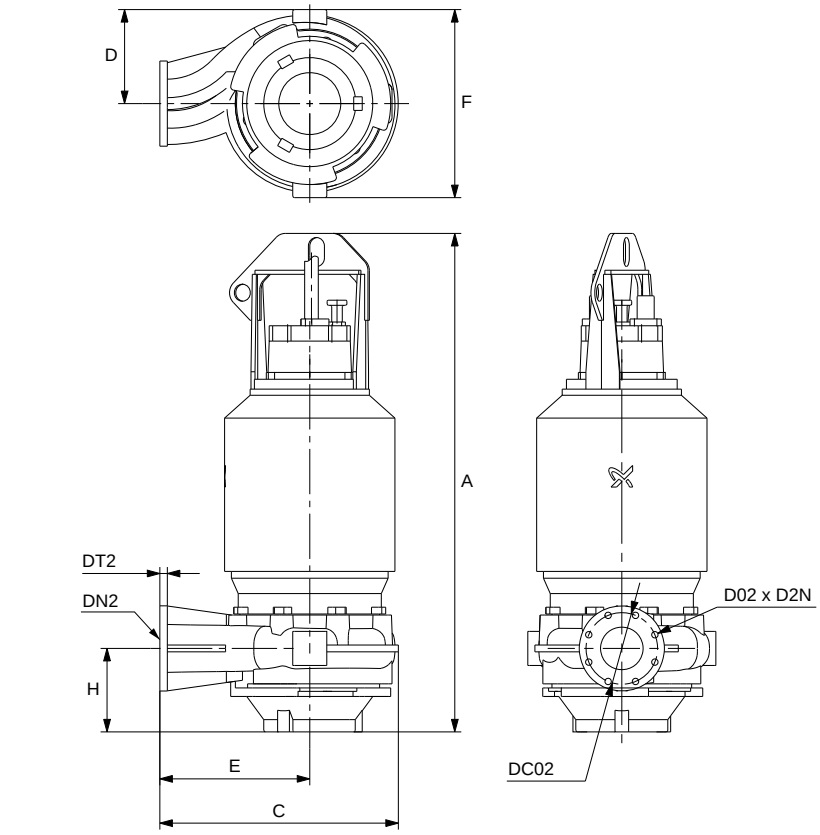
Dry installation (type H and D):

Dry installation	Anchor bolts	Pull-out strength [kip (kN)]
ANSI 4" (DN 100)	3 x 3/4" (3 x M20)	4.0 (18)
ANSI 6" (DN 150)	6 x 3/4" (6 x M20)	
ANSI 8" (DN 200)		
ANSI 10" (DN 250)	6 x 1" (6 x M24)	5.6 (25)
ANSI 12" (DN 300)		
ANSI 16" (DN 400)		
ANSI 20"/ANSI 16" (DN500/DN400)[1]		
ANSI 20" (DN 500)		
ANSI 24" (DN 600)		
ANSI 32" (DN 800)		

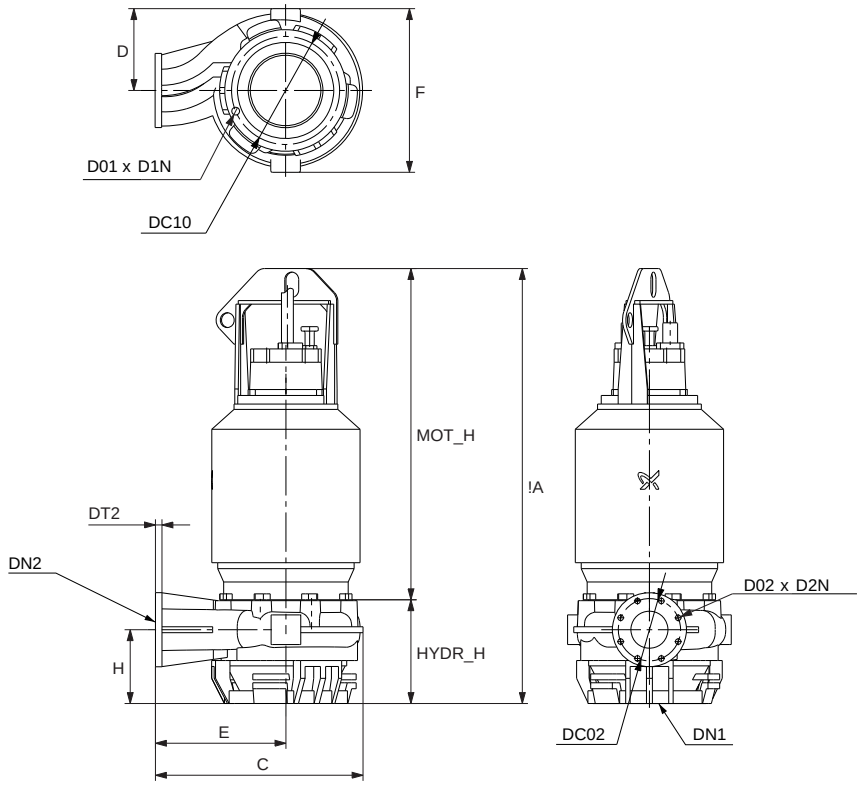
[1] Base plate inlet ANSI 20" (DN 500) and pump inlet ANSI 16" (DN 400).

Basic pump

Installation types S and C



Installation types D and H



TM04 6361 2018 - TM04 6360 2118

Fig. 30 Basic pumps

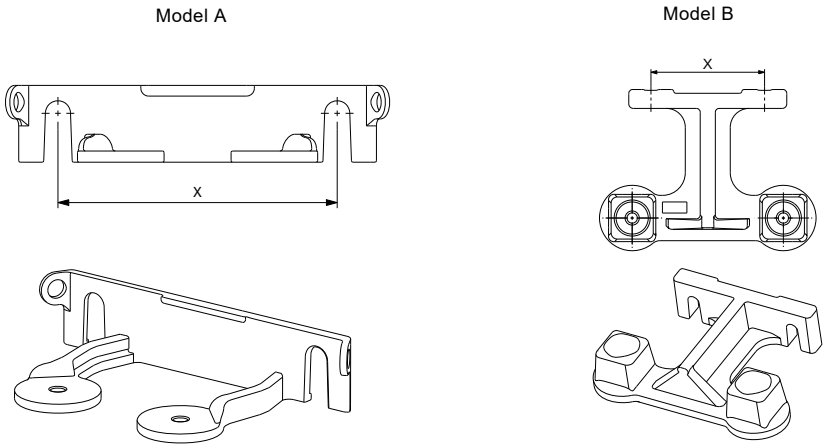
Note: Dimensions D01, D1N, DC10 and DN1 are equal to zero for installation types C and S because of the inlet type.

Pump type	[inch (mm)]					Pc.		[inch (mm)]	
	A	C	D	D01	D02	D1N	D2N	DC02	DC10
S1.30.A50.540.4.62H.C/S	56.5 (1435)	27.2 (690)	10.2 (260)	-	0.9 (22)	-	8	8.5 (216)	-
S1.30.A50.540.4.62H.D/H	58.1 (1477)	27.2 (690)	10.2 (260)	3/4" (M20)	0.9 (22)	8	8	8.5 (216)	9.5 (240)
S1.30.A50.700.4.62H.C/S	56.5 (1435)	27.2 (690)	10.2 (260)	-	0.9 (22)	-	8	8.5 (216)	-
S1.30.A50.700.4.62H.D/H	58.1 (1477)	27.2 (690)	10.2 (260)	3/4" (M20)	0.9 (22)	8	8	8.5 (216)	9.5 (240)
S1.30.A50.790.4.62H.C/S	56.5 (1435)	27.2 (690)	10.2 (260)	-	0.9 (22)	-	8	8.5 (216)	-
S1.30.A50.790.4.62H.D/H	58.1 (1477)	27.2 (690)	10.2 (260)	3/4" (M20)	0.9 (22)	8	8	8.5 (216)	9.5 (240)
S1.40.A50.540.4.62M.C/S	57.6 (1463)	27.2 (690)	10.9 (276)	-	0.9 (22)	-	8	8.5 (216)	11.7 (298)
S1.40.A50.540.4.62M.D/H	57.8 (1467)	27.2 (690)	10.9 (276)	3/4" (M20)	0.9 (22)	8	8	8.5 (216)	11.7 (298)
S1.40.A50.700.4.62M.C/S	57.6 (1463)	27.2 (690)	10.9 (276)	-	0.9 (22)	-	8	8.5 (216)	11.7 (298)
S1.40.A50.700.4.62M.D/H	57.8 (1467)	27.2 (690)	10.9 (276)	3/4" (M20)	0.9 (22)	8	8	8.5 (216)	11.7 (298)
S1.40.A50.790.4.62M.C/S	57.6 (1463)	27.2 (690)	10.9 (276)	-	0.9 (22)	-	8	8.5 (216)	11.7 (298)
S1.40.A50.790.4.62M.D/H	57.8 (1467)	27.2 (690)	10.9 (276)	3/4" (M20)	0.9 (22)	8	8	8.5 (216)	11.7 (298)
S2.40.A80.540.4.52L.C/S	57.9 (1471)	27.2 (690)	14.0 (356)	-	0.9 (24)	-	8	11.7 (298)	14.3 (362)
S2.40.A80.540.4.52L.D/H	58.8 (1494)	27.2 (690)	14.0 (356)	3/4" (M20)	0.9 (24)	12	8	11.7 (298)	14.3 (362)
S2.40.A80.700.4.52L.C/S	57.9 (1471)	27.2 (690)	14.0 (356)	-	0.9 (24)	-	8	11.7 (298)	14.3 (362)
S2.40.A80.700.4.52L.D/H	58.8 (1494)	27.2 (690)	14.0 (356)	3/4" (M20)	0.9 (24)	12	8	11.7 (298)	14.3 (362)
S2.40.A80.790.4.52L.C/S	57.9 (1471)	27.2 (690)	14.0 (356)	-	0.9 (24)	-	8	11.7 (298)	14.3 (362)
S2.40.A80.790.4.52L.D/H	58.8 (1494)	27.2 (690)	14.0 (356)	3/4" (M20)	0.9 (24)	12	8	11.7 (298)	14.3 (362)

Pump type	[inch (mm)]							
	DN1	DN2	DT2	E	F	H	HYDR H	MOT H
S1.30.A50.540.4.62H.C/S	-	ANSI 5" (DN 125)	0.9 (22)	17.3 (440)	20.9 (523)	9.1 (230)	12.4 (315)	45.1 (1145)
S1.30.A50.540.4.62H.D/H	ANSI 6" (DN 150)	ANSI 5" (DN 125)	0.9 (22)	17.3 (440)	20.9 (523)	10.7 (272)	14.1 (357)	45.1 (1145)
S1.30.A50.700.4.62H.C/S	-	ANSI 5" (DN 125)	0.9 (22)	17.3 (440)	20.9 (523)	9.1 (230)	12.4 (315)	45.1 (1145)
S1.30.A50.700.4.62H.D/H	ANSI 6" (DN 150)	ANSI 5" (DN 125)	0.9 (22)	17.3 (440)	20.9 (523)	10.7 (272)	14.1 (357)	45.1 (1145)
S1.30.A50.790.4.62H.C/S	-	ANSI 5" (DN 125)	0.9 (22)	17.3 (440)	20.9 (523)	9.1 (230)	12.4 (315)	45.1 (1145)
S1.30.A50.790.4.62H.D/H	ANSI 6" (DN 150)	ANSI 5" (DN 125)	0.9 (22)	17.3 (440)	20.9 (523)	10.7 (272)	14.1 (357)	45.1 (1145)
S1.40.A50.540.4.62M.C/S	-	ANSI 5" (DN 125)	0.9 (22)	17.3 (440)	21.7 (552)	9.6 (245)	13.5 (343)	45.1 (1145)
S1.40.A50.540.4.62M.D/H	ANSI 8" (DN 200)	ANSI 5" (DN 125)	0.9 (22)	17.3 (440)	21.7 (552)	9.8 (249)	13.7 (347)	45.1 (1145)
S1.40.A50.700.4.62M.C/S	-	ANSI 5" (DN 125)	0.9 (22)	17.3 (440)	21.7 (552)	9.6 (245)	13.5 (343)	45.1 (1145)
S1.40.A50.700.4.62M.D/H	ANSI 8" (DN 200)	ANSI 5" (DN 125)	0.9 (22)	17.3 (440)	21.7 (552)	9.8 (249)	13.7 (347)	45.1 (1145)
S1.40.A50.790.4.62M.C/S	-	ANSI 5" (DN 125)	0.9 (22)	17.3 (440)	21.7 (552)	9.6 (245)	13.5 (343)	45.1 (1145)
S1.40.A50.790.4.62M.D/H	ANSI 8" (DN 200)	ANSI 5" (DN 125)	0.9 (22)	17.3 (440)	21.7 (552)	9.8 (249)	13.7 (347)	45.1 (1145)
S2.40.A80.540.4.52L.C/S	-	ANSI 8" (DN 200)	1.0 (26)	26.0 (660)	25.4 (646)	9.5 (240)	13.8 (351)	45.1 (1145)
S2.40.A80.540.4.52L.D/H	ANSI 8" (DN 200)	ANSI 8" (DN 200)	1.0 (26)	26.0 (660)	25.4 (646)	10.4 (263)	14.7 (374)	45.1 (1145)
S2.40.A80.700.4.52L.C/S	-	ANSI 8" (DN 200)	1.0 (26)	26.0 (660)	25.4 (646)	9.5 (240)	13.8 (351)	45.1 (1145)
S2.40.A80.700.4.52L.D/H	ANSI 8" (DN 200)	ANSI 8" (DN 200)	1.0 (26)	26.0 (660)	25.4 (646)	10.4 (263)	14.7 (374)	45.1 (1145)
S2.40.A80.790.4.52L.C/S	-	ANSI 8" (DN 200)	1.0 (26)	26.0 (660)	25.4 (646)	9.5 (240)	13.8 (351)	45.1 (1145)
S2.40.A80.790.4.52L.D/H	ANSI 8" (DN 200)	ANSI 8" (DN 200)	1.0 (26)	26.0 (660)	25.4 (646)	10.4 (263)	14.7 (374)	45.1 (1145)

Installation on auto-coupling system

Upper guide rail bracket dimensions

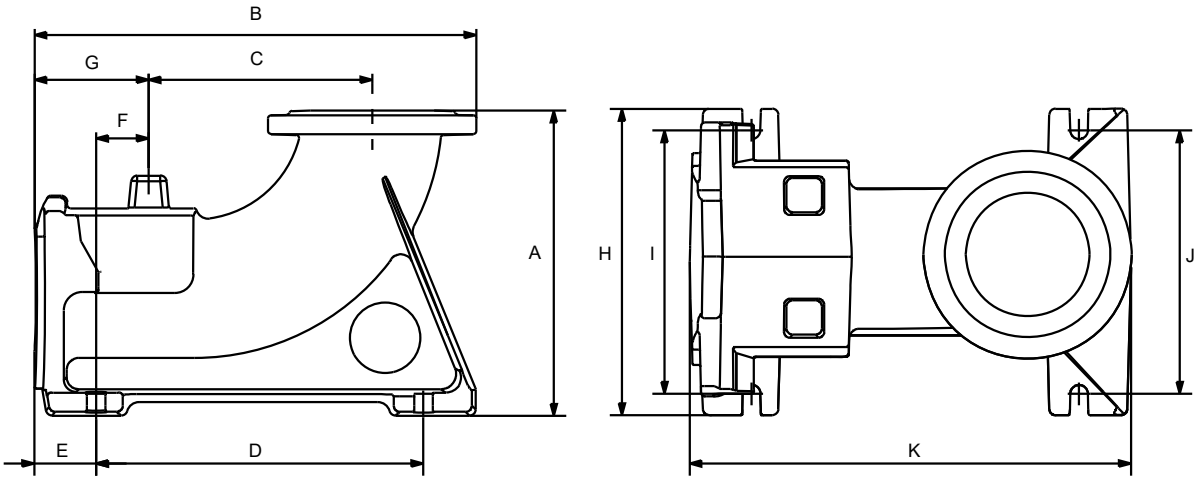


TM06 9913 3617 - TM06 9915 3617

Fig. 31 Installation dimensions for upper guide rail holder

Auto coupling			X [inch (mm)]
Product number	**Model**	**Size**	
97626242	A	ANSI 5"/ANSI 6" DN 125/DN 150)	200
97506541	B	ANSI 8" (DN 200)	150

Auto-coupling dimensions



TM06 6497 1516

Fig. 32 Dimension for cast-iron base unit

Product number	Size	[inch (mm)]										
		A	B	C	D	E	F	G	H	I	J	K
97626242	ANSI 5"/ANSI 6" (DN 125/DN 150)	17.7 (450)	19.8 (502)	11.0 (280)	11.0 (280)	3.1 (78)	0	3.1 (78)	13.4 (340)	11.8 (300)	11.8 (300)	16.5 (420)
97506541	ANSI 8" (DN 200)	19.0 (485)	28.0 (710)	14.4 (365)	21.0 (535)	3.5 (89)	3.4 (86)	6.9 (175)	19.7 (500)	16.9 (430)	16.9 (430)	28.0 (710)

Pump installation dimensions

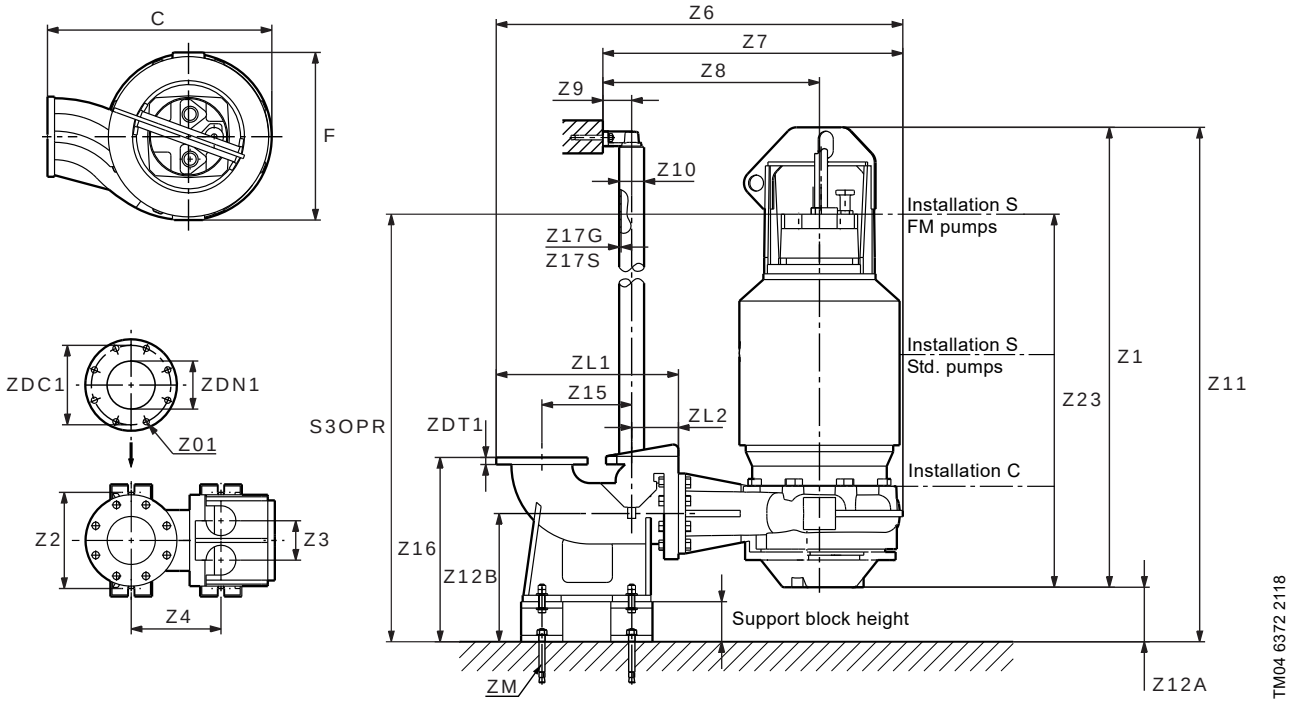


Fig. 33 Installation on auto-coupling system - version 1 (with support block)

Note: Height of the support block = 5 inches (125 mm).

Note: Distance between the centre of the anchor bolt hole and the edge of the screw hole = 0.4 inches (10 mm).

Pump type	[in. (mm)]													
	C	F	Z01	Z1	Z2	Z3	Z4	Z6	Z7	Z8	Z9	Z10	Z11	Z12A
S1.30.A50.540.4.62H.C...	27.1 (690)	20.6 (523)	8 x 0.9 (8 x 23)	56.5 (1435)	11.8 (300)	4.8 (123)	11.0 (280)	49.6 (1261)	37.3 (947)	27.4 (697)	4.3 (110)	3.5 (88)	63.2 (1605)	3.1 (80)
S1.30.A50.540.4.62H.S...	27.1 (690)	20.6 (523)	8 x 0.9 (8 x 23)	56.5 (1435)	11.8 (300)	4.8 (123)	11.0 (280)	49.6 (1261)	37.3 (947)	27.4 (697)	4.3 (110)	3.5 (88)	63.2 (1605)	3.1 (80)
S1.30.A50.700.4.62H.C...	27.1 (690)	20.6 (523)	8 x 0.9 (8 x 23)	56.5 (1435)	11.8 (300)	4.8 (123)	11.0 (280)	49.6 (1261)	37.3 (947)	27.4 (697)	4.3 (110)	3.5 (88)	63.2 (1605)	3.1 (80)
S1.30.A50.700.4.62H.S...	27.1 (690)	20.6 (523)	8 x 0.9 (8 x 23)	56.5 (1435)	11.8 (300)	4.8 (123)	11.0 (280)	49.6 (1261)	37.3 (947)	27.4 (697)	4.3 (110)	3.5 (88)	63.2 (1605)	3.1 (80)
S1.30.A50.790.4.62H.C...	27.1 (690)	20.6 (523)	8 x 0.9 (8 x 23)	56.5 (1435)	11.8 (300)	4.8 (123)	11.0 (280)	49.6 (1261)	37.3 (947)	27.4 (697)	4.3 (110)	3.5 (88)	63.2 (1605)	3.1 (80)
S1.30.A50.790.4.62H.S...	27.1 (690)	20.6 (523)	8 x 0.9 (8 x 23)	56.5 (1435)	11.8 (300)	4.8 (123)	11.0 (280)	49.6 (1261)	37.3 (947)	27.4 (697)	4.3 (110)	3.5 (88)	63.2 (1605)	3.1 (80)
S1.40.A50.540.4.62M.C...	27.1 (690)	21.7 (552)	8 x 0.9 (8 x 23)	57.6 (1463)	11.8 (300)	4.8 (123)	11.0 (280)	49.6 (1261)	37.3 (947)	27.4 (697)	4.3 (110)	3.5 (88)	63.7 (1618)	3.9 (100)
S1.40.A50.540.4.62M.S...	27.1 (690)	21.7 (552)	8 x 0.9 (8 x 23)	57.6 (1463)	11.8 (300)	4.8 (123)	11.0 (280)	49.6 (1261)	37.3 (947)	27.4 (697)	4.3 (110)	3.5 (88)	63.7 (1618)	3.9 (100)
S1.40.A50.700.4.62M.C...	27.1 (690)	21.7 (552)	8 x 0.9 (8 x 23)	57.6 (1463)	11.8 (300)	4.8 (123)	11.0 (280)	49.6 (1261)	37.3 (947)	27.4 (697)	4.3 (110)	3.5 (88)	63.7 (1618)	3.9 (100)
S1.40.A50.700.4.62M.S...	27.1 (690)	21.7 (552)	8 x 0.9 (8 x 23)	57.6 (1463)	11.8 (300)	4.8 (123)	11.0 (280)	49.6 (1261)	37.3 (947)	27.4 (697)	4.3 (110)	3.5 (88)	63.7 (1618)	3.9 (100)
S1.40.A50.790.4.62M.C...	27.1 (690)	21.7 (552)	8 x 0.9 (8 x 23)	57.6 (1463)	11.8 (300)	4.8 (123)	11.0 (280)	49.6 (1261)	37.3 (947)	27.4 (697)	4.3 (110)	3.5 (88)	63.7 (1618)	3.9 (100)
S1.40.A50.790.4.62M.S...	27.1 (690)	21.7 (552)	8 x 0.9 (8 x 23)	57.6 (1463)	11.8 (300)	4.8 (123)	11.0 (280)	49.6 (1261)	37.3 (947)	27.4 (697)	4.3 (110)	3.5 (88)	63.7 (1618)	3.9 (100)

Pump type	[inch (mm)]												
	Z12B	Z15	Z16	Z17		Z23	S3OPR	ZDC1	ZDN1	ZDT1	ZL1	ZL2	ZM
				G	S								
S1.30.A50.540.4.62H.C...	15.7 (400)	11.0 (280)	22.6 (575)	0.1 (3.0)	0.1 (3.0)	17.1 (435)	23.8 (605)	9.4 (240)	ANSI 6" (DN 150)	1.0 (25)	22.5 (571)	5.8 (147)	4 x 5/8" (4 x M16)
S1.30.A50.540.4.62H.S...	15.7 (400)	11.0 (280)	22.6 (575)	0.1 (3.0)	0.1 (3.0)	45.6 (1158)	52.3 (1328)	9.4 (240)	ANSI 6" (DN 150)	1.0 (25)	22.5 (571)	5.8 (147)	4 x 5/8" (4 x M16)
S1.30.A50.700.4.62H.C...	15.7 (400)	11.0 (280)	22.6 (575)	0.1 (3.0)	0.1 (3.0)	17.1 (435)	23.8 (605)	9.4 (240)	ANSI 6" (DN 150)	1.0 (25)	22.5 (571)	5.8 (147)	4 x 5/8" (4 x M16)
S1.30.A50.700.4.62H.S...	15.7 (400)	11.0 (280)	22.6 (575)	0.1 (3.0)	0.1 (3.0)	45.6 (1158)	52.3 (1328)	9.4 (240)	ANSI 6" (DN 150)	1.0 (25)	22.5 (571)	5.8 (147)	4 x 5/8" (4 x M16)
S1.30.A50.790.4.62H.C...	15.7 (400)	11.0 (280)	22.6 (575)	0.1 (3.0)	0.1 (3.0)	17.1 (435)	23.8 (605)	9.4 (240)	ANSI 6" (DN 150)	1.0 (25)	22.5 (571)	5.8 (147)	4 x 5/8" (4 x M16)
S1.30.A50.790.4.62H.S...	15.7 (400)	11.0 (280)	22.6 (575)	0.1 (3.0)	0.1 (3.0)	45.6 (1158)	52.3 (1328)	9.4 (240)	ANSI 6" (DN 150)	1.0 (25)	22.5 (571)	5.8 (147)	4 x 5/8" (4 x M16)
S1.40.A50.540.4.62M.C...	15.7 (400)	11.0 (280)	22.6 (575)	0.1 (3.0)	0.1 (3.0)	18.2 (463)	24.3 (618)	9.4 (240)	ANSI 6" (DN 150)	1.0 (25)	22.5 (571)	5.8 (147)	4 x 5/8" (4 x M16)
S1.40.A50.540.4.62M.S...	15.7 (400)	11.0 (280)	22.6 (575)	0.1 (3.0)	0.1 (3.0)	46.7 (1186)	52.8 (1341)	9.4 (240)	ANSI 6" (DN 150)	1.0 (25)	22.5 (571)	5.8 (147)	4 x 5/8" (4 x M16)
S1.40.A50.700.4.62M.C...	15.7 (400)	11.0 (280)	22.6 (575)	0.1 (3.0)	0.1 (3.0)	18.2 (463)	24.3 (618)	9.4 (240)	ANSI 6" (DN 150)	1.0 (25)	22.5 (571)	5.8 (147)	4 x 5/8" (4 x M16)
S1.40.A50.700.4.62M.S...	15.7 (400)	11.0 (280)	22.6 (575)	0.1 (3.0)	0.1 (3.0)	46.7 (1186)	52.8 (1341)	9.4 (240)	ANSI 6" (DN 150)	1.0 (25)	22.5 (571)	5.8 (147)	4 x 5/8" (4 x M16)
S1.40.A50.790.4.62M.C...	15.7 (400)	11.0 (280)	22.6 (575)	0.1 (3.0)	0.1 (3.0)	18.2 (463)	24.3 (618)	9.4 (240)	ANSI 6" (DN 150)	1.0 (25)	22.5 (571)	5.8 (147)	4 x 5/8" (4 x M16)
S1.40.A50.790.4.62M.S...	15.7 (400)	11.0 (280)	22.6 (575)	0.1 (3.0)	0.1 (3.0)	46.7 (1186)	52.8 (1341)	9.4 (240)	ANSI 6" (DN 150)	1.0 (25)	22.5 (571)	5.8 (147)	4 x 5/8" (4 x M16)

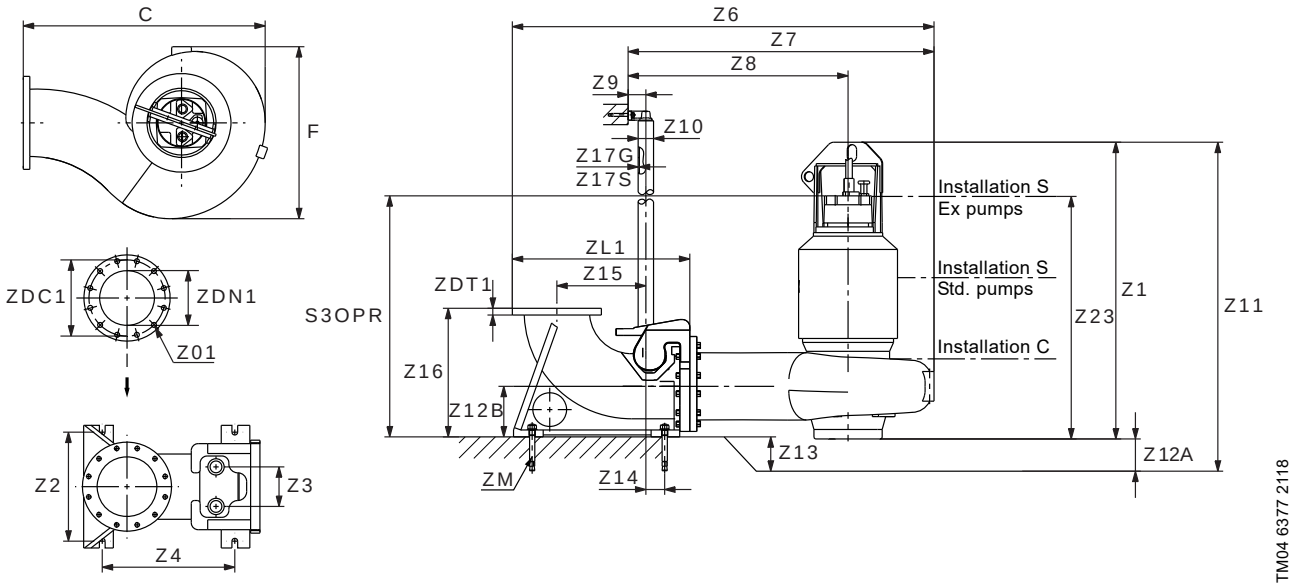


Fig. 34 Installation on auto-coupling system - version 2 (without support block)

Note: Z12A is the minimum recommended distance from pit bottom to bottom of pump inlet port.

Note: Z11 is the total height of pump installed on Grundfos installation accessory in the pit.

Note: The pump in this figure might not equal Z12A + Z1.

Pump type	[inch (mm)]													
	C	F	Z01	Z1	Z2	Z3	Z4	Z6	Z7	Z8	Z9	Z10	Z11	Z12A
S2.40.A80.540.4.62L.C...	37.8 (900)	25.4 (646)	8 x 0.9 (8 x 23)	57.9 (1471)	16.2 (430)	7.9 (200)	21.1 (535)	67.7 (1721)	53.2 (1352)	41.4 (1052)	6.7 (170)	3.5 (88)	64.0 (1627)	6.1 (156)
S2.40.A80.540.4.62L.S...	37.8 (900)	25.4 (646)	8 x 0.9 (8 x 23)	57.9 (1471)	16.2 (430)	7.9 (200)	21.1 (535)	67.7 (1721)	53.2 (1352)	41.4 (1052)	6.7 (170)	3.5 (88)	64.0 (1627)	6.1 (156)
S2.40.A80.700.4.62L.C...	37.8 (900)	25.4 (646)	8 x 0.9 (8 x 23)	57.9 (1471)	16.2 (430)	7.9 (200)	21.1 (535)	67.7 (1721)	53.2 (1352)	41.4 (1052)	6.7 (170)	3.5 (88)	64.0 (1627)	6.1 (156)
S2.40.A80.700.4.62L.S...	37.8 (900)	25.4 (646)	8 x 0.9 (8 x 23)	57.9 (1471)	16.2 (430)	7.9 (200)	21.1 (535)	67.7 (1721)	53.2 (1352)	41.4 (1052)	6.7 (170)	3.5 (88)	64.0 (1627)	6.1 (156)
S2.40.A80.790.4.62L.C...	37.8 (900)	25.4 (646)	8 x 0.9 (8 x 23)	57.9 (1471)	16.2 (430)	7.9 (200)	21.1 (535)	67.7 (1721)	53.2 (1352)	41.4 (1052)	6.7 (170)	3.5 (88)	64.0 (1627)	6.1 (156)
S2.40.A80.790.4.62L.S...	37.8 (900)	25.4 (646)	8 x 0.9 (8 x 23)	57.9 (1471)	16.2 (430)	7.9 (200)	21.1 (535)	67.7 (1721)	53.2 (1352)	41.4 (1052)	6.7 (170)	3.5 (88)	64.0 (1627)	6.1 (156)

Pump type	[inch (mm)]													
	Z12B	Z13	Z14	Z15	Z16	Z17		Z23	S3OPR	ZDC1	ZDN1	ZDT1	ZL1	ZL2	ZM
						G	S								
S2.40.A80.540.4.62L.C...	7.7 (196)	7.9 (200)	3.4 (86)	14.4 (365)	19.1 (485)	0.1 (3.0)	0.1 (3.0)	18.5 (471)	16.8 (427)	11.6 (295)	ANSI 8" (DN 200)	1.2 (31)	30.0 (761)	8.7 (22)	4 x 1" (4 x M24)
S2.40.A80.540.4.62L.S...	7.7 (196)	7.9 (200)	3.4 (86)	14.4 (365)	19.1 (485)	0.1 (3.0)	0.1 (3.0)	47.0 (1194)	45.3 (1150)	11.6 (295)	ANSI 8" (DN 200)	1.2 (31)	30.0 (761)	8.7 (22)	4 x 1" (4 x M24)
S2.40.A80.700.4.62L.C...	7.7 (196)	7.9 (200)	3.4 (86)	14.4 (365)	19.1 (485)	0.1 (3.0)	0.1 (3.0)	18.5 (471)	16.8 (427)	11.6 (295)	ANSI 8" (DN 200)	1.2 (31)	30.0 (761)	8.7 (22)	4 x 1" (4 x M24)
S2.40.A80.700.4.62L.S...	7.7 (196)	7.9 (200)	3.4 (86)	14.4 (365)	19.1 (485)	0.1 (3.0)	0.1 (3.0)	47.0 (1194)	45.3 (1150)	11.6 (295)	ANSI 8" (DN 200)	1.2 (31)	30.0 (761)	8.7 (22)	4 x 1" (4 x M24)
S2.40.A80.790.4.62L.C...	7.7 (196)	7.9 (200)	3.4 (86)	14.4 (365)	19.1 (485)	0.1 (3.0)	0.1 (3.0)	18.5 (471)	16.8 (427)	11.6 (295)	ANSI 8" (DN 200)	1.2 (31)	30.0 (761)	8.7 (22)	4 x 1" (4 x M24)
S2.40.A80.790.4.62L.S...	7.7 (196)	7.9 (200)	3.4 (86)	14.4 (365)	19.1 (485)	0.1 (3.0)	0.1 (3.0)	47.0 (1194)	45.3 (1150)	11.6 (295)	ANSI 8" (DN 200)	1.2 (31)	30.0 (761)	8.7 (22)	4 x 1" (4 x M24)

Dry, vertical installation on base stand

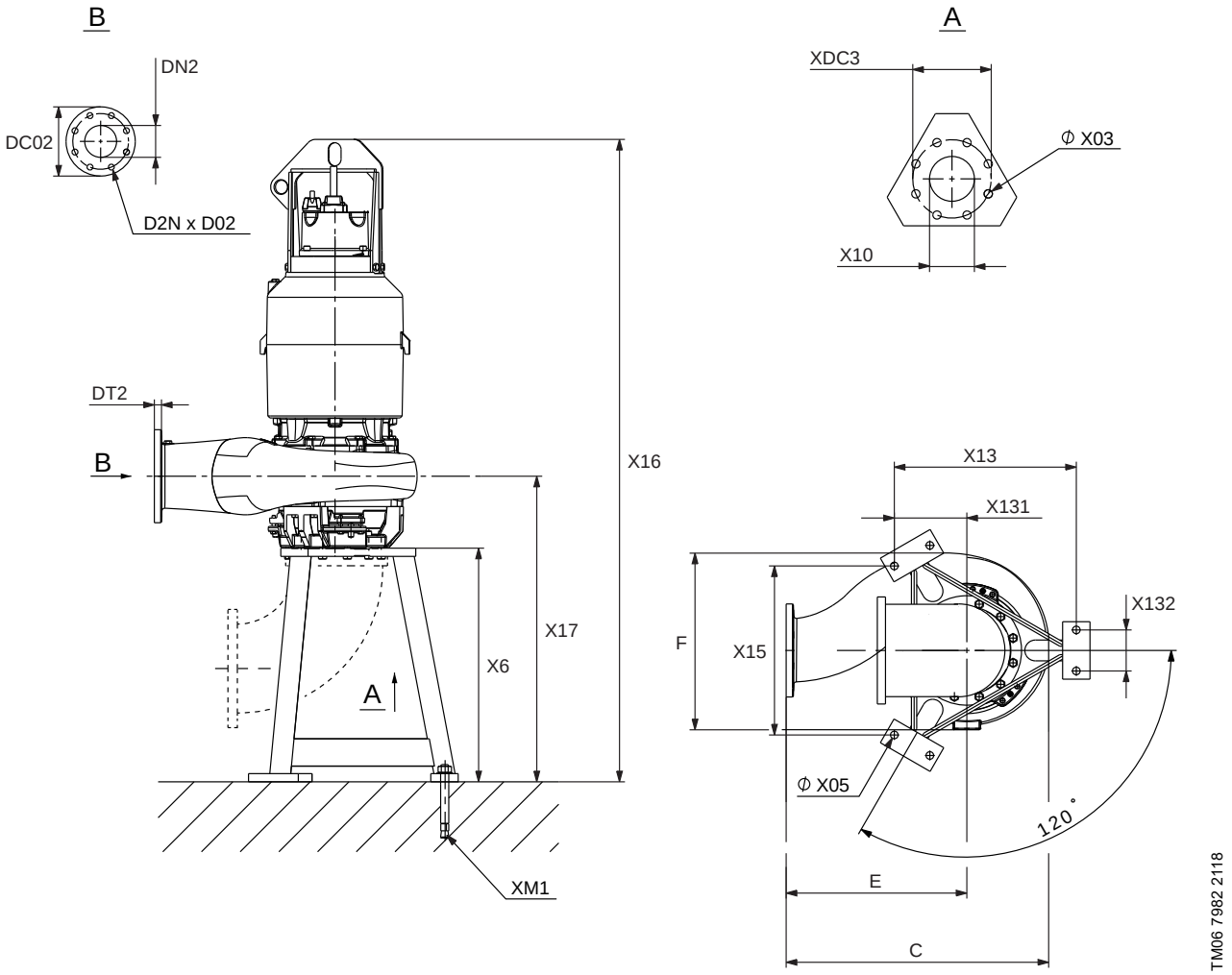


Fig. 35 Dry, vertical installation on base stand

Pump type	[inch (mm)]									
	C	E	F	X03	X05	X6	X10	X13	X131	X132
S1.30.A50.540.4.62H.D...	27.1 (690)	17.3 (440)	20.6 (523)	0.9 (24)	0.9 (24)	24.4 (621)	ANSI 6" (DN 150)	17.7 (450)	5.9 (150)	4.7 (120)
S1.30.A50.700.4.62H.D...	27.1 (690)	17.3 (440)	20.6 (523)	0.9 (24)	0.9 (24)	24.4 (621)	ANSI 6" (DN 150)	17.7 (450)	5.9 (150)	4.7 (120)
S1.30.A50.790.4.62H.D...	27.1 (690)	17.3 (440)	20.6 (523)	0.9 (24)	0.9 (24)	24.4 (621)	ANSI 6" (DN 150)	17.7 (450)	5.9 (150)	4.7 (120)
S1.40.A50.540.4.62M.D...	27.1 (690)	17.3 (440)	21.7 (552)	0.9 (24)	0.9 (24)	28.3 (719)	ANSI 8" (DN 200)	20.7 (525)	6.9 (175)	4.7 (120)
S1.40.A50.700.4.62M.D...	27.1 (690)	17.3 (440)	21.7 (552)	0.9 (24)	0.9 (24)	28.3 (719)	ANSI 8" (DN 200)	20.7 (525)	6.9 (175)	4.7 (120)
S1.40.A50.790.4.62M.D...	27.1 (690)	17.3 (440)	21.7 (552)	0.9 (24)	0.9 (24)	28.3 (719)	ANSI 8" (DN 200)	20.7 (525)	6.9 (175)	4.7 (120)
S2.40.A80.540.4.62L.D...	37.8 (960)	26.0 (660)	25.4 (646)	0.9 (24)	1.1 (28)	33.7 (857)	ANSI 8" (DN 200)	23.6 (600)	7.9 (200)	5.9 (150)
S2.40.A80.700.4.62L.D...	37.8 (960)	26.0 (660)	25.4 (646)	0.9 (24)	1.1 (28)	33.7 (857)	ANSI 8" (DN 200)	23.6 (600)	7.9 (200)	5.9 (150)
S2.40.A80.790.4.62L.D...	37.8 (960)	26.0 (660)	25.4 (646)	0.9 (24)	1.1 (28)	33.7 (857)	ANSI 8" (DN 200)	23.6 (600)	7.9 (200)	5.9 (150)

Pump type	[inch (mm)]							Pc.	[inch (mm)]	
	X15	X16	X17	XDC3	DN2	DC02	D02	D2N	DT2	XM1
S1.30.A50.540.4.62H.D...	20.5 (520)	82.6 (2098)	35.1 (893)	9.4 (240)	ANSI 5" (DN 125)	8.5 (216)	0.86 (22)	8	0.9 (24)	6 x 3/4" (6 x M20)
S1.30.A50.700.4.62H.D...	20.5 (520)	82.6 (2098)	35.1 (893)	9.4 (240)	ANSI 5" (DN 125)	8.5 (216)	0.86 (22)	8	0.9 (24)	6 x 3/4" (6 x M20)
S1.30.A50.790.4.62H.D...	20.5 (520)	82.6 (2098)	35.1 (893)	9.4 (240)	ANSI 5" (DN 125)	8.5 (216)	0.86 (22)	8	0.9 (24)	6 x 3/4" (6 x M20)
S1.40.A50.540.4.62M.D...	23.9 (606)	86.0 (2186)	38.1 (968)	11.6 (295)	ANSI 5" (DN 125)	8.5 (216)	0.86 (22)	8	1.0 (26)	6 x 3/4" (6 x M20)
S1.40.A50.700.4.62M.D...	23.9 (606)	86.0 (2186)	38.1 (968)	11.6 (295)	ANSI 5" (DN 125)	8.5 (216)	0.86 (22)	8	1.0 (26)	6 x 3/4" (6 x M20)
S1.40.A50.790.4.62M.D...	23.9 (606)	86.0 (2186)	38.1 (968)	11.6 (295)	ANSI 5" (DN 125)	8.5 (216)	0.86 (22)	8	1.0 (26)	6 x 3/4" (6 x M20)
S2.40.A80.540.4.62L.D...	27.2 (692)	92.6 (2351)	44.1 (1120)	14.2 (362)	ANSI 8" (DN 200)	11.7 (298)	0.94 (24)	8	1.1 (28)	6 x 1" (6 x M24)
S2.40.A80.700.4.62L.D...	27.2 (692)	92.6 (2351)	44.1 (1120)	14.2 (362)	ANSI 8" (DN 200)	11.7 (298)	0.94 (24)	8	1.1 (28)	6 x 1" (6 x M24)
S2.40.A80.790.4.62L.D...	27.2 (692)	92.6 (2351)	44.1 (1120)	14.2 (362)	ANSI 8" (DN 200)	11.7 (298)	0.94 (24)	8	1.1 (28)	6 x 1" (6 x M24)

Dry, horizontal installation on base stand

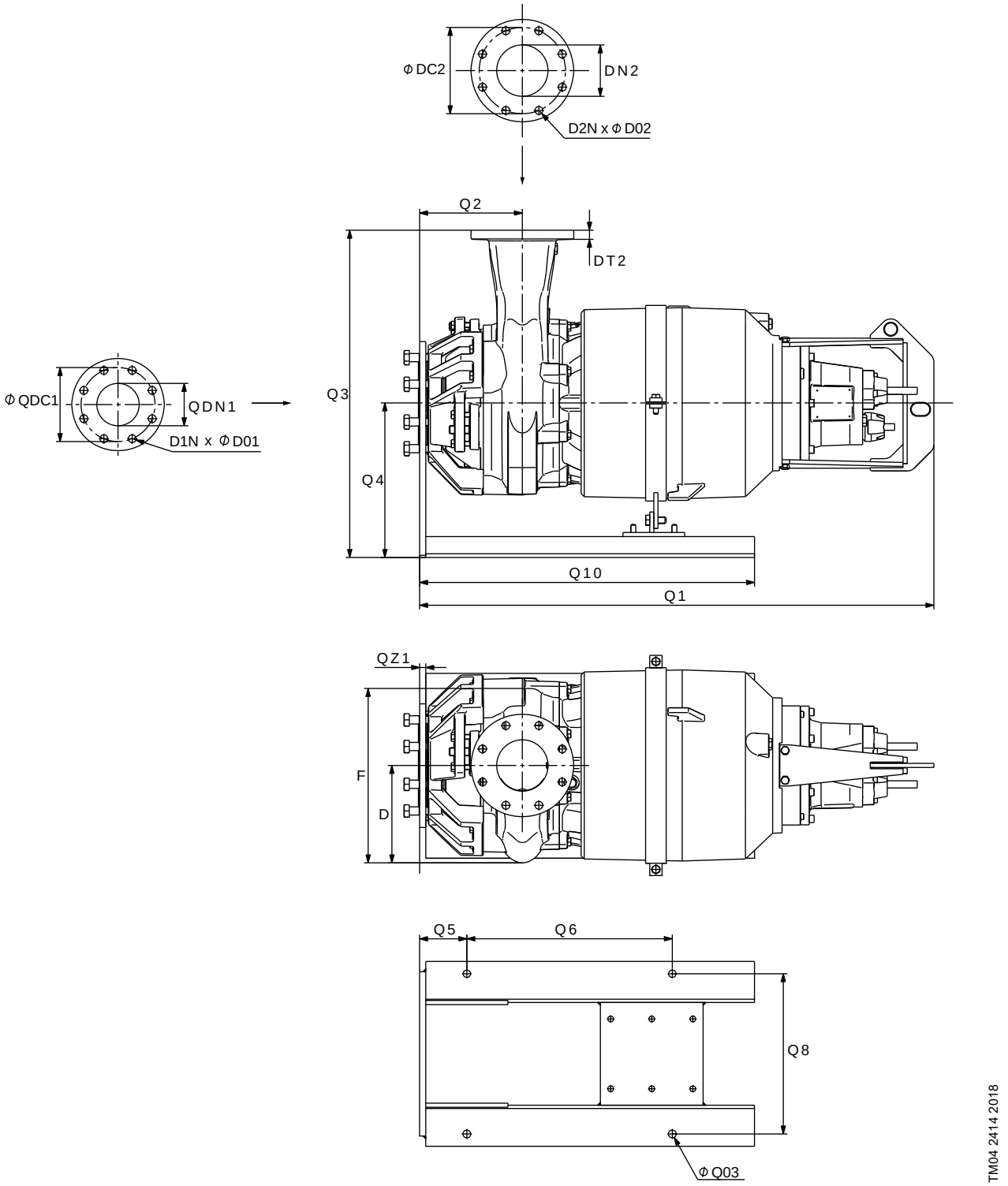


Fig. 36 Dry, horizontal installation on base stand

Pump type	[inch (mm)]											
	D	F	ØQ03	Q1	Q2	Q3	Q4	Q5	Q6	Q8	Q10	QDC1
S1.30.A50.540.4.62H.H...	10.2 (260)	20.6 (523)	0.71 (18)	58.9 (1495)	11.4 (290)	32.1 (815)	14.7 (375)	4.5 (115)	19.7 (500)	15.4 (390)	32.1 (815)	9.4 (240)
S1.30.A50.700.4.62H.H...	10.2 (260)	20.6 (523)	0.71 (18)	58.9 (1495)	11.4 (290)	32.1 (815)	14.7 (375)	4.5 (115)	19.7 (500)	15.4 (390)	32.1 (815)	9.4 (240)
S1.30.A50.790.4.62H.H...	10.2 (260)	20.6 (523)	0.71 (18)	58.9 (1495)	11.4 (290)	32.1 (815)	14.7 (375)	4.5 (115)	19.7 (500)	15.4 (390)	32.1 (815)	9.4 (240)
S1.40.A50.540.4.62M.H...	10.9 (276)	21.7 (552)	0.71 (18)	58.5 (1485)	10.5 (267)	32.1 (815)	14.7 (375)	4.5 (115)	19.7 (500)	15.4 (390)	32.1 (815)	11.7 (298)
S1.40.A50.700.4.62M.H...	10.9 (276)	21.7 (552)	0.71 (18)	58.5 (1485)	10.5 (267)	32.1 (815)	14.7 (375)	4.5 (115)	19.7 (500)	15.4 (390)	32.1 (815)	11.7 (298)
S1.40.A50.790.4.62M.H...	10.9 (276)	21.7 (552)	0.71 (18)	58.5 (1485)	10.5 (267)	32.1 (815)	14.7 (375)	4.5 (115)	19.7 (500)	15.4 (390)	32.1 (815)	11.7 (298)
S2.40.A80.540.4.62L.H...	14.0 (356)	25.4 (646)	0.75 (19)	59.5 (1512)	11.1 (281)	47.6 (1210)	21.7 (550)	4.5 (115)	19.7 (500)	15.4 (390)	34.1 (865)	14.3 (362)
S2.40.A80.700.4.62L.H...	14.0 (356)	25.4 (646)	0.75 (19)	59.5 (1512)	11.1 (281)	47.6 (1210)	21.7 (550)	4.5 (115)	19.7 (500)	15.4 (390)	34.1 (865)	14.3 (362)
S2.40.A80.790.4.62L.H...	14.0 (356)	25.4 (646)	0.75 (19)	59.5 (1512)	11.1 (281)	47.6 (1210)	21.7 (550)	4.5 (115)	19.7 (500)	15.4 (390)	34.1 (865)	14.3 (362)

Pump type	[inch (mm)]		Pc.	[inch (mm)]		Pc.	[inch (mm)]			
	DN1	Q01	D1N	QZ1	DN2	D2N	D02	DC2	DT2	QZ1
S1.30.A50.540.4.62H.H...	ANSI 6" (DN 150)	3/4" (M20)	8	0.71 (18)	ANSI 5" (DN 125)	8	0.9 (22.9)	8.5 (216)	0.9 (22.9)	0.7 (18)
S1.30.A50.700.4.62H.H...	ANSI 6" (DN 150)	3/4" (M20)	8	0.71 (18)	ANSI 5" (DN 125)	8	0.9 (22.9)	8.5 (216)	0.9 (22.9)	0.7 (18)
S1.30.A50.790.4.62H.H...	ANSI 6" (DN 150)	3/4" (M20)	8	0.71 (18)	ANSI 5" (DN 125)	8	0.9 (22.9)	8.5 (216)	0.9 (22.9)	0.7 (18)
S1.40.A50.540.4.62M.H...	ANSI 8" (DN 200)	3/4" (M20)	8	0.71 (18)	ANSI 5" (DN 125)	8	0.9 (22.9)	8.5 (216)	0.9 (22.9)	0.7 (18)
S1.40.A50.700.4.62M.H...	ANSI 8" (DN 200)	3/4" (M20)	8	0.71 (18)	ANSI 5" (DN 125)	8	0.9 (22.9)	8.5 (216)	0.9 (22.9)	0.7 (18)
S1.40.A50.790.4.62M.H...	ANSI 8" (DN 200)	3/4" (M20)	8	0.71 (18)	ANSI 5" (DN 125)	8	0.9 (22.9)	8.5 (216)	0.9 (22.9)	0.7 (18)
S2.40.A80.540.4.62L.H...	ANSI 8" (DN 200)	3/4" (M20)	12	0.71 (18)	ANSI 8" (DN 200)	8	0.9 (22.9)	11.7 (297)	1.0 (25.4)	0.7 (18)
S2.40.A80.700.4.62L.H...	ANSI 8" (DN 200)	3/4" (M20)	12	0.71 (18)	ANSI 8" (DN 200)	8	0.9 (22.9)	11.7 (297)	1.0 (25.4)	0.7 (18)
S2.40.A80.790.4.62L.H...	ANSI 8" (DN 200)	3/4" (M20)	12	0.71 (18)	ANSI 8" (DN 200)	8	0.9 (22.9)	11.7 (297)	1.0 (25.4)	0.7 (18)

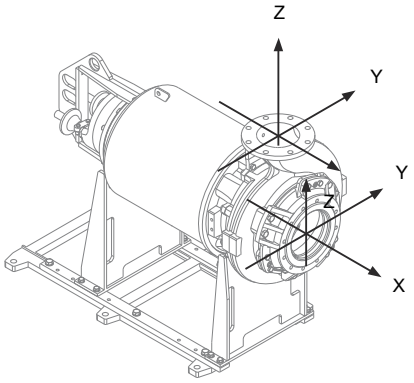
13. Weights

Weights include 50 ft (15 m) cable.

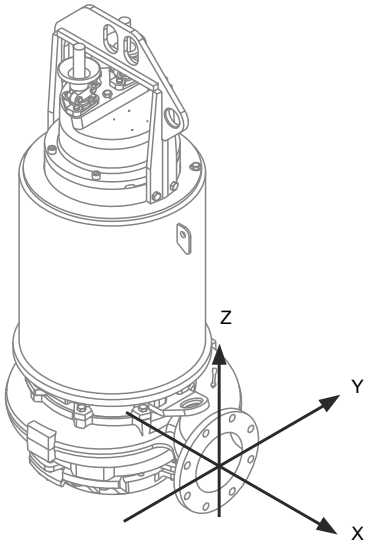
Pump type	Weight [lb (kg)]
S1.30.A50.540.4.62H.S...	1323 (600)
S1.30.A50.540.4.62H.C...	1455 (660)
S1.30.A50.540.4.62H.D...	1587 (720)
S1.30.A50.540.4.62H.H...	1698 (770)
S1.30.A50.700.4.62H.S...	1323 (600)
S1.30.A50.700.4.62H.C..	1455 (660)
S1.30.A50.700.4.62H.D...	1587 (720)
S1.30.A50.700.4.62H.H...	1587 (720)
S1.30.A50.790.4.62H.S...	1367 (620)
S1.30.A50.790.4.62H.C...	1499 (680)
S1.30.A50.790.4.62H.D...	1499 (680)
S1.30.A50.790.4.62H.H..	1631 (740)
S1.40.A50.540.4.62M.S...	1323 (600)
S1.40.A50.540.4.62M.C...	1455 (660)
S1.40.A50.540.4.62M.D...	1587 (720)
S1.40.A50.540.4.62M.H...	1698 (770)
S1.40.A50.700.4.62M.S...	1323 (600)
S1.40.A50.700.4.62M.C...	1455 (660)
S1.40.A50.700.4.62M.D...	1455 (660)
S1.40.A50.700.4.62M.H...	1587 (720)
S1.40.A50.790.4.62M.S...	1367 (620)
S1.40.A50.790.4.62M.C...	1499 (680)
S1.40.A50.790.4.62M.D...	1499 (680)
S1.40.A50.790.4.62M.H...	1631 (740)
S2.40.A80.540.4.62L.S...	1411 (640)
S2.40.A80.540.4.62L.C...	1543 (700)
S2.40.A80.540.4.62L.D...	1587 (720)
S2.40.A80.540.4.62L.H...	1698 (770)
S2.40.A80.700.4.62L.S...	1411 (640)
S2.40.A80.700.4.62L.C...	1543 (700)
S2.40.A80.700.4.62L.D...	1587 (720)
S2.40.A80.700.4.62L.H...	1698 (770)
S2.40.A80.790.4.62L.S...	1455 (660)
S2.40.A80.790.4.62L.C...	1609 (730)
S2.40.A80.790.4.62L.D...	1609 (730)
S2.40.A80.790.4.62L.H...	1742 (790)

14. Flange forces

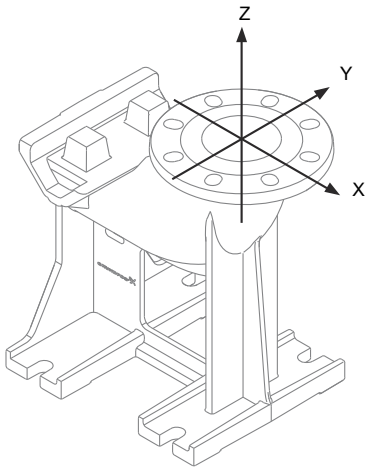
Horizontal installations



Vertical installations



Base unit



TM06 4901 3115 - TM06 4903 3115 - TM06 4902 3115

The flange forces and moments are according to EN ISO 5199.

Forces can be found for both horizontal and vertical installations in Table B.3 in EN ISO 5199 by selecting the correct flange dimension. Forces cannot be used directly for end-suction wastewater pumps without using a coefficient which can be found in Table B.5 in EN ISO 5199 by selecting the correct pump family.

For Grundfos wastewater pumps, the pump families and coefficients are as stated below.

Horizontally installed pumps
Pump family A4 = Coefficient 0.35

Vertically installed pumps
Pump family 10A = Coefficient 0.30

15. Grundfos Product Center

Online search and sizing tool to help you make the right choice.
http://product-selection.grundfos.com

All the information you need in one place

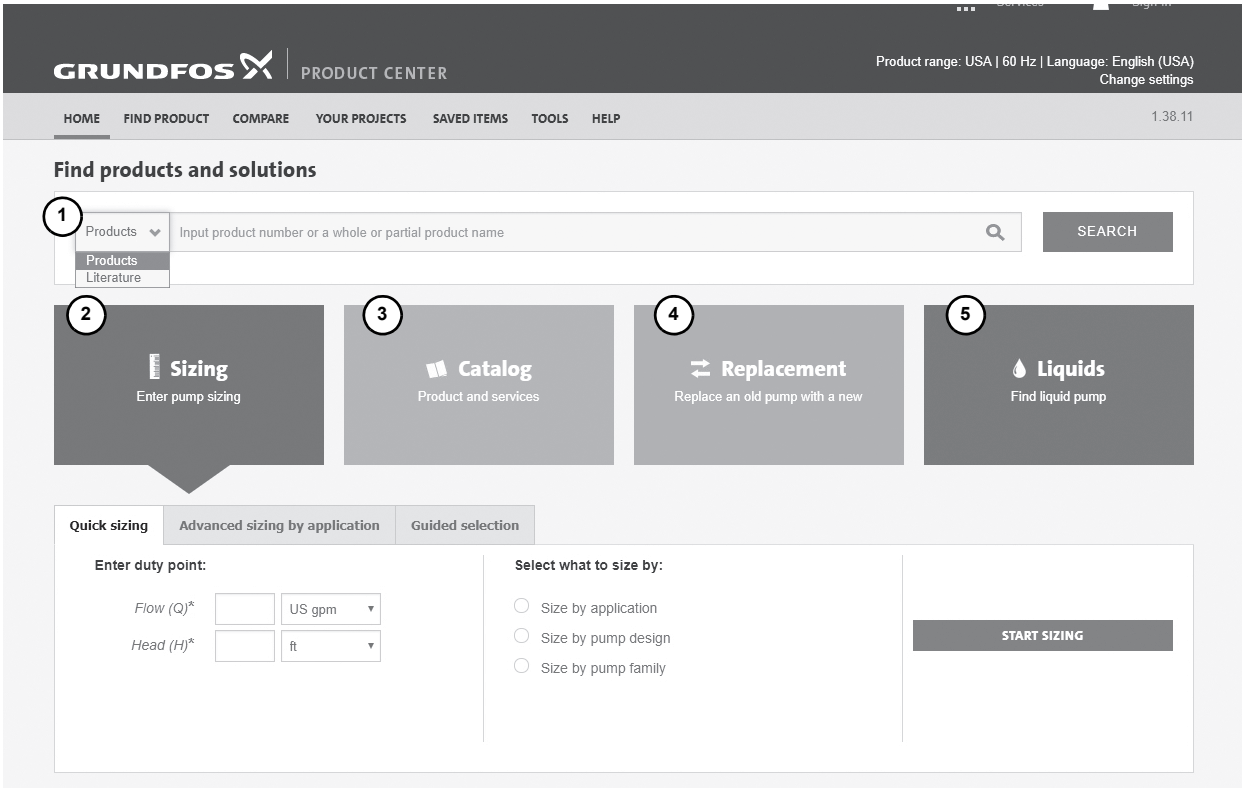
Performance curves, technical specifications, pictures, dimensional drawings, motor curves, wiring diagrams, spare parts, service kits, 3D drawings, documents, system parts. The Product Center displays any recent and saved items - including complete projects - right on the main page.

Downloads

On the product pages, you can download installation and operating instructions, data booklets, service instructions, etc. in PDF format.



TM07 2384



TM07 2383

Pos.	Description
1	This drop-down menu enables you to set the search function to "Products" or "Literature".
2	**SIZING** enables you to size a pump based on entered data and selection choices.
3	**CATALOGUE** gives you access to the Grundfos product catalogue.
4	**REPLACEMENT** enables you to find a replacement product. Search results will include information on • the lowest purchase price • the lowest energy consumption • the lowest total life cycle cost.
5	**LIQUIDS** enables you to find pumps designed for aggressive, flammable or other special liquids.

Grundfos GO

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Grundfos GO is the mobile tool box for professional users on the go. It is the most comprehensive platform for mobile pump control and pump selection including sizing, replacement and documentation. It offers intuitive, handheld assistance and access to Grundfos online tools, and it saves valuable time for reporting and data collection.



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GRUNDFOS

S pumps, Range 50-70

S1, S2, S3, ST, SV 10-208 hp

Installation and operating instructions



FM
APPROVED

GRUNDFOS

S pumps, Range 50-70

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Original installation and operating instructions

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1. Limited warranty

New equipment manufactured by seller or service supplied by seller is warranted to be free from defects in material and workmanship under normal use and service for a minimum of twelve (12) months from date of installation, eighteen (18) months from date of shipment, unless otherwise stated in product warranty guide (available upon request). In the case of spare or replacement parts manufactured by seller, the warranty period shall be for a period of twelve months from shipment. Seller's obligation under this warranty is limited to repairing or replacing, at its option, any part found to its satisfaction to be so defective, provided that such part is, upon request, returned to seller's factory from which it was shipped, transportation prepaid. Parts replaced under warranty shall be warranted for twelve months from the date of the repair, not to exceed the original warranty period. This warranty does not cover parts damaged by decomposition from chemical action or wear caused by abrasive materials, nor does it cover damage resulting from misuse, accident, neglect, or from improper operation, maintenance, installation, modification or adjustment. This warranty does not cover parts repaired outside seller's factory without prior written approval. Seller makes no warranty as to starting equipment, electrical apparatus or other material not of its manufacture. If purchaser or others repair, replace, or adjust equipment or parts without seller's prior written approval, seller is relieved of any further obligation to purchaser under this paragraph with respect to such equipment or parts, unless such repair, replacement, or adjustment was made after seller failed to satisfy within a reasonable time seller's obligations under this paragraph. Seller's liability for breach of these warranties (or for breach of any other warranties found by a court of competent jurisdiction to have been given by seller) shall be limited to: (a) accepting return of such equipment exw plant of manufacture, and (b) refunding any amount paid thereon by purchaser (less depreciation at the rate of 15 % per year if purchaser has used equipment for more than thirty [30] days), and canceling any balance still owing on the equipment, or (c) in the case of service, at seller's option, redoing the service, or refunding the purchase order amount of the service or portion thereof upon which such liability is based. These warranties are expressly in lieu of any other warranties, express or implied, and seller specifically disclaims any implied warranty of merchantability or fitness for a particular purpose, and in lieu of any other obligation or liability on the part of the seller whether a claim is based upon negligence, breach of warranty, or any other theory or cause of action. In no event shall seller be liable for any consequential, incidental, indirect, special or punitive damages of any kind. For purposes of this paragraph, the equipment warranted shall not include equipment, parts, and work not manufactured or performed by seller. With respect to such equipment, parts, or work, seller's only obligation shall be to assign to purchaser the warranties provided to seller by the manufacturer or supplier providing such equipment, parts or work. No equipment furnished by seller shall be deemed to be defective by reason of normal wear and tear, failure to resist erosive or corrosive action of any fluid or gas, purchaser's failure to properly store, install, operate, or maintain the equipment in accordance with good industry practices or specific recommendations of seller, including, but not limited to seller's installation and operation manuals, or purchaser's failure to provide complete and accurate information to seller concerning the operational application of the equipment.

2. General information

2.1 Hazard statements

The symbols and hazard statements below may appear in Grundfos installation and operating instructions, safety instructions and service instructions.

DANGER
Indicates a hazardous situation which, if not avoided, will result in death or serious personal injury.

WARNING
Indicates a hazardous situation which, if not avoided, could result in death or serious personal injury.

CAUTION
Indicates a hazardous situation which, if not avoided, could result in minor or moderate personal injury.

The hazard statements are structured in the following way:

SIGNAL WORD
Description of the hazard
Consequence of ignoring the warning
- Action to avoid the hazard.

2.2 Notes

The symbols and notes below may appear in Grundfos installation and operating instructions, safety instructions and service instructions.

FM Observe these instructions for explosion-proof products.

A blue or grey circle with a white graphical symbol indicates that an action must be taken.

A red or grey circle with a diagonal bar, possibly with a black graphical symbol, indicates that an action must not be taken or must be stopped.

If these instructions are not observed, it may result in malfunction or damage to the equipment.

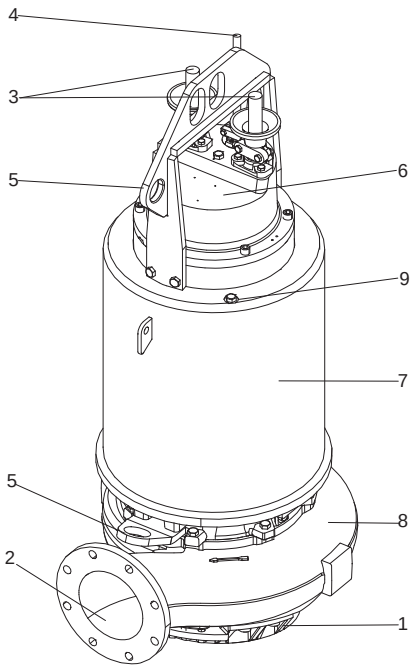
Tips and advice that make the work easier.

2.3 Target group

These installation and operation instructions are intended for professional installers.

3. Product introduction

3.1 Product description



TM066075

S pump

Pos.	Description
1	Inlet
2	Outlet
3	Power supply cables
4	Control cable
5	Lifting bracket
6	Terminal box
7	Submersible motor
8	Pump
9	Air vent screw

3.2 Intended use

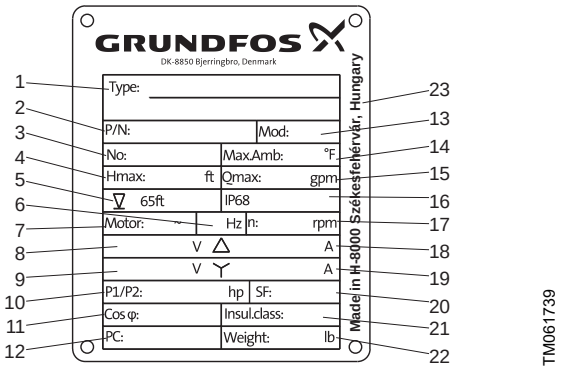
S pumps are designed for the pumping of sewage and wastewater in a wide range of municipal and industrial applications.

3.3 Pumped liquids

S pumps are ideal for transferring the following liquids:
- sewage
- wastewater.

3.4 Identification

3.4.1 Nameplate



TM061739

Pump nameplate

Pos.	Description
1	Type designation
2	SAP code
3	Serial number
4	Maximum head (ft)
5	Maximum installation depth (ft)
6	Frequency (Hz)
7	Number of phases
8	Voltage, delta connection
9	Voltage, star connection
10	Power input/output (hp)
11	Cos φ, 1/1 load
12	Production code (YYWW)
13	Production number
14	Maximum liquid temperature (°F)
15	Maximum flow rate (gpm)
16	Enclosure class
17	Rated speed
18	Current, delta connection
19	Current, star connection
20	Motor safety factor
21	Insulation class
22	Weight (lb)
23	Production site

3.4.2 Type key

The S pumps are identified by the type designation stated on the order confirmation and other documentation supplied with the pump.

Note: The pump type described in this booklet is not available in all variants.

Example: S1.40.A80.9804.66H.S.358.G.N.D.611.Z

Code	Example	Designation
S	Grundfos sewage and wastewater pump	Pump type
ST	Multi-channel impeller pump installed in column pipe	
1	Single-channel	Impeller type
2	Two-channel	
3	Three-channel	
V	SuperVortex	
40	Maximum solids size: code number from type designation / 10 [inch] = 4" (100 mm)	Pump passage [inch]
A80	Nominal diameter of pump outlet port: code number from type designation / 10 [inch] = 8" (200 mm)	Pump outlet, S-type [inch]
	Nominal diameter of column pipe: code number from type designation / 10 [inch] = 8" (200 mm)	Column diameter, ST-type [inch]
980	P2: code number from type designation / 10 [hp] = 98 hp	Output power P2 [hp]
2	2-pole motor	Number of poles
4	4-pole motor	
6	6-pole motor	
8	8-pole motor	
50	Range 50	Pump range
54	Range 54	
58	Range 58	
62	Range 62	
66	Range 66	
70	Range 70	
H	High	Pressure version
M	Medium	
L	Low	
E	Extra-low	
S	Submersible installation without cooling jacket	Installation type
C	Submersible installation with cooling jacket	
D	Dry, vertical installation	
H	Dry, horizontal installation	
	Impeller diameter (average) [mm]	
G	Cast iron impeller, pump housing and motor housing	Material code for impeller, pump housing and motor housing
Q	Stainless steel impeller, AISI 316 (DIN W.-Nr. 1.4408)	
N	Pump with non-explosion-proof motor	Pump version
Ex	Pump with explosion-proof motor	
B	S pump with built-in SM 113 module. PTC sensors are connected directly to IO 113 or other PTC relay.	Sensor version
C	Not in use	
D	S pump without built-in SM 113 module	
6	60 Hz	Frequency
01	3 x 460 V D	Voltage code and connection
11	3 x 460 / (797) V Y/D	
3A	3 x 460 V, factory wired (dual voltage, 230 V or 460 V)	
3B	3 x 230 V, factory wired (dual voltage, 230 V or 460 V)	
Z	Custom-built products	Customization

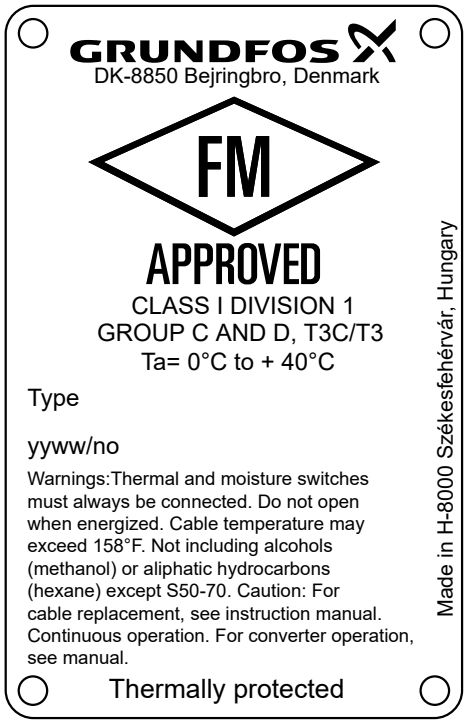
3.5 Approvals (FMus)

The S pumps are approved by FM, and the explosion-proof versions have an FM-type examination certificate No FM21US0018.

3.5.1 FM certification and classification

Pump	Approval
50-70	Class I Division 1 Group C and D Hazardous (Classified) Locations. Temperature class T3C/T3.

3.6 FM approval plate



Approval plate of explosion-proof pumps

According to NEC500, the following classification applies for this electrical equipment:

FM	FM approval symbol.
Class I	Permitted for locations where flammable gases or vapors may be present.
Division 1	Permitted for locations where flammable or combustible gases can exist under normal operating conditions or due to repair, breakdown or faulty operation of the equipment.
Group C and D	Permitted for specific gases or vapors of Group C and D that may be present.
T3C	Temperature class (T code). Maximum surface temperature is 320 °F (160 °C).
T3	Maximum surface temperature of the equipment during frequency converter operation.
Type	FM listing code (such as S50X13.5/4.60).
yyww/no	Production year, week and serial number (such as 1052/123456).

3.6.1 Cable entry approval plate

The cable entry is tested and approved by FM Approvals under project number 449879 for the US and Canadian markets.



Cable entry approval plate

The cable entry approval plates provide the following details:

Pos.	Description
FM	The equipment conforms to the Canadian and US standards.
FM19US0233U	US certificate number
FM19CA0126U	Canadian certificate number
Class I	Explosive atmosphere is caused by gas or vapors.
Div. 1	Division 1. area classification, flammable material is present intermittently.
Groups C and D	Gas groups, ethylene and propane
Zone 1	Area classification, flammable material is present intermittently.
AEx	Explosion protected based on the American National Standard.
db	Type of protection, flameproof
IIB	Gas groups, ethylene and propane
Gb	Equipment protection level, gas atmosphere, „high" level of protection
Ex	Explosion-proof
T_{amb}	Ambient temperature
ID no	Cable entry identification number

FM Ex-approved cable entries must be maintained and replaced by a Grundfos-authorized service.

3.7 Potentially explosive environments

Use the explosion-proof S pumps in potentially explosive environments.

FM The explosion classification of the pump is Class 1, Division 1, Group C and D, T3C and T3 for frequency converter operation.

FM Installation must comply with the relevant requirements of the National Electrical Code® (ANSI/NFPA 70) and this installation and operating instructions.

FM In potentially explosive environments, use only FM-approved pumps.

Special conditions for safe use of explosion-proof pumps:

1. Make sure the moisture- and thermal switches are connected in two separate circuits and have separate alarm outputs (motor stop) in case of high humidity or high temperature in the motor.
2. Bolts used for replacement must be class ASTM F738M-01 (A4-80 or A2-80) according to ISO 3506-1.
3. The flame path gaps of the motor are specified by the manufacturer and are narrower than the standard.

   WARNING: In case of repairs, always use original service parts from the manufacturer to ensure the correct dimensions of the flame path gaps.
4. During operation, the cooling jacket, when fitted, must be filled with the pumped liquid.
5. The level of the pumped liquid must be controlled by level switches connected to the motor control circuit. The minimum level depends on the installation type and is specified in this installation and operating instructions.

FM

6. Dry-running is not allowed.
7. Make sure the permanently attached cables are suitably mechanically protected and terminated in a suitable terminal board.
8. The sewage pumps have an ambient temperature range of 32-104 °F (0-40 °C) and a maximum process temperature of 104 °F (+40 °C).
9. If a WIO sensor is installed, the control unit must protect the WIO sensor against short circuit current from the power supply to which it is connected. The maximum current from the control unit must be limited to 350 mA.
10. The maximum submersion depth is 66 ft (20 m).
11. Dry-installed pumps often have a higher temperature in the cable inlet than submerged pumps. This may reduce the lifetime of the Ex-protection. According to EN 60079-14, it is a user-responsibility to regularly inspect the condition of the permanently attached cable and cable entry for any visual damage, cracks or embrittlement caused by rubber aging.

DANGER



Explosive environment

Death or serious personal injury

- Check the cable entry for any visible damage, cracks or embrittlement to avoid sparks that can cause an explosion.

Special conditions for safe use of the WIO sensor:

1. The IO 113 control unit must protect the sensor against short-circuit currents from the power supply.
2. Install the sensor without being exposed to mechanical impact.
3. The WIO sensor must not be used in oil with a flash point below 482 °F (250 °C).

FM

4. The WIO sensor is approved according to EN 60079-0, EN 60079-7, EN 60079-18, IEC 60079-0, IEC 60079-18, IEC60079-7. In FM and IEC Ex applications, the maximum current supplied to the sensor must be limited to 350 mA according to EN/IEC 60079-18 and EN/IEC 60079-0.
5. The WIO sensor is intended for use only with a galvanically isolated circuit.

3.8 Applications

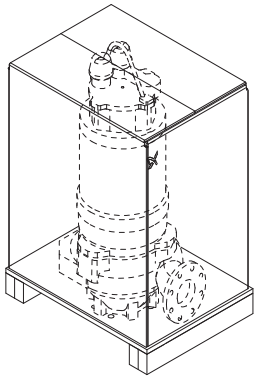
Depending on the installation type, the pumps can be used for submerged or dry, horizontal or vertical installation.

Maximum solids size: 3-6" (80-145 mm) depending on the impeller type.

Installation type	Description	Accessories
S	Sewage pump without cooling jacket for submerged installation on auto coupling.	Auto coupling
C	Sewage pump with cooling jacket for submerged installation on auto coupling.	Auto coupling
D	Sewage pump with cooling jacket for dry, vertical installation.	Ranges 50, 54, 58 and 62: Base stand for vertical installation.
		Ranges 66 and 70: Base plate or stand for vertical installation.
H	Sewage pump with cooling jacket for dry, horizontal installation.	Base stand or plate for horizontal installation
ST	Sewage pump without cooling jacket for installation in vertical column pipe.	Seat ring

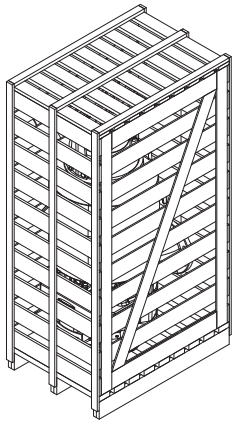
4. Receiving the product

S pumps are supplied from the factory either in a horizontal or vertical position. Range 50 is supplied on a wooden pallet and in a cardboard box. Ranges 54-70 are supplied on a wooden pallet and in a crate.



TM066073

Transportation method S pumps, range 50



TM066068

Transportation method S pumps, range 54-70

Make sure to dispose of pallets and other packaging material according to local waste disposal regulations.

Keep the cable end protectors in storage for later use.

4.1 Handling the product

Before handling the product, check the following:

- Lifting equipment and lifting points. See section Lifting the pump.
- Raising the pump to vertical position. See section Raising the pump to vertical position.
- Move the pump only with a forklift or a lifting crane.

DANGER

Crushing hazard

Death or serious personal injury

- Make sure the center of gravity is between the fork-lift arms when lifting the pump.

4.2 Lifting the pump

S pumps weigh up to 5235.97 lb (2375 kg) without accessories.

It is, therefore, crucial to use the appropriate lifting equipment.

The pump weight is stated on the nameplate.

Always use lifting equipment that is rated for the load.

DANGER

Crushing hazard

Death or serious personal injury

- Always check the lifting bracket and chain for corrosion or wear before lifting.
- Always lift the pump by its lifting bracket or by a forklift truck.

DANGER

Crushing hazard

Death or serious personal injury

- Make sure the center of gravity is between the forklift arms when lifting the pump. The approximate center of gravity is marked with a label attached to the transportation stand.

DANGER

Electric shock

Death or serious personal injury

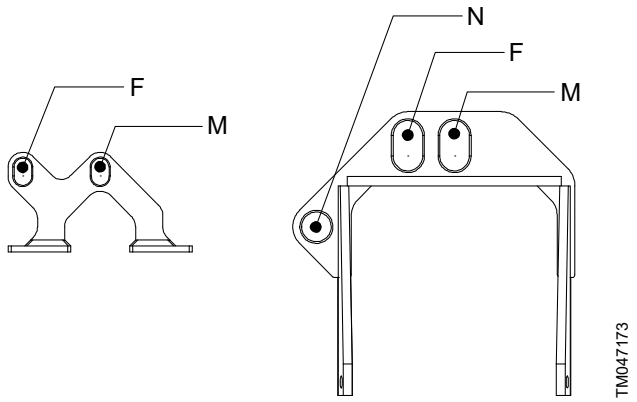
- Never lift the pump by the power supply cables.

Lifting the pump by the power supply cables may result in an electrical short circuit and risk of electric shock when the pump is connected to the mains. The cables and cable entries may be damaged that can lead to loss of water resistance and severe damage to the motor.

If the pump is tilted more than 10° in any direction from its normal position, the pump may lose its stability.

Lifting points (top)

Use the right lifting point to keep the pump balanced. S pumps are equipped with a lifting bracket with lifting points to ensure the pump can be lifted safely.



Lifting points

Range 50 and 54 Range 58, 62, 66 and 70

Pos.	Description
F	Front
M	Middle
N	Nose

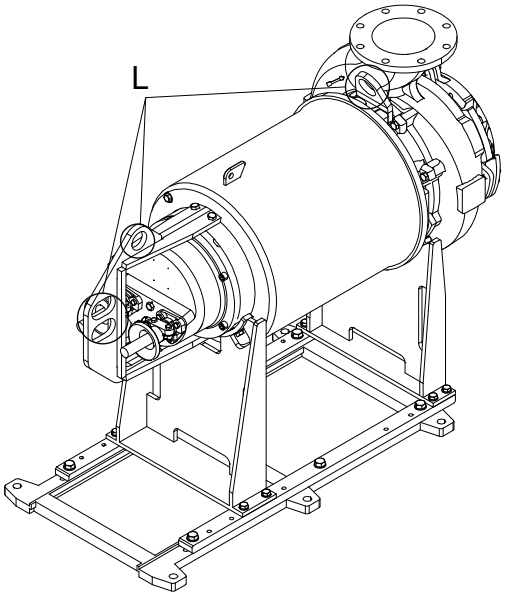
Outlet flange size	Pump range					
	50	54	58	62	66	70
A30 (DN 80)	Middle	Middle	-	-	-	-
A40 (DN 100)	Middle	Middle	-	-	-	-
A50 (DN 125)	Middle	Middle	Middle	Middle	-	-
A80 (DN 200)	Front	Front	Front	Middle	Middle	Middle
A100 (DN 250)	-	Front	-	-	Middle	Middle
A120 (DN 300)	-	-	Front	Middle	Middle	Middle
A200 (DN 500)	-	-	-	-	Nose	Front
A240 (DN 600)	-	-	-	-	Nose	Front

Always lift the installation type ST (submerged in vertical column pipe without cooling jacket) pumps by the lifting bracket to make sure the pump is balanced.

Note: The design of the lifting bracket may differ from the one on the drawing. This difference does not affect the handling of the product.

Lifting points (bottom)

S pumps, ranges 66-70, are equipped with a lifting bracket on the motor top cover and with a lifting bracket on the lower bearing bracket.

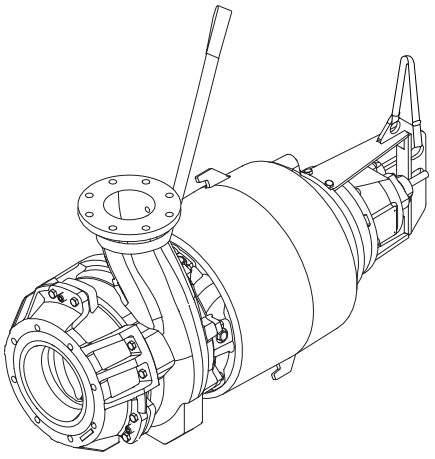


Lifting points for ranges 66-70

Pos.	Description
L	Lifting points

S pumps, ranges 50 and 62, are equipped only with a lifting bracket on the motor top cover. Use the pump outlet as the lower lifting point. Lift the pump by a lifting strap or a lifting chain secured below the pump outlet.

Secure and lift by a strap.



Lifting points for installation type H, range 50-62

Related information

3.4.1 Nameplate

11.3 Dimensions and weights

4.2.1 Raising the pump to vertical position

DANGER

Crushing hazard

Death or serious personal injury

- Make sure the lifting bracket or straps are tightened before lifting the pump.

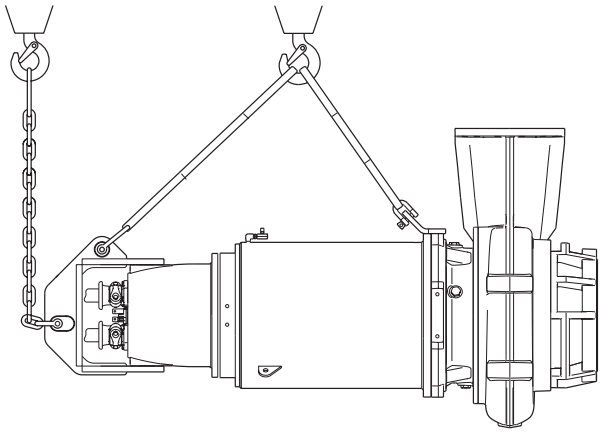
DANGER

Crushing hazard

Death or serious personal injury

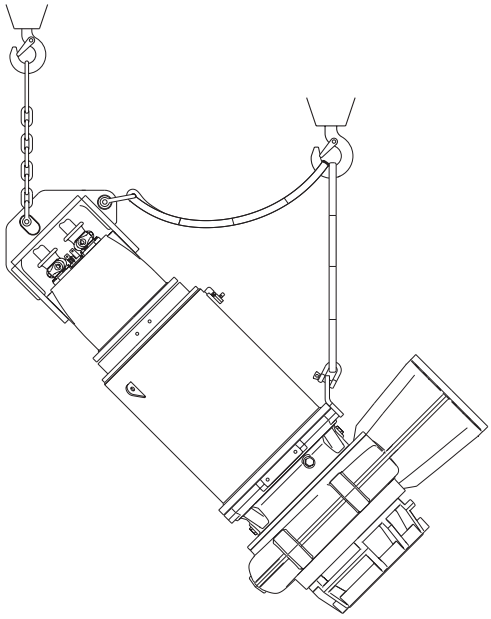
- Do not stand under or next to the pump when raising it to vertical position.
- Make sure the pump is raised carefully into vertical position to avoid the lifting chain slipping off the crane when the pump is unbalanced.

Carelessness during lifting or transportation may cause personal injury or damage to the pump.



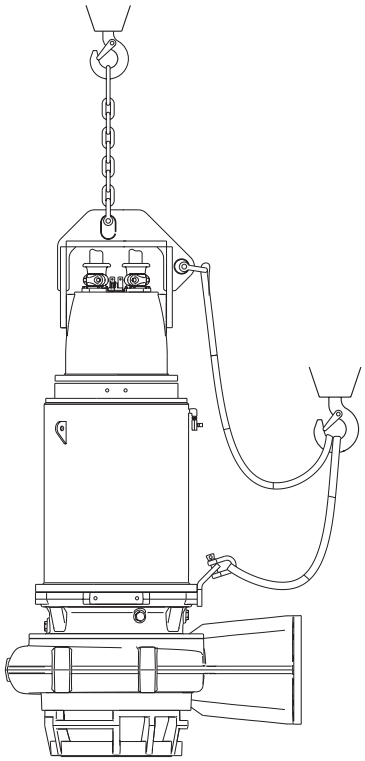
TM033034

Raising the pump to vertical position, step 1



TM033035

Raising the pump to vertical position, step 2

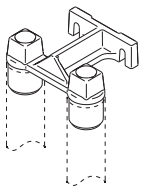


TM033036

Raising the pump to vertical position, step 3

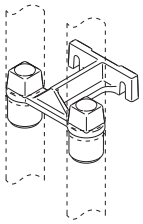
4.2.2 Lowering the pump on auto coupling

The pump can easily be pulled out and lowered into the pit by the guide rails. The stop level is lower for installation type C than for installation type S.



TM033066

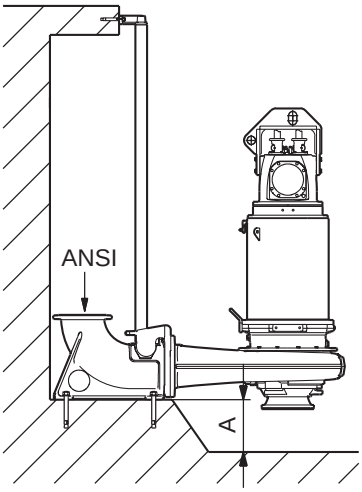
Upper guide-rail bracket



TM033068

Intermediate guide-rail bracket; guide rails longer than 19.7 ft (6 m) require intermediate guide-rail brackets

The correct plinth height for installation on auto coupling is essential to obtain the best efficiency of the pump.



TM079381

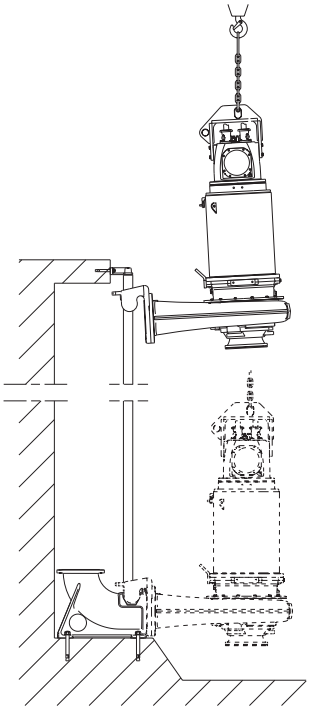
Auto-coupling base installation on a plinth

The minimum required plinth heights (A) for installation on auto coupling are indicated in the following table.

Pump type	Minimum plinth height (A) [in (mm)]
Range 50	
S1.30.A40.xxx	2 (50)
S1.40.A40.xxx	2 (50)
S1.40.A50.xxx	0 (0)
SV.30.A30.xxx	0 (0)
Range 54	
S1.30.A40.xxx	2 (50)
S1.40.A50.xxx	0 (0)
S1.40.A80.xxx	4 (100)
Range 58	
S1.30.A50.xxx	0 (0)
S1.40.A50.xxx	0 (0)
S1.45.A80.xxx	6 (150)
S2.40.A80.xxx	6 (150)
S2.40.A120.xxx	6 (150)
Range 62	
S1.30.A50.xxx	0 (0)
S1.40.A50.xxx	0 (0)
S2.40.A80.xxx	8 (200)
Range 66	
S1.40.A80.xxx	6 (150)
S2.40.A80.xxx	6 (150)
S2.45.A100.xxx	6 (150)
S2.55.A120.430 /550	6 (150)
S2.55.A120.760	16 (400)
S3.45.A200.760	10 (250)
Range 70	
S2.35.A80.xxx	6 (150)

Pump type	Minimum plinth height (A) [in (mm)]
S2.45.A100.xxx	8 (200)
S2.55.A120.xxx	16 (400)
S3.45.A120.xxx	16 (400)
S3.45.A200.xxx	10 (250)

Required tilt angle when the pump is lowered on the auto coupling: ± 5°



TM033067

Lowering the pump on an auto coupling

Related information

5.1.1 Installation types

5. Installing the product

S pumps are designed for various installation types.

Pump installation in pits must be carried out by specially trained persons.

Work in or near pits must be carried out according to local regulations.

DANGER

Electric shock

Death or serious personal injury

- It must be possible to lock the mains switch in position 0. Type and requirements as specified in the National Electrical Code and all local codes.

FM

Persons must not work on the installation area when the atmosphere is potentially explosive.

DANGER

Overhead load

Death or serious personal injury

- Never work under a pump when it is hanging from a crane.

For safety reasons, all work in pits must be supervised by a person outside the pit.

Pits for submersible sewage and wastewater pumps contain sewage and wastewater with toxic and/or contagious substances. Therefore, all persons involved must wear appropriate personal protective equipment and clothing. All work on and near the pump must be carried out in compliance with the hygiene regulations in force.

DANGER

Crushing hazard

Death or serious personal injury

- Make sure the rated capacity of the lifting equipment, including the lifting chain, is adequate for the lifting work.

The rated capacity of the lifting equipment is stated on the equipment nameplate. The weight of the pump is stated on the pump nameplate.

CAUTION

Hot surface

Minor or moderate personal injury

- Do not touch the pump or cables during operation because the surface temperature may exceed 158 °F (70 °C).

Related information

5.1.1 Installation types

5.1 Mechanical installation

DANGER

Electric shock

Death or serious personal injury

- Before installation, switch off the power supply and lock the main power switch in position 0.
- Before working on the pump, switch off any external voltage connected to the pump.

DANGER

Crushing hazard

Death or serious personal injury

- During installation, always support the pump by lifting chains or place it in horizontal position to secure stability.

Fix the extra nameplate supplied with the pump at the installation site.

Observe all safety regulations at the installation site.

CAUTION

Crushing of hands

Minor or moderate personal injury

- Do not put your hands or any tool into the pump inlet or outlet port after the pump is connected to the power supply unless the main power switch is locked in position 0.
- Make sure that the power supply cannot be switched on unintentionally.

Prior to installation, check the oil level in the oil chamber. See section Oil check and change.

Always use Grundfos accessories to ensure correct functioning.

If the installation has to be tested at a pressure higher than 1.3 times the maximum pump head, isolate the pump from the installation before the test to avoid damage to the pump.

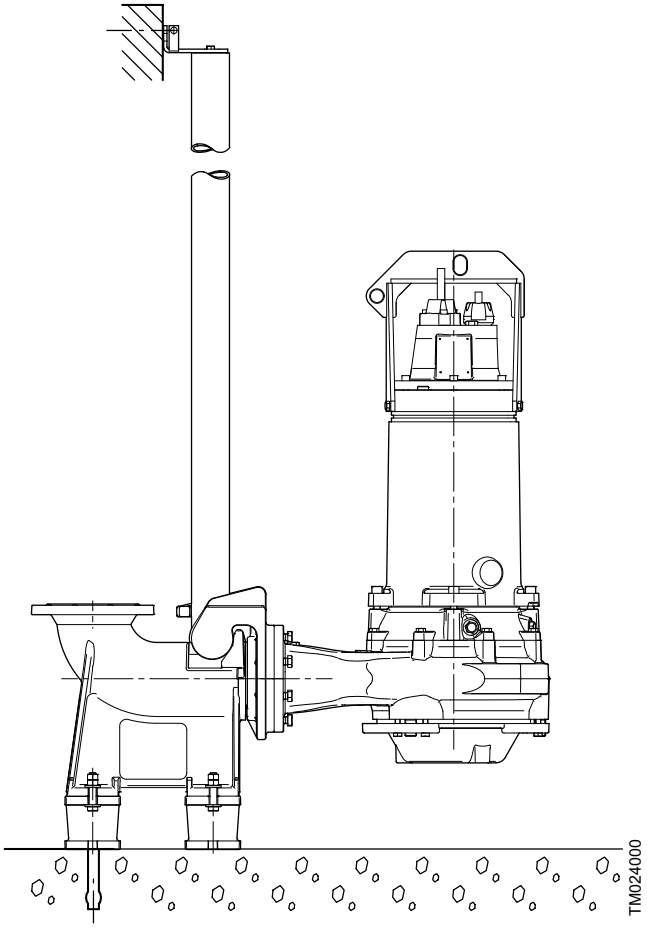
Related information

9.3 Oil check and change

5.1.1 Installation types

Installation types C and S

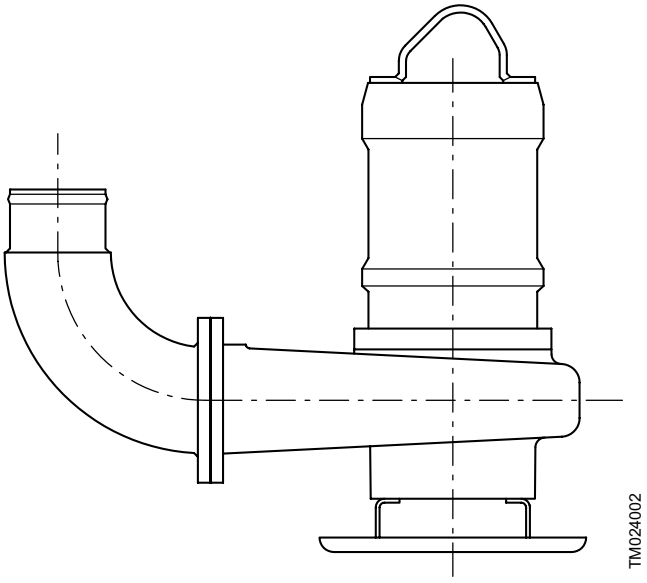
Submerged installation on auto coupling.



Permanent installation in pit

Base stand installation

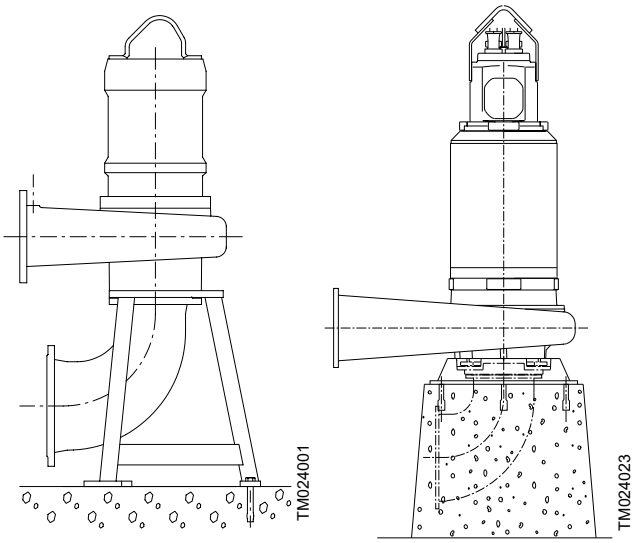
S pumps, ranges 50, 54 and 58, types S and C, can be temporarily installed on a base stand.



Submerged installation on a base stand

Installation type D

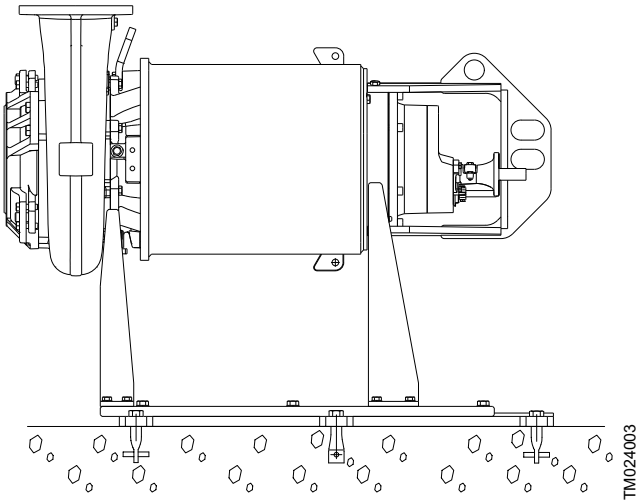
The pump is bolted to the inlet and outlet pipes by flange connections. Pumps with ANSI 20" or ANSI 24" (DN 500 or DN 600) flange are to be installed on a plinth (concrete foundation).



Permanent vertical dry installation with base stand (left) and base plate on two concrete plinths (right)

Installation type H

Permanent, horizontal, dry installation.

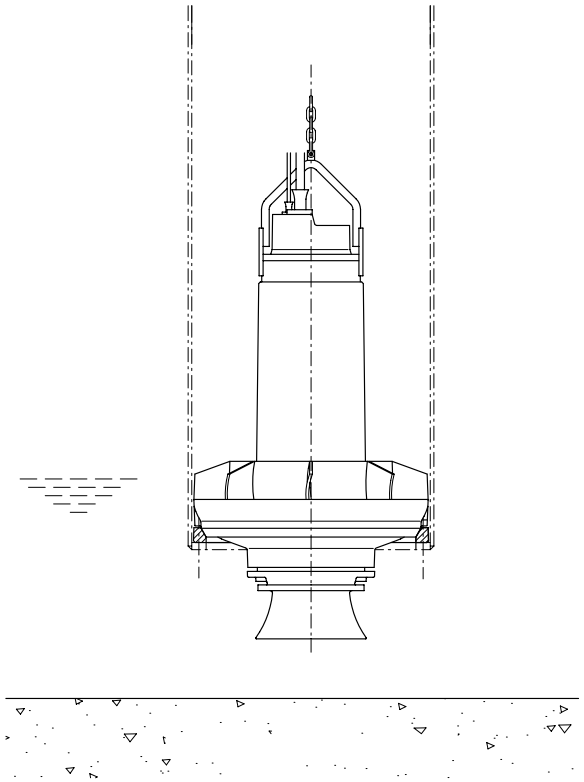


Permanent, horizontal, dry installation

The pump is bolted to the inlet and outlet pipes by flange connections.

Installation type ST

Installation in vertical column pipe.



TM065921

Submerged installation in vertical column pipe

5.1.2 Submerged installation on auto coupling

Pumps for permanent installation can be installed on a stationary auto coupling and operated completely or partially submerged in the pumped liquid.

Before installing the auto-coupling base unit, ensure the quality and strength of the concrete foundation. See the pull-out strengths required for anchor bolts in the table at the end of this section. To ensure adequate pull-out strength, weld the threaded bushings to the steel reinforcement in the concrete.

For auto-coupling installations, types S and C, including A100 (DN 250) and upwards, the guide claw is mounted on the outlet flange from the factory.

1. Drill mounting holes for the guide-rail bracket on the inside of the pit and fasten the guide-rail bracket provisionally with two anchor screws.
2. Place the auto-coupling base unit on the bottom of the pit. Use a plumb line to establish the correct positioning. Fasten the auto coupling with expansion bolts. If the bottom of the pit is uneven, the auto-coupling base unit must be supported so that it is level when being fastened.
3. Assemble the outlet pipe in accordance with the generally accepted procedures and without exposing the pipe to distortion or tension. Do not allow loads from the weight of the pipes to be carried by the auto coupling.
4. Fit the guide rails. An intermediate guide-rail bracket is required if guide rails are more than 19.7 ft (6 m) long. Place the guide rails on the auto coupling, then place the guide-rail bracket on the guide rails and fasten the guide-rail bracket to the pit wall. Tighten the anchor bolts.
5. Clean out debris from the pit before lowering the pump into it.
6. Before lowering the pump into the wet pit, check the cables visually for cuts or ruptures which may be caused by rough handling during transportation or installation.
7. Slide the guide claw of the pump between the guide rails and lower the pump into the pit by a certified chain secured to the lifting bracket. When the pump reaches the auto-coupling base unit, the pump automatically connects.
8. Hang up the end of the chain on a suitable hook at the top of the pit so the chain cannot come into contact with the pump.
9. Adjust the length of the motor cables, but ensure to have enough cable length to be able to make service on the pump. Make sure that the cables are not sharply bent or pinched. Fix the cables at the top of the pit so that no extra cable slides into the pit.
10. Connect the motor- and the sensor cables.

Avoid pipe tension at flanges and bolts.

The free end of the cables must not be submerged as water may penetrate into the motor.

Pull-out strengths for anchor bolts

Auto-coupling base unit	Bolts	Pull-out strength [kip (kN)]
ANSI 4" (DN 100)	4 x 5/8" (M16)	1.1 (5)
ANSI 5" (DN 125/150)*		7.8 (8)
ANSI 8" (DN 200)	4 x 1" (M24)	3.6 (16)
ANSI 10" (DN 250)		6.7 (30)
ANSI 12" (DN 300)		9.0 (40)
ANSI 20" (DN 500)	6 x 1-1/4" (M30)	9.0 (40)
ANSI 24" (DN 600)		9.0 (40)

* Pump outlet ANSI 5" (DN 125) and base plate outlet ANSI 6" (DN 150).

The pull-out strengths are stated without safety factor. The required safety factor may depend on the materials and the methods used for anchoring.

5.1.3 Submerged installation, portable

1. Fit the ring stand to the pump inlet flange.
2. Fit a 90° elbow to the pump outlet port and connect the outlet pipe or hose. If a hose is used, make sure that the hose does not buckle and the inside diameter matches the outlet port.
3. Lower the pump into the liquid by a chain secured to the lifting bracket of the pump. Place the pump on a plain, solid foundation. Make sure that the pump is hanging from the chain.
4. Hang up the end of the chain on a suitable hook at the top of the pit so that the chain cannot come into contact with the pump housing.
5. Adjust the length of the motor cable by coiling it up on a relief fitting to ensure that the cable is not damaged during operation. Fasten the relief fitting to a suitable hook. Make sure that the cables are not sharply bent or pinched.
6. Connect the motor cable and the control cable, if any.

5.1.4 Dry installation

Install pumps in dry installation permanently in a pump room.

The motor is enclosed and watertight. It is resistant to water if the installation site is flooded.

For vertical, dry installations, type D, install the pump on a permanent concrete foundation.

For horizontal, dry installations, type H, the pump is mounted on a base stand from factory.

1. Mark and drill mounting holes in the concrete foundation.
2. Fit the bracket or base stand on the concrete with anchor bolts. Check the pull-out strengths required for bolts at the end of this section.
3. Check that the bracket or base stand is horizontal or vertical.
4. Fasten the pump to the bracket or base stand.

   To facilitate service on the pump, fit isolating valves on either side of the pump.
5. Fit the inlet and outlet pipes and isolating valves, if used, and ensure that the pump is not stressed by the pipes.
6. Adjust the length of the motor cable by coiling it up on a relief fitting to ensure that the cable is not damaged during operation, but ensure to have enough cable length to be able to service the pump. Fasten the relief fitting to a suitable hook. Make sure that the cables are not sharply bent or pinched.
7. Connect the motor cable and the control cable, if any.

Use a reducer between the inlet pipe and the pump in horizontal installations. In horizontal installations, the reducer must be eccentric and must be installed so that the straight edge is pointing upwards. In this way, the accumulation of air in the inlet pipe is avoided and the risk of operation disturbance is eliminated.

Make sure that the pipes are installed without the use of undue force. Do not allow loads from the weight of the pipes to be carried by the pump. Use loose flanges to ease the installation and to avoid pipe tension at flanges and bolts.

Do not use elastic elements or bellows in the pipes. Never use these elements to align the pipes.

The inlet and outlet pipes are bolted to the pump by flange connections.

Foundation

To ensure acceptable vibration levels in the field, all parts of the system should be sufficiently stiff and firmly anchored to minimize vibrations:

- The foundation and concrete must be adequate to support the weight of the pump including accessories, the weight of the liquid passing through the pump, and the forces generated by the pump.
- The mass of the concrete foundation must be minimum three to five times the mass of the supported equipment and must have sufficient rigidity to withstand the axial, transverse and torsional loads generated by these machines.
- The foundation must be 6 in (15 cm) wider than the base plate for pumps up to 470 hp (350 kW) and 9.8 in (25 cm) wider for larger pumps.
- The concrete used in the foundation must have a minimum tensile strength of 363 psi (250 N/cm^2).
- Always use epoxy grout to fasten the pump base plate to the foundation.

Pull-out strengths for anchor bolts

Installation type H

Range	Bolts	Pull-out strength [kip (kN)]
50-62	4 x 5/8" (M16)	2.2 (10)
66-70	6 x 1" (M24)	5.6 (25)

Installation type D

Dry installation	Bolts	Pull-out strength [kip (kN)]
ANSI 4" (DN 100)	3 x 3/4" (M20)	4.0 (18)
ANSI 6" (DN 150	6 x 3/4" (M20)	
ANSI 8" (DN 200)		
ANSI 10" (DN 250)	6 x 1" (M24)	5.6 (25)
ANSI 12" (DN 300)		
ANSI 20" (DN 500/400)*		
ANSI 20" (DN 500)		

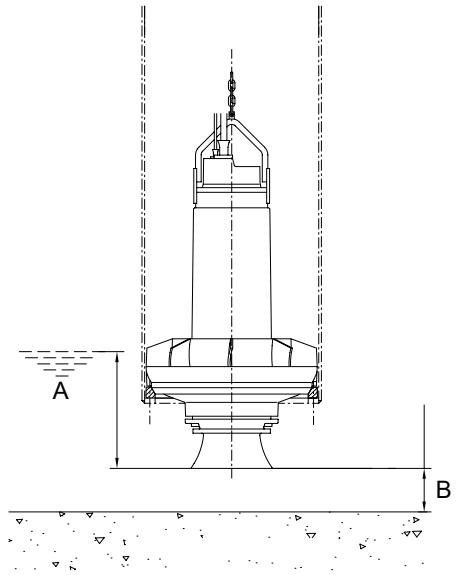
* Base plate inlet ANSI 20" (DN 500) and pump inlet ANSI 16" (DN 400).

The pull-out strengths stated are without safety factor. The required safety factor may depend on the materials and the methods used for anchoring.

5.1.5 Column pipe installation

Pumps for column pipe installation are installed permanently in a column pipe. Grundfos usually does not supply the column pipe. Dimensioning of the column pipes is suggested in the pump-specific dimensional drawings.

1. Fit the seat ring to the bottom of the column pipe.
2. Clean out debris from the pit.
3. Before lowering the pump into the column pipe, check the cables visually for cuts or ruptures which may be caused by rough handling during transportation or installation.
4. Lower the pump into the column pipe by a certified chain secured to the lifting bracket of the pump. The pump rests on the conical surface of the seat ring. Normally the friction between the conical surfaces prevents the pump from rotating. As an extra precaution, there are three guide pins on the seat ring which limit the possible rotation to a maximum of 60°.
5. Hang up the end of the chain above or at the top of the column pipe so that the chain cannot come into contact with the pump.
6. Adjust the length of the cables, but ensure to have enough cable length to be able to service the pump. Make sure that the cables are not sharply bent or pinched. Fix the cables so that there is no extra slack inside the column pipe. In case of long column pipes, it may be necessary to arrange cable support for the cable inside the column pipe. If necessary, contact Grundfos.
7. Connect the motor cables and the sensor cable.



TM022494

Column pipe installation type ST

Pos.	Description
A	Minimum 14" (350 mm)
B	Minimum 6" (150 mm)

5.2 Electrical connection

DANGER



Electric shock

Death or serious personal injury

- Before starting any work on the product, make sure that the power supply is switched off and that it cannot be switched on unintentionally.

Connect the pump to an external main switch to ensure all-pole disconnection with a contact separation according to the National Electrical Code. It must be possible to lock the main switch in position 0. Type and requirements as specified in the National Electrical Code and all local codes.

The supply voltage and frequency are marked on the nameplate. Make sure that the motor is suitable for the power supply available at the installation site.



Carry out the electrical connection in accordance with local regulations.

The pump must be connected to a motor-protective circuit breaker.



Connect the pumps to a control box with a motor protection relay with an IEC trip class 10 or 15.



Connect pumps installed in hazardous locations to a control box with a motor protection relay with an IEC trip class 10.

The motor is effectively earthed through the earth conductor of the power cable and the pipes. The motor top cover for Ex pumps is equipped with connections for external earthing or an equipotential bonding conductor.

DANGER



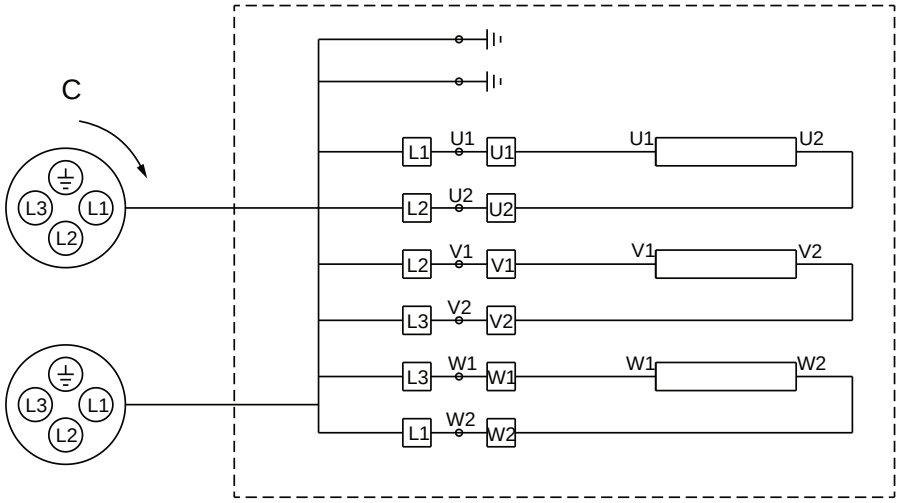
Short-circuit

Death or serious personal injury

- For Ex models in dry-installation, version D and H, connect an external earthing.

5.2.1 Wiring diagrams

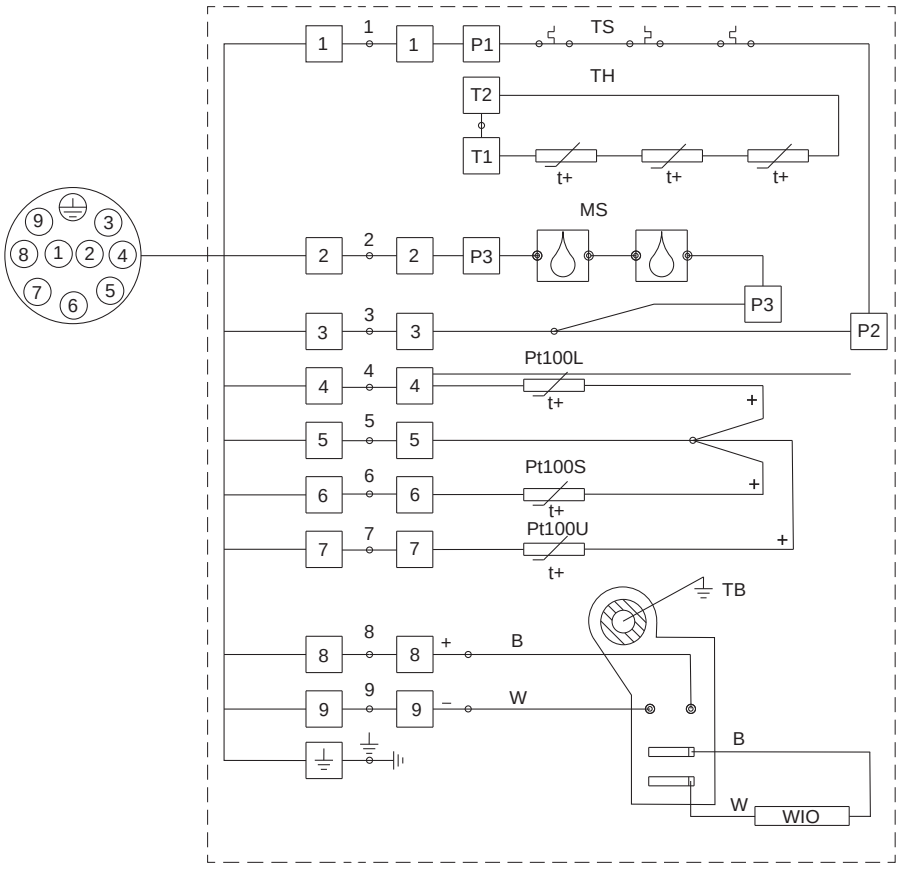
Power cable



Wiring diagram for power cable - DOL starting, dual cables

Pos.	Description
C	Read clockwise

5.2.2 Sensors



Wiring diagram for sensors

Pos.	Description
TS	Thermal switches
TH	Thermistors
MS	Moisture switches
Pt100L	Pt100 in lower bearing
Pt100S	Pt100 in stator
Pt100U	Pt100 in upper bearing
TB	Transient barrier
WIO	WIO sensor

The wiring diagrams in custom-built products may differ from the standard. In this case, contact the nearest Grundfos company or an authorized workshop.

5.2.3 Frequency converter operation

FM Connect pumps installed in hazardous locations to a control box with a motor protection relay with an IEC trip class 10.

In principle, all three-phase motors can be connected to a frequency converter.

However, frequency converter operation often exposes the motor insulation system to a heavier load and causes the motor to be more noisy than usual.

In this product range, only negligible amounts of bearing currents occur during the use of frequency converter.

For frequency converter operation, observe the following:

- The thermal protection of the motor must be connected.
- Peak voltage and dU/dt must be in accordance with the table below. The values stated are maximum values supplied to the motor terminals. The cable influence is not taken into account. See the frequency converter datasheet regarding the actual values and the cable influence on the peak voltage and dU/dt.
- Minimum switching frequency is 2 kHz. Variable switching frequency is accepted.
- If the pump is an Ex-approved pump, check if the Ex certificate of the specific pump allows the use of a frequency converter.
- Set the frequency converter U/f ratio according to the motor data.
- Local regulations or standards must be complied with.
- Before installing a frequency converter, calculate the lowest permissible frequency in the installation to avoid zero flow.
- Do not reduce the motor speed to less than 50 %.
- Keep the flow rate above 3.3 ft/s (1 m/s).
- Let the pump run at rated speed at least once a day to prevent sedimentation in the pipe network.
- Do not exceed the frequency indicated on the nameplate as this may cause motor overload.
- Keep the power cable as short as possible. The peak voltage increases with the length of the power cable.
- Use input and output filters on the frequency converter.
- Use a screened power cable if there is a risk that electrical noise may disturb other electrical equipment.
- Set frequency converter for constant-torque operation. Pulse width modulation should be used.

When operating the pump by a frequency converter, consider the following:

- The locked-rotor torque can be lower depending on the frequency converter type.
- The noise level may increase. See the installation and operating instructions for the selected frequency converter.

Maximum repetitive peak voltage [V]	Maximum dU/dt U_N 400 V [V/µ sec.]
850	2000

Frequency converter use may reduce the lifespan of the bearings and the shaft seal, depending on the operating mode and other circumstances.

For more information about the pump speed/torque curves when operated by a frequency converter, visit Grundfos Product Center at https://product-selection.grundfos.com.

For more information about the frequency converter operation, see the datasheet and the installation and operating instructions for the selected frequency converter.

6. Protection and control functions

6.1 Motor protective devices

The motors have three thermal protectors connected in series and one moisture switch. Ex pumps have two moisture switches connected in series. Protectors and switches are connected in two separate circuits. The thermal protectors are reversible, and the moisture switches are irreversible. The thermal protection circuit, conductors 1 and 3, and the moisture protection circuit, conductors 2 and 3, have separate outputs to enable separate alarms if the motor is overheated or affected by moisture.

All other sensor connections are either led out of the motor, sensor version D, through conductors 4 to 9, or connected to the sensor board, sensor version B, and led out of the motor through conductors 4 and 5.

6.2 Pump controller

S pumps can be connected to a separate Grundfos pump controller for level control, which is available as an accessory:

- Grundfos Dedicated Controls (DC) for one- to six-pump installations.

The Dedicated Controls system starts/stops the S pumps by:

- float switches
- pressure sensor
- ultrasonic sensor.

Furthermore, it is possible to control the water level by both float switches and an analog pressure sensor or ultrasonic sensor.

Optionally, DC can control a mixer. The DC system can be extended with an IO 113 module per pump (for S pumps, with a built-in sensor).

When installing the level switches, observe the following:

- To prevent air intake and vibrations in submerged pumps, fit the stop level switch so that the pump is stopped before the liquid level is lowered below the top of the pump housing. As a principal rule for pumps in dry installations, the lowest stop level must be at least 8" (20 cm) above the opening of the inlet pipe.
- Install the start level switch so that the pump is started at the required start level; however, the pump must always be started before the liquid level reaches the bottom inlet pipe to the pit.
- If installed, always install the high-level alarm switch about 4" (10 cm) above the start level switch; however, an alarm must always be given before the liquid level reaches the inlet pipe to the pit.

Do not install the pump controller in potentially explosive atmospheres.

FM Level switches must comply with IEC/EC 50495, Annex D.

6.3 IO 113

IO 113 forms the interface between a Grundfos sewage and wastewater pump with analog and digital sensors and the pump controller. The most important sensor data are indicated on the front panel.

One pump can be connected to an IO 113 module.

Together with the sensors, the IO 113 forms a galvanic separation between the motor voltage in the pump and the controller connected.

IO 113 can do the following as standard:

- protect the pump against overheating
- monitor the moisture in the pump
- measure the stator insulation resistance. See section Measurement of insulation resistance
- stop the pump in case of alarm
- remotely monitor the pump through RS-485 communication, Modbus or GENIbus
- control the pump by a frequency converter.

Combined with SM 113, IO 113 can monitor the bearing temperature and rotor speed when the motor is switched off.

Related information

6.3.2 Measurement of insulation resistance

6.3.1 Motor protection

Galvanic separation

Double-insulated sensors for all measurements of high voltages ensure electrical safety. Furthermore, there is a galvanic separation inside the IO 113.

6.3.2 Measurement of insulation resistance

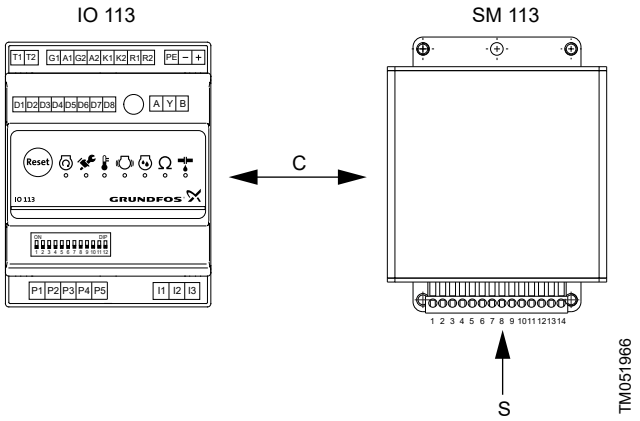
IO 113 measures the insulation resistance between a stator winding and earth:

- Resistance above 10 megaohms is ok.
- Resistance between 10 and 1 megaohms causes a warning.

Resistance below 1 megaohm causes an alarm.

6.4 SM 113, optional

SM 113 is designed and used for the collection and transfer of additional sensor data. SM 113 works together with IO 113 with a communication module, product number 98097390, as indicated in the figure below.



IO 113 and SM 113

Pos.	Description
C	Power line communication using Grundfos GENIbus protocol
S	Sensor inputs

SM 113 can collect data from the following devices:

- Current sensors, 4-20 mA *
- Pt100 ** thermal sensors.

* Vibration sensor (FPV)

** Maximum three Pt100 sensors.

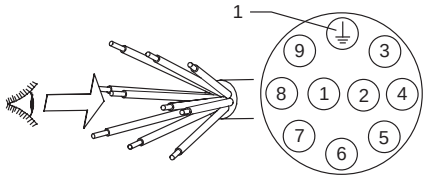
6.5 Switches and sensors

Do not let the pump run dry.

Install an additional level switch to ensure that the pump is stopped in case the primary stop level switch is not operating.

A pump includes the following switches and sensors:

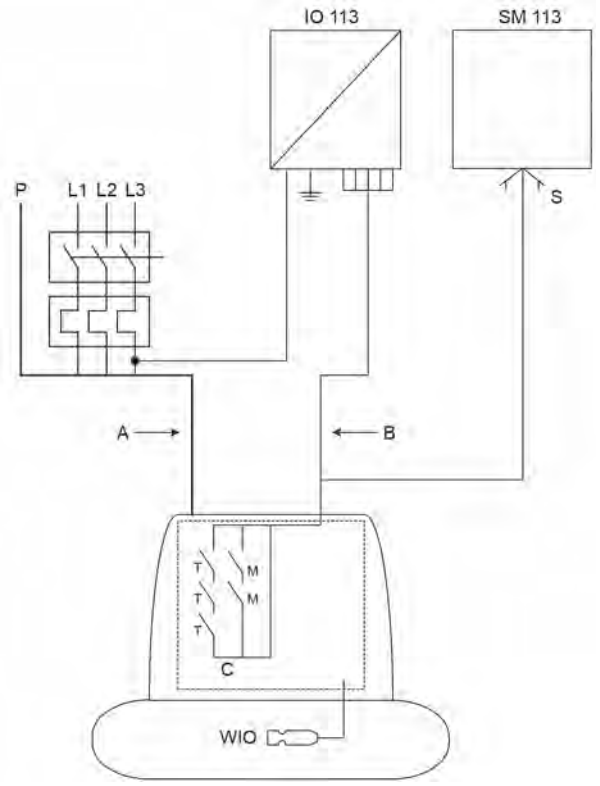
- three thermal switches or three thermal protectors in the stator windings
- moisture switches:
  - in range 50-70: one under the motor top cover
  - in Ex-pumps, range 50-58 and 66-70: one under the motor top cover and one in the stator housing
  - in Ex pump, range 62: two under the motor top cover.
- one optional Pt100 sensor in the bearing or in the stator winding
- one analog and optional WIO sensor in the oil chamber.



TM032802

Sensor cable

Pos.	Description
1	Yellow and green



TM046067

Sensor connections, SM 113 outside the motor

Symbol	Description
A	Power side
B	Signal side
WIO	WIO sensor "mb" approval
C	"d" enclosure
T	Thermal switch
M	Moisture switch
P	Power input
S	Sensor input
SM 113	Sensor board
IO 113	IO 113 with internal alarm relay (250 VAC)
"d"	Flameproof enclosure
"mb"	Protection according to EN/IEC 60079-18:2004

6.5.1 Thermal switches

The thermal protection against overheating is ensured through bimetallic switches as standard or thermistors as optional.

The three thermal switches that are hardwired from the pump to IO 113, or a similar controller, open if the stator windings become overheated. The thermal switches are reversible and close again when the motor is cooled down.

This generates both a hardware and a software alarm in IO 113, and the alarm relay opens.

Install an automatic circuit breaker, which disconnects the power supply in case the thermal switches or the moisture switches are not operating.

Maximum switching current for the thermal switch is 0,5 A at cos φ 0.6.

6.5.2 Moisture switches

Non-explosion-proof pumps have one moisture switch which is fitted in the chamber below the motor top cover.

Ranges 50-58 and 66-70 explosion-proof pumps have two moisture switches, one below the motor top cover and one in the stator housing in the bottom of the motor.

Range 62 has both moisture switches placed below the motor top cover.

The moisture switches are hardwired from the pump to IO 113, or a similar controller. They open if moisture is detected and break an electric circuit. This generates both a hardware and a software alarm in IO 113, and the alarm relay opens.

The switching current on the moisture switch is 6 A.

6.5.3 Pt100, optional

The Pt100 temperature sensor is available as an accessory or as a Factory Product Variant (FPV).

The Pt100 sensor is primarily used for the monitoring of the bearing temperature, but it can also be used in the stator.

If the pump does not have an SM 113, hardwire the Pt100 sensor out of the pump and connect it to an external unit. See fig. Sensor connections, SM 113 outside the motor. If the pump has an SM 113, connect the Pt100 sensor to SM 113. An external unit is not required.

For range 50 and 54 explosion-proof pumps, the temperature sensor is only available for monitoring the lower bearing temperature.

The maximum alarm temperatures are indicated in the table below:

Pump range	Alarm temperatures		
	Winding temperature [°F (°C)]	Upper bearing [°F (°C)]	Lower bearing [°F (°C)]
50-54	302 (150)	266 (130)	194 (90)
58-70	302 (150)	248 (120)	212 (100)

In case of overheating, the Pt100 sensor trips an alarm and disconnects the power supply at a preset temperature.

For the maximum acceptable alarm temperature, see the table above.

Related information

6.5 Switches and sensors

6.5.4 Thermistors, optional

Thermistors are available as an accessory or as an FPV.

The thermistors can be used as motor protection devices to monitor stator temperature instead of thermal switches and must be connected to the thermistor relay in the control cabinet.

6.5.5 WIO sensor, optional

Lack of oil may cause overheating and damage to the mechanical shaft seals. The WIO sensor in the oil chamber trips the alarm if the oil quality or quantity is inadequate.

Do not use Shell Ondina X420 oil without emulsifying detergent in a pump fitted with a WIO sensor.

The WIO sensor is available as an accessory for pumps with 10 to 208 hp (7.5 to 155 kW) motors. It can be factory-fitted or installed after the pump is already operating.

The oil chamber is filled with oil acting as lubricant and coolant for both mechanical seals. The WIO sensor measures the water content in the oil chamber:

- 0-20 % water in the oil causes no reaction
- water content outside the measuring range causes a warning
- too low oil level causes an alarm.

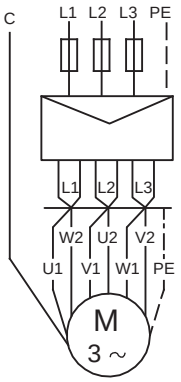
The sensor consists of a plate capacitor that is immersed in the oil and measures the electronic circuit, emitting a 4-20 mA proportional current signal.

More detailed information can be found in the installation and operation instructions (96591899) or on Grundfos Product Center at www.grundfos.com.

7. Starting up the product

The pump can be started direct-on-line (DOL).

The wiring diagrams for direct-on-line starting are indicated in fig. Direct-on-line starting, dual cables. See also the wiring diagram for sensors in fig. Wiring diagram for sensors.



TM068311

Direct-on-line starting, dual cables

Pos.	Description
C	Control cable

Related information

5.2.2 Sensors

7.1 Preparations for starting up

DANGER

Rotating elements

Death or serious personal injury

- Before manual startup or changeover to automatic control, make sure that no persons are working on or near the pump.

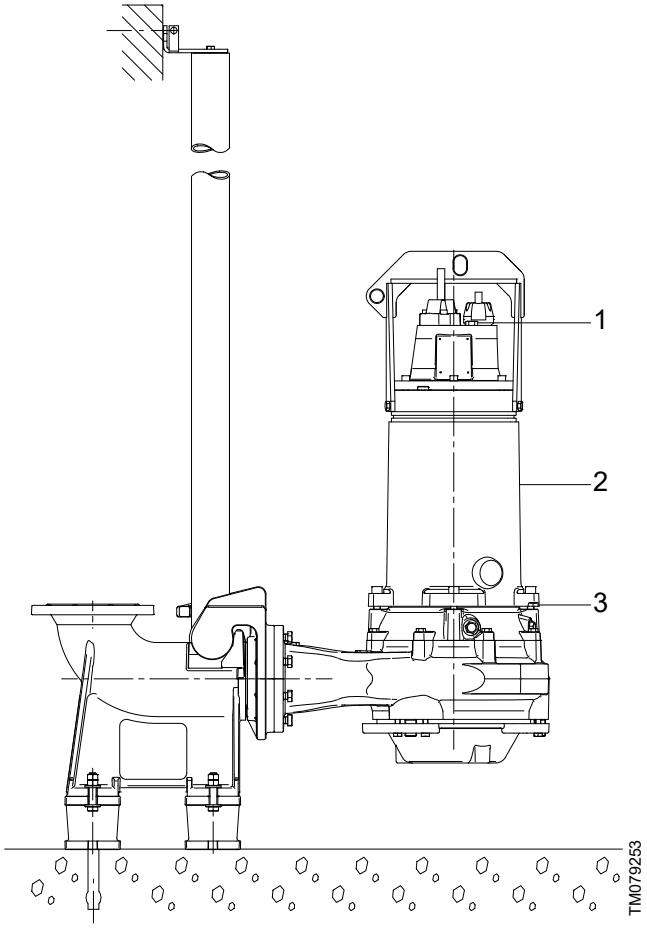
Before the first startup and after a long standstill period, make sure that the pump is filled with the pumped liquid.

In dry installations with cooling jacket, the cooling jacket must always be filled with pumped liquid during operation. Ensure this by venting before the first startup.

7.1.1 Start and stop levels for auto-coupling installation

The start and stop levels are specified during the design stage. Always check that the start and stop levels function and possibly alter them when commissioning the pump to ensure proper operation.

Stop levels



Stop levels for auto-coupling installations

Pos.	Description
1	Installation type S (Ex pumps)
2	Installation type S (standard pumps)
3	Installation type C (standard and Ex pumps)

In the case of an Ex pump, install an additional level sensor for the stop level.

Ex pumps must always be completely submerged.

Set the stop level according to fig. Stop levels for auto-coupling installations, so that the flow velocity in the pit increases towards the end of the working cycle. In pits with several different stop levels, such as in frequency-controlled installations, program the control sequence to pump down to the lowest stop level at least once a day to clean out the bottom of the pit.

The stop level limits are determined by the motor submergence required to ensure cooling, prevent cavitation, or avoid air being sucked into the pump inlet. The lowest level cannot always be foreseen but must be confirmed through trials during commissioning.

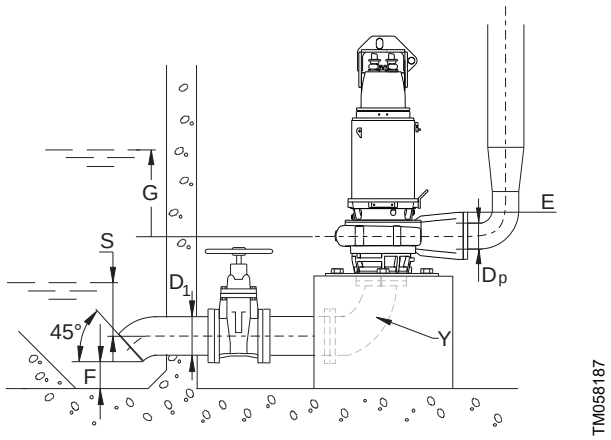
7.1.2 Start and stop levels for dry installation

Stop levels

The stop level setting for dry-installed pumps depends on the inlet pipe height, shape and flow velocity. Set the stop level approximately one inlet pipe diameter above the inlet pipe. The final stop level must be confirmed through test runs during commission.

Start levels

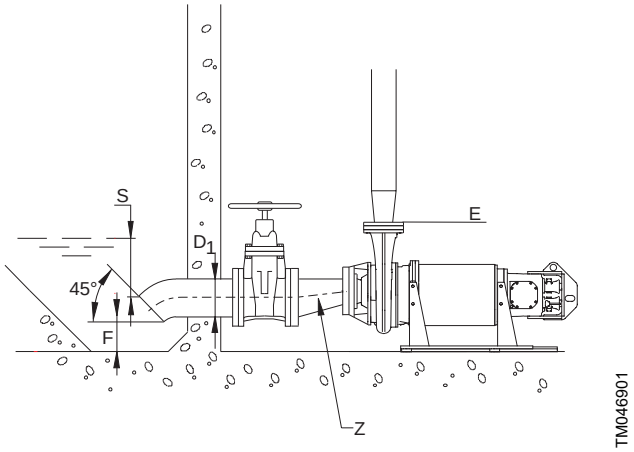
In pits with dry-installed pumps, set the starting level above the pump housing to ensure that the cooling jacket is filled up before the pump starts pumping. For vertical pumps, this height may be considerable and should be set with a margin according to fig. Vertical, dry installation (D).



Vertical, dry installation (D)

Pos.	Description
Y	Reduction elbow

Horizontal pumps do not normally require special considerations for the start level if the inlet pipe is designed to prevent air pockets from forming. See fig. Horizontal, dry installation (H).



Horizontal, dry installation (H)

Pos.	Description
Z	Eccentric reducer

Minimum stop level	$S = D_1$
Minimum distance between the bottom of the pit and the lowest part of the inlet pipe	$F = 0.5 \times D_1$
Minimum start level	$G = D_p$

S is the minimum stop level. The minimum distance S above the inlet pipe is required to avoid the formation of vortices at the inlet pipe and to avoid air being sucked into the pump. Air in the pumped liquid may cause vibrations, cavitation and loss of pump performance.

G is the minimum start level of a dry-installed, vertical pump if other actions are not taken to ensure the pump housing is filled with pumped liquid when the pump is started.

Other possible actions:

- Use a vacuum pump to suck liquid into the pump housing. This requires an isolating valve on the outlet side.
- Install a non-return valve in the outlet pipe after the first startup. This prevents the draining of the pump housing between running periods.

7.2 Checking the direction of rotation

Only start an unsubmerged pump for a few seconds to check the direction of rotation.

A label with an arrow on the pump housing indicates the correct direction of rotation. The direction of rotation is clockwise.

DANGER

Crushing of hands

Death or serious personal injury

- Do not touch the pump when starting it up.

Make sure that the bottom of the pit is clean before startup to avoid material or objects being sucked into the impeller.

Installation types S, C and ST

Proceed as follows:

1. Lift the pump approximately 0.8 - 2 in (2-5 cm) from the ground or base by the lifting chain and a crane.
2. Start the pump for a few seconds.
3. Observe the jerk of the pump. If the pump jerks counter-clockwise, the direction of rotation is correct.

In case the direction of rotation is wrong, interchange two phases in the power supply cable.

Installation types D and H

Check the duty point.

7.3 Startup

Before installation and the first startup of the pump, check the condition of the cables visually to avoid short circuits.

Proceed as follows:

1. Lock the main switch in position 0.
2. Check the oil level in the oil chamber. See section Oil check and change.
3. Check that the impeller can rotate freely.
4. Check whether the monitoring units, if used, are operating properly.
5. Open the isolation valves, if fitted.
6. **Pumps in installation types S and C:** Ensure visually that the pump is properly connected to the auto coupling.
7. Make sure that the pump is submerged in the liquid.
8. **Pumps in installation types D and H:** Make sure that there is liquid in the pit and that the pump housing and cooling jacket are filled with water. Open the air vent screw on the top of the cooling jacket, pos. 9 in fig. S pump, before or during the startup until water comes out. Close the screw.

   Pumps in installation type ST: Make sure that the pump is properly seated in the column pipe and secured against rotation.
9. Start the pump and check the operation for abnormal noise or vibrations.

   In case of abnormal noise or vibrations, stop the pump immediately. Do not restart the pump until the cause of the fault is identified and eliminated.
10. After startup, establish the actual pump duty point as accurately as possible so it can be checked whether the operating conditions are as desired.

Always operate the pump in accordance with established routines with scheduled checks of the pump monitoring equipment and accessories. Make sure that the pump and equipment settings cannot be changed by unauthorized persons.

Related information

3.1 Product description

9.3 Oil check and change

8. Storing the product

8.1 Storing the product

Leave the cable end protectors on the power supply and sensor cables until making the electrical connection. Whether insulated or not, the free cable end must never be exposed to moisture or water.

Non-compliance with this may cause damage to the motor.

For long periods of storage (six months or longer), the pump must be protected against moisture and heat.

If the pump is being stored for more than two months, turn the impeller by hand at least every two months to prevent the seal faces of the lower mechanical shaft seal from seizing up.

Avoiding this may cause the shaft seal to be damaged when the pump is started.

If the impeller cannot be turned by hand, contact an authorized service workshop.

For dry-installed pumps, make sure the cooling jacket is empty before storing the pump.

After a long period of storage (six months or longer), inspect the pump before putting it into operation. Make sure that the impeller can rotate freely.

Pay attention to the condition of the shaft seals, O-rings and the cable entry.

9. Servicing and maintaining the product

9.1 Safety instructions and requirements

DANGER

Pump can tilt

Death or serious personal injury

- During maintenance and service, including transportation to service workshops, always support the pump by lifting chains or place it in horizontal position to secure stability.

DANGER

Electric shock

Death or serious personal injury

- Before starting work on the pump, make sure that the main switch is locked in position 0. Make sure that the power supply cannot be switched on unintentionally.

WARNING

Crushing of hands

Death or serious personal injury

- Make sure that all rotating parts are stopped moving.

Maintenance and service must be carried out by specially trained persons.

Maintenance and service work on explosion-proof pumps must be carried out by Grundfos or a service workshop authorized by Grundfos.

FM

In case of repairs, always use original service parts from the manufacturer to ensure correct dimensions of flame path gaps.

The bolts used in the motor must be class A4-80 or A2-80 according to EN/ISO 3506-1. VER 2.

A defective bearing may reduce the Ex safety.

WARNING

Toxic material

Death or serious personal injury

- Flush the pump thoroughly with clean water before maintenance and service. Rinse the pump parts after dismantling.

9.2 Maintenance schedule

Inspect pumps running normal operation once a year.

Check the following points:

- **Power consumption**
- **Oil level and oil condition**
- **Cable entry** Make sure that the cable entry is waterproof, the cables are not sharply bent or pinched, and the cable sheaths have no visual defects.
- **Impeller clearance**
- **Pump parts** Check the pump parts for possible wear. Replace defective parts.
- **Ball bearings** Check the shaft for noisy or heavy operation; turn the shaft by hand. Replace defective bearings. A general overhaul of the pump is usually required in case of defective bearings or poor motor function. This work must be carried out by an authorized service workshop.

Related information

9.4 Inspection and adjustment of the impeller clearance

12. Disposing of the product

9.3 Oil check and change

The oil chamber is filled with oil acting as a lubricant and coolant for both mechanical seals.

Check the oil once a year to avoid damage and breakdown of the pump.

Low oil level may indicate that the upper mechanical shaft seal is defective. Contact an authorized service workshop for further overhaul of the pump and repair, if required.

FM

Lack of oil may cause overheating and damage to the mechanical seals. The WIO sensor in the oil chamber trips the alarm if the oil quality or quantity is inadequate.

Use oil with viscosity grade SAE 10W-30 or SAE 10W-40.

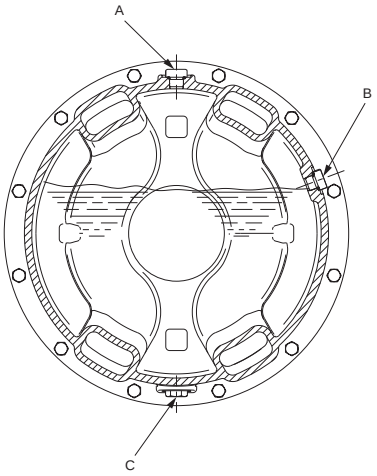
Range	Oil quantity	
	Installation type	
	S [qal (l)]	C, D and H [qal (l)]
50	0.7 (2.6)	0.5 (1.9)
54	0.9 (3.5)	0.7 (2.5)
58	1.2 (4.6)	1.0 (3.8)
62	2.4 (9.0)	1.9 (7.1)
66	3.30 (12.5)	2.6 (9.2)
70	3.28 (12.4)	2.4 (9.0)

The oil in the oil chamber can be changed with the pump in either horizontal or vertical position. However; it is recommended to carry out the oil change with the pump in a horizontal position as it is much easier to drain all the used oil out of the chamber.

Horizontal position

Proceed as follows:

1. Place the pump in such a position that inspection screw A is pointing upwards.



TM031628

Pump with inspection screw A upwards

CAUTION

Pressurized system

Minor or moderate personal injury

- When loosening the screw of the oil chamber, note that pressure may have built up in the chamber. Do not remove the screw until the pressure is completely relieved.

2. Place a clean container under the pump to collect all the drained-off oil. Remove screw B and observe the oil level.
3. Check the oil level and take an oil sample to inspect the condition of the oil. The oil becomes greyish white like milk if it contains water. In normal operation, a small leakage through the mechanical shaft seals is expected, but if the water content in the oil is high, this may be the result of a defective shaft seal. Change the oil if it contains water. Oil not containing water can be reused.
4. If the oil needs to be changed, remove screw C and allow all the oil to drain from the chamber into the container. Emulsified oil must be changed and disposed of.

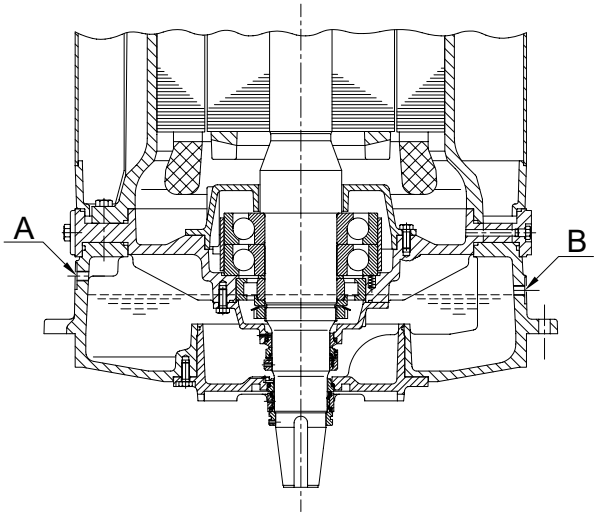
Used oil must be disposed of in accordance with local regulations.

5. Replace the O-rings, refit screw C and tighten securely. Fill the oil chamber with oil to the correct level. Refit screws A and B and tighten securely.

Vertical position

Proceed as follows:

1. Identify the screws A, B and C and their positions to each other. See fig. Pump with inspection screw A upwards.



TM024005

Correct oil level of a vertical pump

1. Use screw B for indication of the level of oil in the oil chamber. See fig. Correct oil level of a vertical pump.
2. When the pump is vertical, the oil has to be pumped out of the oil chamber. Use a suction pump with a flexible suction hose that can be inserted deep into the oil chamber.
3. Pump out the oil using all the screw holes in turns so as to reach all sections of the interior of the oil chamber. Collect the drained oil in a clean container.
4. Replace the O-rings, refit screw C and tighten securely. Fill the oil chamber with oil to the correct level. Refit screws A and B and tighten securely.

9.4 Inspection and adjustment of the impeller clearance

The correct axial clearance is 0.03" ± 0.0079 in (0.7 mm ± 0.2). Reset the clearance if it is 0.03 in (0.7 mm) or more. The method for resetting the clearance is different for submersible pumps, installation types S, C and ST, and for dry-installed pumps, installation types D and H.

9.4.1 Submersible pumps, installation types S, C and ST

Submersible pumps have a separate, adjustable pump inlet cover which may be shaped as an inlet bell. When the pump is installed or pulled out of the pit for service, locate the six fastening screws of the inlet cover and the three set screws.

Use a feeler gauge to check the clearance between the impeller and the inlet cover all around the perimeter of the inlet opening. See fig. Impeller clearance adjustment.

DANGER

Overhead load

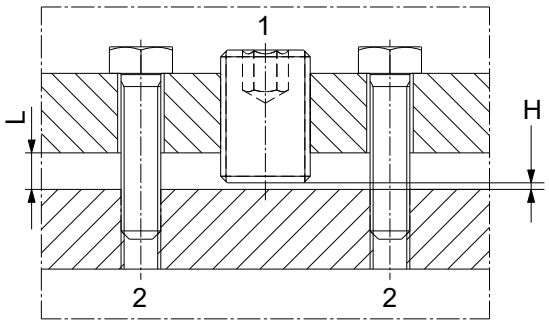
Death or serious personal injury

- Never work under a pump when it is hanging from a crane.

Before adjusting the clearance, clean the gap between the impeller and the inlet cover.

1. Loosen the set screws by two full turns each.
2. Close the impeller clearance by lightly tightening the fastening screws diagonally until the impeller touches the pump housing.

   Do not use too much force when tightening the fastening screws as this may damage the bearings. The movement is usual 0.04 to 0.12 in (1 to 3 mm).
3. Loosen the fastening screws to make a 0.03 in (0.7 mm) gap under the heads of the fastening screws. See fig. Impeller clearance adjustment.
4. Tighten the set screws.
5. Tighten the fastening screws diagonally.



Impeller clearance adjustment

Pos.	Description
H	0.03 in
1	Set screw
2	Fastening screw

9.4.2 Dry-installed pumps, installation types D and H

Depending on the pump range, there are two ways to set the impeller clearance. Method 1 is for ranges 50-54 and method 2 for ranges 58-70.

Method 1

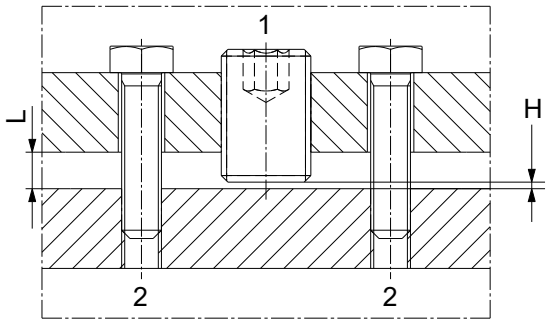
1. Loosen the set screws by two full turns each.
2. Close the impeller clearance by tightening the fastening screws diagonally until the impeller touches the pump housing.

   Do not use too much force when tightening the fastening screws as this may damage the bearings. The movement is usually 0.04 to 0.12 in (1 to 3 mm).
3. Loosen the fastening screws to make a 0.03 in (0.7 mm) gap under the heads of the fastening screws. See fig. Impeller clearance adjustment.
4. Tighten the set screws.
5. Tighten the fastening screws diagonally.

Method 2

1. Loosen the six fastening screws and close the impeller clearance by tightening the three set screws. Tighten the screws diagonally to move the inlet cover evenly.

   Do not use too much force when tightening the fastening screws as this may damage the bearings. The movement is usually 0.04 to 0.12 in (1 to 3 mm).
1. Measure the distance "L" between the inlet cover and the pump housing at three points next to the set screws, using feeler gauges or calipers, and note the distance.
2. Loosen the set screws and draw back the inlet cover between 0.02 to 0.035 in (0.5 to 0.9 mm) using the six fastening screws (approximately one 270° turn of a 1/2" (M12) fastening screw) and the distance "L" as reference. See fig. Impeller clearance adjustment.
3. Tighten all set screws and check that the distance "L" at the three reference points is stable at the new value.



Impeller clearance adjustment

Pos.	Description
H	0.02 - 0.035 in
1	Set screw
2	Fastening screw

Related information

9.4.1 Submersible pumps, installation types S, C and ST

9.5 Pump cleaning and inspection

A simple maintenance measure is to clean the pumps at regular intervals. Lift the pumps out of the wet pit and clean the pumps on site. Hose down the pump externally using a high-pressure jet cleaner at maximum 1450 PSI (100 bar). Remove caked dirt from the motor to ensure good heat conductivity. A mild detergent approved for disposal into the sewage system may be used. The pumps may be scrubbed, using a soft brush, if necessary.

Visual inspection of the pump must include the following:

- Search for cracks or other external damage.
- Check the lifting brackets and lifting chain for wear and corrosion.
- Inspect the motor cables for cracks or lacerations in the sheath, for kinks, or any other damage.
- Inspect visible parts of the cable entry for cracks.
- Check that the cables are firmly connected to the motor top cover.
- Check all visible screws for self-loosening and tighten if necessary.

The pumps are fitted with an air vent valve at the top of the cooling jacket. The valve may be removed and cleaned, if necessary. Clean the vent hole before refitting the valve after cleaning.

9.6 Motor cables

Use only cables that are approved by the manufacturer and suitable for the cable entry as to diameter, number of conductors, conductor cross-section and sheath material.

9.6.1 Cable entry

Secure the cable entry to the motor top cover by tightening the screws evenly one by one until the cable entry is lying flat against the top cover.

The minimum bending radius for cables are indicated in the following table:

Range	Cable type	Cable size		Min. bending radius [in (cm)]
50 54 58	Power cables	7 x 1.5 mm^2	7 x 16 AWG	3.9 (10)
		7 x 2.5 mm^2	7 x 14 AWG	4.3 (11)
		4 x 6.0 mm^2	4 x 10 AWF	3.9 (10)
62		4 x 6.0 mm^2	4 x 10 AWG	3.9 (10)
		4 x 10.0 mm^2	4 x 8 AWG	5.5 (14)
		4 x 16.0 mm^2	4 x 6 AWG	6.3 (16)
66		4 x 10.0 mm^2	4 x 8 AWG	5.5 (14)
		4 x 16.0 mm^2	4 x 6 AWG	6.3 (16)
		4 x 25.0 mm^2	4 x 4 AWG	7.5 (19)
70		4 x 25.0 mm^2	4 x 4 AWG	7.5 (19)
		4 x 35.0 mm^2	4 x 2 AWG	8.3 (21)
		4 x 50.0 mm^2	4 x 1 AWG	9.8 (25)
		4 x 70.0 mm^2	4 x 2/0 AWG	11.0 (28)
All	Control cables	7 x 1.5 mm^2	7 x 16 AWG	3.9 (10)

9.7 Spare parts

Damaged motor parts must always be replaced by new and approved parts. Motor parts must never be reconditioned.

9.8 Contaminated pumps and service

CAUTION

Biological hazard

Minor or moderate personal injury

- Flush the pump thoroughly with clean water and rinse the pump parts after dismantling.

If a pump is used for a toxic or contagious liquid, the pump is classified as contaminated.

9.8.1 Sending the pump to service

Contact Grundfos with the following details about the pumped liquid before returning the pump for service. Otherwise, Grundfos can refuse to accept the product for service.

- customer ID and/or installation ID, contact information
- pump type and type designation
- type of malfunction or fault
- pumped liquid
- frequency converter, if used
- level switch type, if used
- control panel information, if available.

Costs of returning the product are to be paid by the customer.

10. Fault finding the product

Fault	Cause	Remedy
The pump does not start or it stops without visible cause.	No power supply.	Re-establish the power supply, start the pump manually and check contactor operation.
	Moisture in the stator housing or in the terminal box. The moisture switch interrupts the supply voltage.	Contact an authorized service workshop.
	The WIO sensor is not covered by oil. The sensor interrupts the supply voltage.	Contact an authorized service workshop.
The pump does not start or it stops. The control panel of the controller indicates that the motor-protective circuit breaker or protection equipment is tripped out.	Missing phase.	Re-establish all phases.
	The pump is overloaded.	Let the pump cool down for approximately 10 minutes and start it again. In case the pump starts now, the first stop was caused by a tripping thermal switch. If the fault occurs again, find the cause of the overload. Check the control panel fuses and switch them on in case they have tripped. Wait for approximately 10 minutes until the pump is cooled down, and start it again. In case the pump does not start, the overload relay has tripped and the pump needs service. Contact an authorized service workshop.
	The impeller is clogged by impurities.	Clean the impeller.
	The motor-protective circuit breaker is set incorrectly.	Set the motor-protective circuit breaker as required in relation to the rated current.
	The thermal switches are tripped out. Insufficient motor cooling.	Re-establish motor cooling.
	The moisture switch in the motor is tripped out.	Contact an authorized service workshop.
	A motor cable is defective.	Contact an authorized service workshop.
	Fluctuating voltage.	Re-establish correct voltage supply. The permissible deviation is ± 10 %.
The pump runs but does not deliver the rated flow.	Wrong direction of rotation.	Interchange two phases in the power supply to the motor.
	The impeller is loose or worn.	Tighten or replace the impeller.
	The pump or the pipes are blocked by impurities.	Clean the pump or the pipes.
	The pump head is too high.	Measure the differential pressure and compare the value with the pump performance curve. Remove the blockage in the outlet pipe. Contact Grundfos, if necessary.
	The valves are closed or blocked. The non-return valve is not operating.	Open, clean or replace the valves as required.
	There is air in the pump or the inlet pipe.	Vent the pump or the inlet pipe. Set a higher stop level in the pit.
	The pumped liquid is too dense.	Dilute the pumped liquid.
	The pump is improperly connected to the auto coupling.	Pump down the liquid level in the pit. Lift out the pump and relocate it on the auto coupling.
	There is leakage in the pipes.	Repair or replace the pipes.
	The pump pit flushing system is inadvertently activated.	Check the function of the flushing system and repair as required.
The pump starts but stops immediately.	A clogged pump causes the motor-protective circuit breaker to trip out.	Clean the pump.
	An overheated motor causes the thermal switches to trip out.	Allow the pump to cool. Clean the pump.

Fault	Cause	Remedy
	The level switch is out of adjustment or defective.	Clean or reset the level switch or replace as required.
The pump is vibrating or emitting excessive noise.	The pump is partly clogged by impurities.	Clean the pump.
	Wrong direction of rotation.	Interchange two phases in the power supply to the motor.
	The pump is operating outside the specified operating range.	Re-establish proper operating conditions.
	The pump is defective.	Repair the pump or contact an authorized workshop, if necessary.
	The pump is improperly connected to the auto coupling.	Pump down the liquid level in the pit. Lift out the pump and relocate it on the auto coupling.
	The pump is cavitating.	Clean the inlet.
	The base stand, the auto coupling, the ring stand or the guide rails are installed incorrectly.	Install the components correctly.
The oil is watery or emulsified.	The lower mechanical shaft seal is leaking.	Contact an authorized service workshop.
The oil level is low.	The upper mechanical shaft seal is leaking.	Contact an authorized service workshop.

Related information

9.1 Safety instructions and requirements

11. Technical data

11.1 Operating conditions

11.1.1 pH value

All pumps can be used for pumping liquids with a pH value between 4 and 10.

11.1.2 Liquid temperature

The allowed temperature is 32-104 °F (0-40 °C).

In special situations, if the motor is not completely loaded, the temperature of the pumped liquid may be higher.

In this case, contact the nearest Grundfos company or service workshop.

FM Explosion-proof pumps must never pump liquids with a temperature higher than 104 °F (40 °C).

11.1.3 Ambient temperature

The allowed ambient temperature is -4 °F to 104 °F (-20 °C to +40 °C).

In special situations, if the motor is not completely loaded, the ambient temperature may be higher than 104 °F (40 °C).

In this case, contact the nearest Grundfos company or service workshop.

FM For explosion-proof pumps, the ambient temperature on the installation site must be in the range between -4 °F to 104 °F (-20 and +40 °C).

11.1.4 Density and viscosity of the pumped liquid

Density: 133.5 ounces/gallon (1000 kg/m^3).

Kinematic viscosity: 1 cSt (1 mm^2/s).

When pumping liquids with a density and/or a kinematic viscosity higher than the values stated above, use motors with correspondingly higher outputs.

11.1.5 Flow velocity

Keep a minimum flow velocity to avoid sedimentation in the piping system.

Recommended velocities:

Vertical pipes:	2.3 ft/s (0.7 m/s)
Horizontal pipes:	3.3 ft/s (1.0 m/s)

11.1.6 Installation depth

The maximum submersion depth is 66 ft (20 m).

11.1.7 Level of the pumped liquid

FM An Ex motor without cooling jacket, installation types S and ST, must be completely submerged during operation.

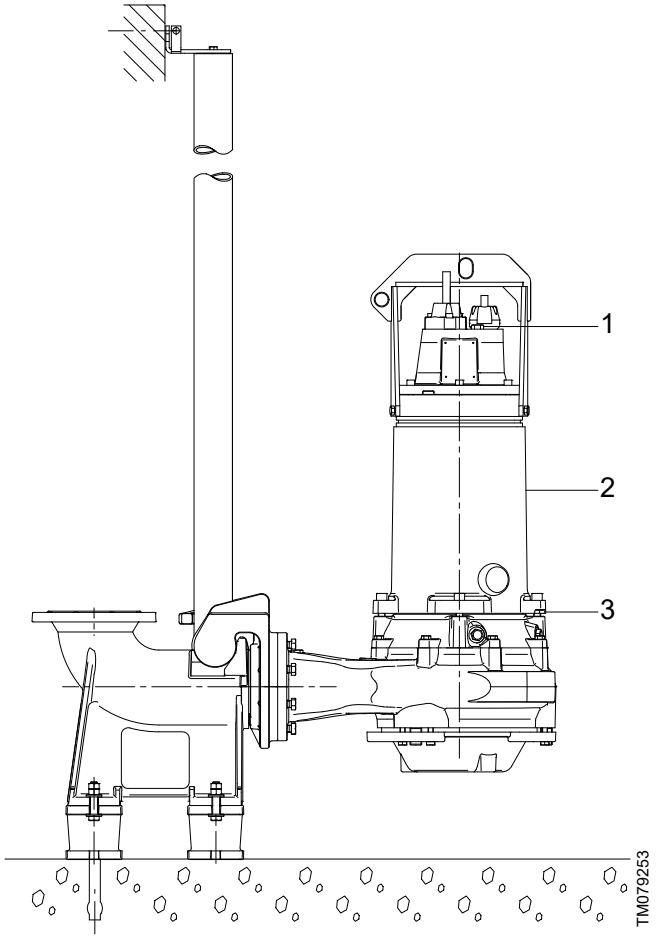
FM Install an additional level switch to ensure that the pump is stopped in case the stop level switch is not operating.

To avoid air being sucked into the pump and to ensure adequate cooling of the motor during operation, make sure to meet the following minimum requirements:

- **Installation type S:** Submerge the Ex pump to the top of the motor and the standard pump to the middle of the motor.

  FM Installation type S pumps must always be completely submerged in the pumped liquid to be Ex protected.

- **Installation type C:** Submerge the pump to the top of the pump housing so that the liquid level is always above the pump housing.



Liquid level

Pos.	Description
1	Installation type S (Ex pumps)
2	Installation type S (standard pumps)
3	Installation type C (standard and Ex pumps)

- **Installation types D and H:**

  For installation type D, air venting can be fulfilled through an air-vent screw in the top of the cooling jacket.

  For installation type H, air venting is not necessary after the pump is filled with water.

- **Installation type ST:** For standard pumps, the liquid level must be at least 14 in (350 mm) above the pump inlet.

Related information

5.1.4 Dry installation

5.1.1 Installation types

11.1.8 Operating mode

The pumps are designed for continuous operation with the maximum number of starts per hour stated in the table below:

S pump, range	Starts per hour
50, 54 and 58	20
62, 66 and 70	15

11.1.9 Enclosure class

IEC IP68.

11.1.10 Sound pressure level

CAUTION

Sound pressure level

Minor or moderate personal injury

- Use a hearing protection when working nearby an installation in operation. Depending on the installation type, the sound pressure level of the pump can be higher than 70 dB (A).

11.1.11 Storage temperature

Storage temperature: -4 to 131 °F (-20 °C to +55 °C). Maximum 158 °F (70 °C) for short periods not exceeding 24 hours (EN 60204-1, 4.5).

11.2 Electrical data

Voltage tolerances for the motor and the motor protection devices:

Component	Voltage	Tolerance
Motor	See the pump nameplate	± 10 %
Thermal switches	Maximum 240 V	± 10 %
Thermistors	2.5 - 7.5 V	-
Moisture switches	Maximum 240 V	-
Other sensors (optional)	Maximum 14 VDC	± 1 V
SM 113 (optional)	Maximum 14 VDC	± 1 V

11.3 Dimensions and weights

11.3.1 Dimensions

For pump dimensions, see the data booklet for each pump range at www.grundfos.com.

11.3.2 Weights

The weights stated include 49 ft (15 m) cable.

The weights of installation type S and C pumps include the weight of the guide claw.
The weight of installation type H pumps includes the weight of the horizontal base stand.

The weights stated are net weights including the accessories mounted from the factory.

Pump type	Net weight [lb (kg)]			
Range 50	S	C	D	H
SV.30.A30.139.2.50H	375 (170)	-	-	-
SV.30.A30.172.2.50H	419 (190)	-	-	-
S1.30.A40.134.4.50H.x.200	397 (180)	419 (190)	-	507 (230)
S1.30.A40.134.4.50H.x.212	441 (200)	485 (220)	-	552 (250)
S1.30.A40.147.4.50H	441 (200)	485 (220)	-	274 (260)
S1.30.A40.181.4.50H	441 (200)	485 (220)	-	274 (260)
S1.40.A40.134.4.50M	419 (190)	263 (210)	-	563 (255)
S1.40.A40.181.4.50H	419 (190)	263 (210)	-	274 (260)
S1.40.A50.134.4.50L	552 (250)	596 (270)	-	695 (315)
S1.40.A50.181.4.50L	552 (250)	596 (270)	-	695 (315)
Range 54	S	C	D	H
S1.30.A40.210.4.54H	662 (300)	728 (330)	-	794 (360)
S1.30.A40.270.4.54H	706 (320)	772 (350)	-	838 (380)
S1.40.A50.210.4.54M	662 (300)	728 (330)	-	794 (360)
S1.40.A50.270.4.54H	706 (320)	772 (350)	-	838 (380)
S1.40.A80.210.4.54L	794 (360)	860 (390)	-	948 (430)
S1.40.A80.270.4.54L	816 (370)	904 (410)	-	970 (440)
Range 58	S	C	D	H
S1.30.A50.340.4.58H	970 (440)	1059 (480)	1059 (480)	1147 (520)
S1.30.A50.420.4.58H	970 (440)	1059 (480)	1059 (480)	1147 (520)
S1.40.A50.420.4.58M	992 (450)	1103 (500)	1103 (500)	1191 (540)
S1.45.A80.420.4.58L	1081 (490)	1191 (540)	1191 (540)	1301 (590)
S2.40.A80.430.6.58L	1081 (490)	1191 (540)	1191 (540)	1301 (590)
S2.40.A120.430.6.58E	1235 (560)	1367 (620)	1323 (600)	1455 (660)
S range 62	S	C	D	H
S1.30.A50.540.4.62H	1323 (600)	1455 (660)	1588 (720)	1698 (770)
S1.30.A50.700.4.62H	1323 (600)	1455 (660)	1588 (720)	1698 (770)

Pump type	Net weight [lb (kg)]			
S1.30.A50.790.4.62H	1367 (620)	1500 (680)	1500 (680)	1632 (740)
S1.40.A50.540.4.62M	1323 (600)	1455 (660)	1588 (720)	1698 (770)
S1.40.A50.700.4.62M	1323 (600)	1455 (660)	1455 (660)	1698 (770)
S1.40.A50.790.4.62M	1367 (620)	1500 (680)	1500 (680)	1632 (740)
S2.40.A80.540.4.62L	1411 (640)	1544 (700)	1544 (700)	1698 (770)
S2.40.A80.700.4.62L	1411 (640)	1544 (700)	1588 (720)	1698 (770)
S2.40.A80.790.4.62L	1455 (660)	1610 (730)	1610 (730)	1742 (790)
S range 66	S	C	D	H
S1.40.A80.980.4.66H	1985 (900)	2183 (990)	2381 (1080)	2381 (1080)
S2.45.A100.760.8.66H	2205 (1000)	2426 (1100)	2426 (1100)	2646 (1200)
S2.40.A80.980.4.66M	1985 (900)	2183 (990)	2381 (1080)	2381 (1080)
S2.55.A120.430.8.66M	2426 (1100)	2668 (1210)	2911 (1320)	2911 (1320)
S2.55.A120.550.8.66M	2426 (1100)	2668 (1210)	2911 (1320)	2911 (1320)
S2.55.A120.760.8.66M	2536 (1150)	1800 (1270)	3043 (1380)	3043 (1380)
S3.45.A200.760.8.66L	2977 (1350)	3285 (1490)	3285 (1490)	3528 (1600)
S range 70	S	C	D	H
S2.35.A80.1270.4.70H	2315 (1050)	2558 (1160)	2558 (1160)	2866 (1300)
S2.35.A80.1610.4.70H	2425 (1100)	2536 (1150)	2756 (1250)	3087 (1400)
S2.45.A100.1070.8.70H	2536 (1150)	2800 (1270)	2800 (1270)	3043 (1380)
S2.45.A100.1470.6.70H	2536 (1150)	2800 (1270)	2800 (1270)	3043 (1380)
S2.45.A100.1880.6.70H	2800 (1270)	3087 (1400)	3087 (1400)	3351 (1520)
S2.40.A80.1270.4.70M	2315 (1050)	2558 (1160)	2558 (1160)	2778 (1260)
S2.40.A80.1610.4.70M	2315 (1050)	2558 (1160)	2558 (1160)	2778 (1260)
S2.55.A120.1470.6.70M	2866 (1300)	3153 (1430)	3153 (1430)	3440 (1560)
S3.45.A120.1070.8.70M	2866 (1300)	3153 (1430)	2977 (1350)	3285 (1490)
S3.45.A120.1880.6.70M	3131 (1420)	3440 (1560)	3440 (1560)	3748 (1700)
S3.45.A200.1070.8.70L	3858 (1750)	3967 (1800)	3967 (1800)	4233 (1920)
S3.45.A200.1880.8.70L	4300 (1950)	4630 (2100)	4410 (2000)	4718 (2140)

12. Disposing of the product

This product or parts of it must be disposed of in an environmentally sound way:

1. Use the public or private waste collection service.
2. If this is not possible, contact the nearest Grundfos company or service workshop.

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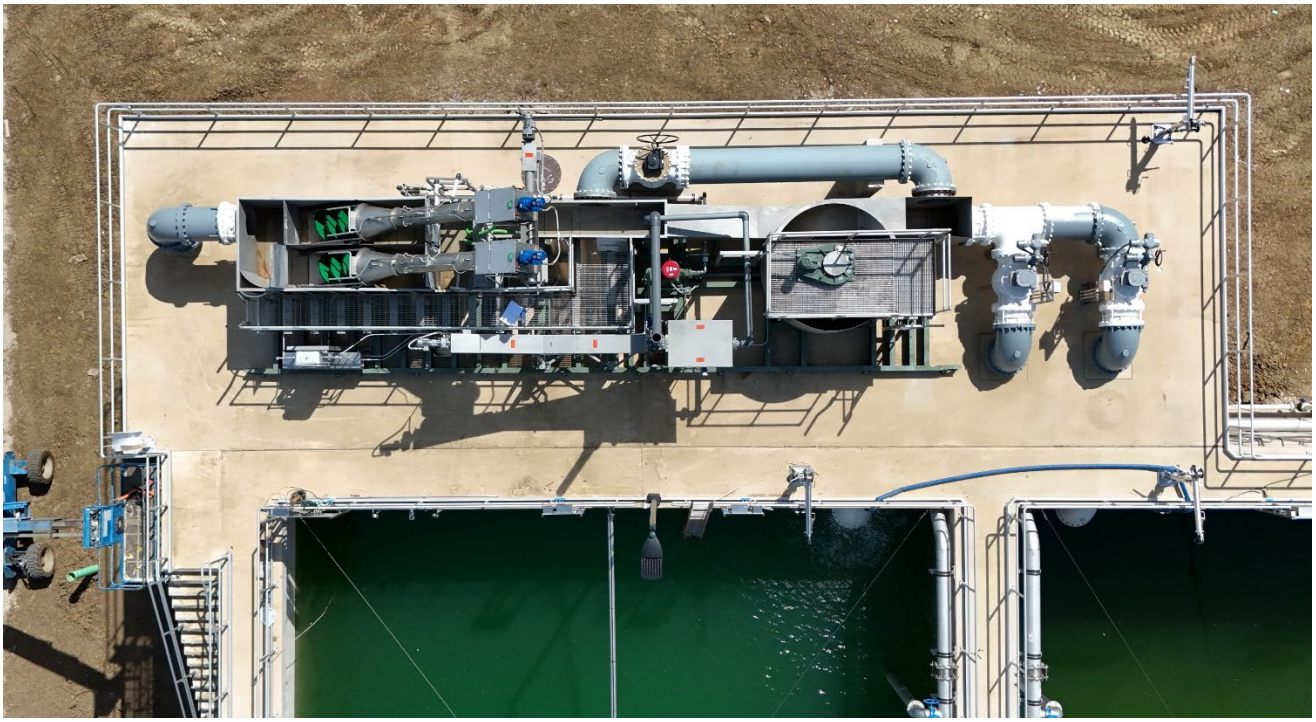
GRUNDFOS

Packaged Headworks

Smith & Loveless, Inc.

Proposal

PISTAWORKS® With V-Force Baffle Grit Removal System



Proposal Prepared for:

Northeastern University – Boston, MA

March 27, 2026

Presented by:

Smith & Loveless, Inc.

14040 Santa Fe Trail Drive
Lenexa, KS

Russell Resources

Brewer, ME

Dear Ms. Scott,

Thank you for your interest in Smith & Loveless regarding your grit system equipment needs for the **Northeastern University WWTP** project. With the original introduction of the **PISTA®** Vortex Grit Removal System in 1973, to the **now over 3,300 installed units**, we are pleased to submit information on our latest generation grit chamber, grit pump, grit washing & dewatering equipment, and system controls. A few key items to consider:

1) The proposed vortex **grit chamber from S&L is designed for 95% capture of grit >105 micron (140 mesh) at all flows with a 10:1 turndown**. Not all grit equipment suppliers can achieve these results. Test data is available from numerous S&L projects demonstrating these higher removal rates. Our grit washer/dewatering equipment matches the particle capture of chambers with use of parallel plates in the receiving hopper. A properly designed headworks system will consider how the entire grit system works together to optimize grit removal, not just on individual components.

2) While a vortex chamber looks like a clarifier, it is not a laminar or quiescent basin; the baffled **PISTA®** chamber design is based on a hydraulically induced vortex. With these generated currents, grit removal doesn't rely on gravity-based settling or surface overflow rates (SOR). **This means the S&L vortex chamber isn't de-rated** and captures a wide range of particle specific gravities – not only limited to 2.65. Computational Fluid Dynamics (CFD) modeling and particle cut off equations demonstrating our system design can be provided.

3) With decades of experience, we are helping to shape the grit industry and offer value to our customers through quality and proven technological advances. Value is a word that often gets over-used in buying and selling arenas and thus its true worth is often de-valued. More than just meaning "better" or "lower" price, best value incorporates the total installed cost. Total installed costs include operating costs, durability of the equipment, and post-sale support. With the intent of properly investing in a modern design with future goals, one must look past the emphasis on initial price and be *best value conscious*. **There are three ways to structure the bid format and be *value conscious*: pre-purchase, single source specification, or base bid specification (award on base bid)**. If you need additional details to maintain control over the selection of equipment, please contact us for specific examples and/or pros-and-cons of each format.

We would also invite your team to our manufacturing facility in Lenexa, KS to observe our American Made products and a **full scale 4 MGD R&D grit removal facility**. This hands-on tool shows how the S&L equipment functions and can be utilized for operator training and certification. We can even customize the grit feed entering the demo unit to your specific site needs.

We at S&L and our local representative, appreciate this opportunity and look forward to offering further information as the project progresses, including CAD files, Revit model(s), hydraulic analysis, grit characteristic evaluation and ongoing headworks design assistance backed by decades of industry leading experience.

Sincerely,

Jeffery Hunninghake
Manager, Municipal Treatment Systems

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Smith & Loveless, Inc., having an office at 14040 Santa Fe Trail Drive, Lenexa, Kansas 66215 (hereinafter referred to as “Seller”), hereby agrees to sell to the City of _____ designated below (hereinafter referred to as “Buyer”), the following equipment subject to all of the provisions set forth in this Sales Agreement. The Sales Representative is not an agent or employee of Seller and is not authorized to enter into any agreement on Seller’s behalf or bind Seller in any way.

The information contained herein is considered proprietary and confidential. It is not to be released without prior written permission from Smith & Loveless, Inc.

1.0 GENERAL DESCRIPTION: One (1) Model 0.5B **PISTAWORKS®** skid mounted factory-built grit removal systems, suitable for installation on a concrete pad. Each **PISTAWORKS®** shall be complete with the following: mechanical fine screen, inlet channel, drive motor, spur gear final drive head, propeller, fluidizer vanes, **V-Force Baffle™,** drive tube, and grit pump. Automatic QuickSmart PLC controls in NEMA 4X-316SS enclosure also included. Each **PISTAWORKS®** grit removal system is designed for a peak flow of 0.5 MGD while maintaining grit removal performance as specified. All wetted components to be 316SS.

Grit System Performance Requirements

Design Peak Flow	Design ADF	Particle Size	Removal Efficiency
0.5 MGD	na MGD	>140 mesh (105 micron)	95%

*removal efficiency valid for all flows up to rated peak flow rate.

Benefits of Smith & Loveless Grit Removal System:

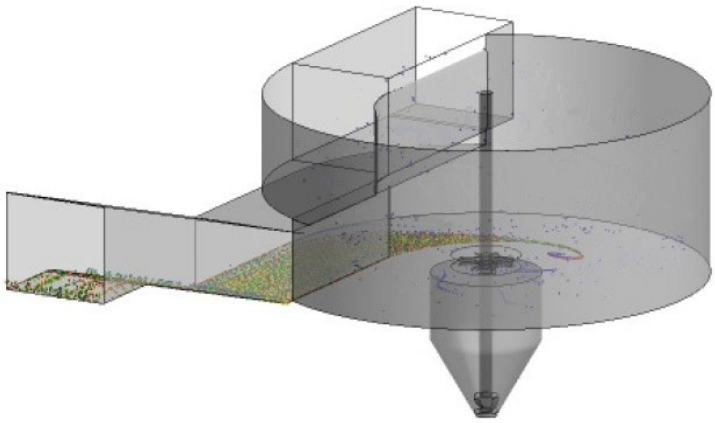
- Fully Integrated System Includes Screen, Grit Chamber, Grit Pump, Grit Classifier/Washer, & Controls
- Industry Leading Grit Removal Performance 95% of Grit greater than 105 microns at all flow conditions
  - Option available to upgrade for 95% Removal of all Grit greater than 75-micron
- Capability to Produce Clean, Dry Grit for Disposal (<10% Water, <5% Putrescible Organics)
- Long Life Recessed Impeller Designed Grit Pumps (35+ Years Engineering, Design & Mfg Experience)
- PLC Based Controls System to Manage Integrated Components

2.0 OBEX™ FINE SCREEN: Mechanical fine screen shall consist of a 6 mm stationary perforated plate cleaned by brushes mounted on the outer edge of a shafted screw. A single drive for each screen is used for conveying the screening material to a washer/compactor zone and discharging to a conveyor to dumpster. The operation of the screen is automatically initiated at the preset high liquid level and/or by a programmable timer and the unit shall remove solids from the screenings basket by the action of a concentric screw conveyor. Option for duty/standby available.



3.0 PISTA® GRIT REMOVAL EQUIPMENT: The flow in the removal chamber shall travel between the inlet and outlet a minimum of 360 degrees, providing maximum travel of the liquid for effective grit removal. The **PISTA®** with **V-FORCE BAFFLE ™** shall remove 95% of grit particles down to 140 mesh (105 micron) particle size at the designed hydraulic peak flow rate, with no decrease at flows less than the designed peak flow of 2.5 MGD. **Inlet ramp** used to condition particles of various settling velocities for capture in main chamber hydraulic vortex. **Propeller blades** reduce organic capture and lower burden of the dewatering equipment. **Fluidizer vanes** provide mechanical fluidization of the lower grit hopper and eliminate the need for additional water lines to the chamber, eliminating at least 20 gpm of continuous water addition. **Lower grit storage hopper** allows for intermittent pump operation and removal of accumulated grit.

CFD modeling of grit path:



S&L recommends the water level be controlled by **V-FORCE BAFFLE™**, which results in industry leading **10:1 turndown & maintains grit removal performance**. Internal baffle headloss numbers at peak flow shall be provided once chamber size/configuration is specified.

The **PISTAWORKS®** with **V-FORCE BAFFLE ™** shall remove 95% of grit particles down to 140 mesh (105 micron) particle size at all flows up to the design peak flow. The Table(s) below provides velocity and headloss calculations for the selected PISTA Model up to 110% of designed peak flow.

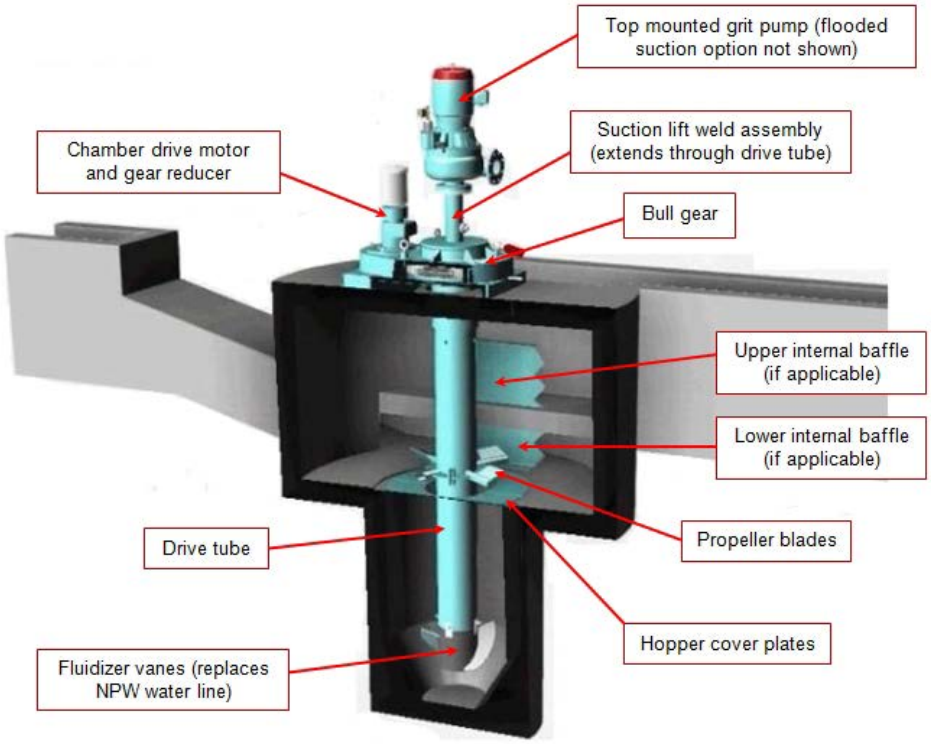
0.5B PISTA with V-Force Baffle Controlling the Velocity					
Flow (MGD)	H1 (Q) (ft)	V1 (ft/s)	H2 (P) (ft)	Headloss (ft)	Headloss (in)
0.05	0.13	1.15	0.09	0.04	0.5
0.10	0.21	1.44	0.14	0.07	0.8
0.15	0.28	1.65	0.19	0.09	1.1
0.20	0.34	1.82	0.23	0.11	1.3
0.25	0.40	1.95	0.26	0.13	1.6
0.30	0.45	2.07	0.30	0.15	1.8
0.35	0.50	2.18	0.33	0.16	2.0
0.40	0.54	2.28	0.36	0.18	2.2
0.45	0.59	2.37	0.39	0.19	2.3
0.50	0.63	2.46	0.42	0.21	2.5
0.55	0.67	2.54	0.45	0.22	2.7

4.0 DIMENSIONS: The standard dimensions of the Model 0.5B PISTAWORKS are as follows:

Skid Width	8'-0"
Skid Length	31'-0"
Approximate Weight	20,000 lbs
Flanged Inlet	12"
Inlet Elevation to Center Line	4'-3"
Flanged Outlet	12"
Outlet Elevation to Center Line	1'-9"



5.0 GRIT REMOVAL OPERATION: Chamber drive mechanism runs continuous to provide organic separation and grit fluidization. The chamber lower grit hopper provides storage capacity to allow for intermittent pump operation - typical factory setting is 15 minutes every 4 hours. During storm events the pump can run continuously to ensure storage capacity is not exceeded.



The **Model 15** grit dewatering equipment runs when the grit pump runs, then for a field adjustable duration after pump cycle is completed - typical factory setting is 10 minutes after pump. The optional **Model 250 Turbo Grit Washers** provide optimal performance (see table) be required**.** Grit Washer dewatering equipment runs independent of the grit pump and uses mechanical

agitation, air infusion, and water flushing for washing cycles. Grit level depth probe will initiate ejection cycles.

Model 250 Turbo Grit Washer Performance Features	
Max. Grit Slurry Feed Rate	275 GPM
Max. Water Content	≤ 10% (passing "Paint Filter" test)
Organic Removal	≤ 5% putrescible material
Grit Retention	95% of Grit > 140 mesh (105 microns)
Capacity	2.47 tons/hr



6.0 UTILITY REQUIREMENTS

Item	Motor	Water Usage
OBEX Fine Screen w Washer-Compactor	2.0 HP	30gpm Intermittent
Chamber drive motor	0.75 Hp	0 gallons/day
Grit slurry pump	5 Hp	50gpm Intermittent[1]
Grit cyclone	0 Hp	0 gallons/day
Model 15 Grit Classifier	1 Hp	0 gallons/day
Model 250 Grit Washer	3 Hp	20gpm Intermittent

[1] Example: 50-75 gpm (250gpm pump) for 5 min. before and after each pump cycle (flooded suction pump only).

7.0 CORROSION PROTECTION

All fabricated steel components shall be commercial blasted and prime coated by the Manufacturer with one 3-mil DFT coat of Tnemec 66-1211 prior to shipment. All motors and gearboxes shall be furnished with the original manufacturer's coating. Final touch up and finish painting is the responsibility of the purchasing contractor. 304 or 316 stainless steel available.

8.0 DELIVERY, TERMS, BUDGET PRICING

Submittal drawings and other technical engineering details are expected to be complete in 8 weeks after receipt of a purchase order. Once Smith & Loveless receives approved drawings, manufacturing would take 36-40 weeks. **Payment Terms -**To be determined

Budget Pricing (FOB Factory) - Estimate Valid for 30 days	
One (1) Model 0.5B **PISTAWORKS®** Grit Removal Skid Mounted System (316SS Chamber)	$ 685,000
One (1) Grit Chamber Mechanisms and 316SS Wettable Internals	Included
One (1) 316SS **V-FORCE Baffles** for Increased Removal and Turndown	Included
One (1) Mounted 250 GPM **Turbo Grit Pump** with NiHard Impeller and Volute	Included
One (1) 316SS **Model 15 Grit Classifier**	Included
One (1) 250 GPM **NiHard** Concentrator	Included
One (1) OBEX Model 1.0C 316SS Automatic Fine Screens (6mm)	Included
One (1) NEMA 4X MicroLogix QuickSmart PLC Main Control Panels	Included
Carbon Steel Skid	Included
One (1) Trip for Start-Up and Training over 3 Days	Included
Freight	Included
OPTIONS	
Adder for PISTA INVORSOR Internals for 95% of 75-micron Grit Removal	$ 95,000
Adder for One (1) 316SS Model 250 Grit Washer (in lieu of Grit Classier)	$ 49,000

ITEMS NOT INCLUDED

- Heat Tracing or Explosion Proof
- Field assembly/erection or installation
- Interconnecting piping, wiring and conduit
- Field paint, painting, and final surface preparation
- Lubricants
- Anchorage, anchor bolts
- Field testing, if required
- Grouting or any concrete work



PISTA® Overview:



PISTA® GRIT REMOVAL SYSTEM

- **Latest Technology in Grit Removal**
- **Prevents Grit Deposition in Channels and Basins**
- **Retrofit Into Existing Chambers**
- **Grit Classifiers or Grit Washers**

Highest Grit Removal Efficiency	**95% down to 75 microns with no decrease in efficiency at flows less than the peak rated flow. Protects downstream basins from deposition and pumps from premature wear**
Smallest Footprint	**½ the size of Stacked Tray systems, 7 times smaller than Aerated Grit Chambers, and 3 to 4 times smaller than Detritors**
Handles Wide Variations in Flow	**Provides 10:1 turndown from peak to minimum flow versus other systems that can only achieve between 3:1 & 4:1**
Velocity Control Option	**Automatically keeps the inlet velocity between 1.6 & 3.5 ft/s to prevent grit deposition upstream of the PISTA**
Energy Savings	**7 to 10 times less energy than Aerated Grit Chambers, PISTA pumps and classifiers operate only 4 times per day, 15 to 30 minutes each time**
Centrifugal Pump	**Provides much higher velocity than airlifts to prevent grit plugging pump discharge lines**
Fewer Units Required	**Single grit systems designed to handle up to 100 MGD**
Lowest TCoO	**PISTA provides significantly reduced capital costs and much lower operation and maintenance**
TURBO™ Grit Washer	**High Performance grit classification: ≤ 5% Putrescible Organics; ≤ 10% Water Content (passing "Paint Filter" test); 95% of Grit > 105microns**

Grit System Component Selections:

PISTA® TURBO™ Grit Pump

✓ Vertical, recessed impeller, close-coupled design featuring **Ni-Hard** construction of the pump and impeller, oversized stainless steel shaft and long bearing life. Engineered design grit slurry pump that can be located on top or in a flooded suction arrangement.



PISTA® Grit Concentrator

✓ Secondary grit cyclone constructed of **Ni-Hard** abrasion resistant materials. Designed to separate the grit from the slurry to reduce the water and organic load on the grit classifier. 90% of the pumped flow is returned to the inlet of the PISTA. Three configurations available: One-piece all NiHard, Two-piece all NiHard, or Two-piece NiHard/Duralyte



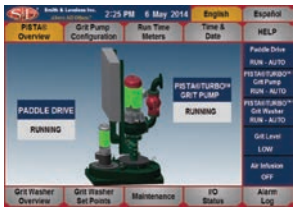
PISTA® Grit Screw Conveyor or Turbo Grit Washer

✓ Designed to retain ultra-fine grit utilizing an energy dissipation zone, parallel plates in the grit hopper and a double sided weir box to reduce the overflow rate.



QuickSmart™ Touchscreen System Controls

✓ PLC controls with intuitive HMI control interface. Designed to integrate with plant SCADA systems



Relay Logic System Controls

✓ Control system comprised of relays and timers along with motor starting controls to allow for simple control.



Stainless Steel Grit Chamber/Hopper & Inlet/Outlet Channels

✓ Alternative to concrete construction available in 304 or 316 SS.





S&L PISTAWORKS® Skid Mounted Grit Removal System



Stainless Steel PISTA® Grit Chamber, Grit Hopper, & Grit Classifier



Steel PISTA® Grit Chamber, Concrete Encased

AN INTRODUCTION TO SMITH & LOVELESS, INC.

Located in Lenexa, Kansas, Smith & Loveless is a leading U. S. manufacturer of water and wastewater treatment and pumping equipment. With its equipment utilized by municipalities and industries in the U.S. and around the world, the Smith & Loveless product line includes:

WASTEWATER PUMPING EQUIPMENT UP TO 100,000 GPM

The Smith & Loveless Non-Clog Pump was the first wastewater pump to use a mechanical seal and a 100% factory-built pump station. Since its invention, the Smith & Loveless pump has proven its reliability in more than 21,000 separate pumping installations worldwide. Smith & Loveless also developed the station that mounts directly on top of a wet well, pumping up to 7,500 GPM.

PRE-ENGINEERED TREATMENT PLANTS

Smith & Loveless developed the market for smaller treatment plants designed for schools, subdivisions, hotels, hospitals, offshore drilling rigs, resorts, various industrial applications and municipalities. These plants have major advantages, which include proven design, lower cost installation and reduced construction time. Our treatment plants range in flow capacity from 1,000 GPD to 5 MGD in single units, with seven (7) separate product lines, including the **TITAN MBR™**.

WASTEWATER TREATMENT EQUIPMENT

Smith & Loveless offers a complete line of wastewater treatment equipment for the larger component type municipal and industrial systems. It is highlighted by the **PISTA®** Grit Removal System. Other well known Smith & Loveless component products are the LOOP Brush Aerator, the Kraus-Fall peripheral feed clarifier, the **PACE®** oil/water separator, the **DI-SEP®** SX Filter and the Marine **FAST®**.

WATER TREATMENT EQUIPMENT

Smith & Loveless also has a complete line of water treatment equipment. Included are the **FIBROTEX®**, the **IMF PROTECTOR™** Ultrafiltration System, the **IRONMAN™** System, the **SCIENCO®** Brinemaker, the **DISEP®** Nitrate Removal Filter, the **SCIENCO®** Sodium Hypochlorite Generator, the **CLAR-I-VATOR®** and more. This line encompasses both component equipment and package treatment plants from 10 GPM (0.6 lps).

COMPANY PROFILE

Smith & Loveless was founded in 1946 by B. Alden Smith and Compere Loveless as a Sales Engineering Firm representing several manufacturers in the wastewater industry. Early in their association, Smith & Loveless recognized the need for complete factory-built wastewater pump stations and began manufacturing this equipment. Their first three stations were built for the municipal wastewater system of Salina, Kansas. These units were fabricated in a converted barn less than three miles from the present plant location.

As demand for this equipment grew, Smith & Loveless built their first manufacturing plant – a modest structure a few miles from the present plant site. Sales increased rapidly and within a short time, Smith & Loveless had sales representatives throughout the United States and Canada. Because of this rapid growth, it was necessary to expand the plant five times in four years.

The present site in Lenexa, Kansas (a Kansas City suburb) was selected in 1957. By 1958, the new manufacturing facility was ready for production. This present plant has been expanded several times, more than tripling the original manufacturing and office space (over 100,000 square feet of manufacturing space). Late in 1959, Smith & Loveless was acquired by Trans Union Corporation, which was based in Lincolnshire, Illinois. This acquisition

complemented markets served by other divisions of that firm, as well as providing additional capital for expansion and research and development, ensuring Smith & Loveless' leadership in the wastewater industry.

In February 1981, Trans Union merged with the Marmon Group, a largely privately held corporation. In October 1981, the management of the Smith & Loveless Division purchased the assets of the Division from the Marmon Group, and Smith & Loveless, Inc., was reborn. Smith & Loveless renewed its commitment to maintain its role as a leader in the water and wastewater treatment and pumping industry through the design and production of quality equipment, and by providing superior service.

To continue to strengthen its leadership position, Smith & Loveless, on October 1, 1984, purchased two firms: **SCIENCO®**, Inc., of St. Louis, Missouri and DI-SEP® Systems International, Inc., of Santa Fe Springs, California. On August 1, 1985, Smith & Loveless added another subsidiary by acquiring St. Louis Marine Systems, Inc., renamed FAST® Systems, Inc. – Later, **SCIENCO®,** Inc., and **FAST®** Systems, Inc. were merged into **SCIENCO/FAST®** Systems, Inc. In 1987, Smith & Loveless made another step to provide additional capabilities in water treatment by acquiring K-W Industries. K-W was previously located in Omaha, Nebraska. In 1993, the above mentioned companies and their products were all absorbed into Smith & Loveless and its product line.

In a move to both strengthen Smith & Loveless, Inc.'s water product line and expand into the European marketplace, Smith & Loveless Limited, an affiliated company of Smith & Loveless, Inc., acquired the majority interest in Kalsep Limited of Camberley, England on March 29, 1995. Licenses granted allow Smith & Loveless products to be sold by Kalsep Limited and Kalsep Limited's water products to be sold in Smith & Loveless' markets.

In June 1996, in a move to specially develop, manufacture and market wastewater treatment systems for the on-site residential marketplace, an affiliated company, Bio-Microbics, Inc., was formed.

Further international expansion occurred on March 20, 1998, when Smith & Loveless New Zealand Ltd. Was granted licenses to market and sell Smith & Loveless, Inc. technology and equipment in New Zealand and Australia. And in a strategic move in August of 1999, Smith & Loveless Limited – UK began to more actively market and sell Smith & Loveless, Inc. technology in the UK.

On the domestic front, in June of 2000, Smith & Loveless Georgia Inc. was formed. This allows the Company to provide superior pump station sales and service for its Georgia customers.

Smith & Loveless actively pursues the patents of its inventions. The Company currently owns more than 50 active U.S. patents, holds foreign patents in 15 different countries, has several patent applications pending and has more than 25 domestic and foreign trademarks.

Smith & Loveless has actively engaged in R&D. Smith & Loveless' approach to research and development is both the search for new applications of existing product lines, as well as development of completely new concepts. Through these efforts, Smith & Loveless has been able to enter previously untapped markets. The Company's products are sold mainly through manufacturers' sales representative companies, with more than 150 such contract companies located worldwide.

Smith & Loveless employs approximately 250 people direct. Approximately 65 employees are represented by the United Steel, Paper and Forestry, Rubber, Manufacturing, Energy, Allied Industrial and Service Workers International Union Local No. 13-18. The total Lenexa, Kansas facility today encompasses 115,000 square feet of manufacturing and office space. Smith & Loveless will continue to expand and offer new and better solutions for a world of water.

Smith & Loveless Inc.



PISTA®
GRIT REMOVAL SYSTEM

Budget Proposal



Project Location:

Northeastern - Student

Proposal Date:

3/26/2026







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Smith & Loveless Inc.

Thank you for your interest in Smith & Loveless regarding your grit system equipment needs.

With the original introduction of the PISTA® Vortex Grit Removal System in 1973 to the now over 2900 units, we are pleased to submit information on our latest generation grit chamber, grit pump, and grit washing/dewatering equipment. A few key items:

1) The vortex grit chamber proposed is designed for 95% capture of grit ≥105 micron (140 mesh). Test data is available from numerous projects demonstrating these higher removal rates. A deduct can be provided if you want to proceed with conventional systems based on the original 1970s design. Our grit washer/dewatering equipment matches the particle capture of chambers with use of parallel plates in the receiving hopper. Remember, a properly designed headworks system will take into account the entire system removal, not only individual components.

2) While a vortex chamber looks like a clarifier, it is not a laminar or quiescent basin; the baffled PISTA® chamber design is based on a hydraulically induced vortex. With these generated currents grit removal doesn't rely on gravity-based settling or surface overflow rates (SOR). This means the vortex chamber isn't de-rated at peak flow and captures a wide range of particle specific gravities – not only limited to 2.65. Computational Fluid Dynamics (CFD) modeling and particle cut off equations demonstrating our system design can be provided.

3) With our decades of experience, we are helping to shape the grit industry and offer value to our customers with quality and proven technological advances. Value is a word that often gets over-used in buying and selling arenas and thus its true meaning itself is often de-valued. More than just meaning "better" or "lower" price, best value incorporates the total installed cost. Total installed costs include operating costs, durability of the equipment, and post-sale support. With the intent of properly investing in a modern design, with future goals, one must look past the emphasis on initial price and be best value conscious. There are at least three good ways to structure the bid format and be value conscious: pre-purchase, single source specification, or base bid specification (award on base bid). If you need additional details to maintain control over the selection of equipment, please contact us for specific examples or pros-and-cons of each format.

We would also invite your team to the manufacturing facility in Lenexa, KS to see our American Made products and a full scale 4 MGD R&D facility. This hands-on tool shows how the S&L equipment functions and can be utilized for operator training and certification. We can even custom build the grit feed entering the demo unit to your specific site needs.

Again, S&L and our local representative, appreciate this opportunity and look forward to offering further information as the project progresses, including CAD files, 3D Revit model(s), hydraulic analysis, grit characteristic evaluation and ongoing headworks design assistance backed by decades of industry leading experience.

Sincerely,

Ryan Asbury
Manager, Municipal Treatment Systems

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Solve Issues of Non-Performing & Under-Performing Grit Removal Systems



Grit Build Up in Digesters



Grit Deposition in Process Basins



Centrifuge Abrasion



Impeller Wear

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Manufacturer's History

Smith and Loveless (S&L) is the industry leader when it comes to vortex grit removal equipment. We have manufactured over 2,900 systems and continued to make advancements of 40 years with four generations of units.

Advancements in Grit Removal through the Decades

1973 1st Gen PISTA - 270deg
1982 TURBO Grit Pump and Concentrator
1977 1st Certified Grit Removal Efficiency Test
1985 NiHard TURBO Grit Pump
1988 2nd Gen PISTA - 360deg
1989 Lamella Plates within a Classifier
2008 3rd Gen PISTA - V-Force Baffle
2009 Sonic Start Streamline
2010 PISTA TURBO Grit Washer
2010 Skid Mounted Headworks - PISTAWORKs
2013 Grit Removal Research Center Opens
2014 1st Gen PISTA - OPTIFLOW
2015 4th Gen PISTA - VIO

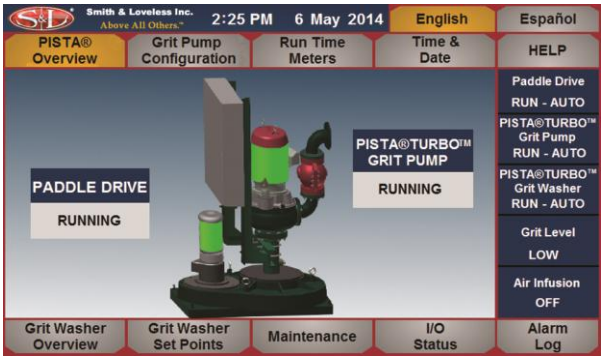
	270°	360°	OPTIFLOW	V-FORCE	VIO
Chamber Type	Conventional Vortex		Baffled Vortex		
300 micron	95% Removal		95% Removal		
210 micron	85% Removal		95% Removal		
150 micron	65% Removal		95% Removal		
105 micron	N/A			95% Removal	
Turndown	4:1			10:1	
Footprint	★	★★	★	★★	★★★
Depth	★★★	★★★	★★★	★★★	★★

One Manufacturer, One Complete System, One Point of Responsibility

S&L is the only manufacturer who makes equipment for the vortex chamber, pumps specifically designed to reliably move abrasive grit slurries, and dewatering classifiers or grit washers that retain fine grit. While the grit chamber is important, it is the system working together that mattters.

QUICKSMART™ Touchscreen System Controls for PISTA®

QUICKSMART™ System Controls provide unparalleled ability to monitor and adjust grit removal functions including pumping, removal and washing. Control modifications, screen navigation and viewing of system status are simplified, while new features like a maintenance log displays periodic recommended operation / maintenance instructions and makes grit pump lubrication suggestions based on actual system run times. It features improved help/troubleshooting support and a new I/O Status screen that displays controller digital and analog I/O status.



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Smith & Loveless Inc.



PISTA
GRIT REMOVAL SYSTEM

- Latest Technology in Grit Removal
- Prevents Grit Deposition in Channels and Basins
- Retrofit In To Existing Chambers
- Low Head Loss

Highest Grit Removal Efficiency	**95% of 105 micron and up versus antiquated specifications of as low as 65% grit removal. Protects downstream basins from deposition as well as pumps and sludge dewatering equipment from premature wear.**
Smallest Footprint	**7 times smaller than Aerated Grit Chambers and 3 to 4 times smaller than Detritors. Less depth than sloped floor circular chambers.**
Handles Wide Variations in Flow	**Provides 10:1 turndown from peak to minimum flow versus other systems that can only achieve between 3:1 & 4:1. Protects upstream channels from deposition during low flow periods.**
Velocity Control	**Automatically keeps the inlet velocity between 1.6 - 3.5 f/s to prevent grit deposition upstream of the PISTA.**
Energy Savings	**7 to 10 times less energy than Aerated Grit Chambers; PISTA® pumps and classifiers operate typically 4 times per day, 15 to 30 minutes each time.**
Recessed Impeller Pump	**Provides much higher velocity than airlifts to prevent grit plugging pump discharge lines.**
Fewer Units Required	**Single grit systems designed to handle up to 100 MGD.**
Lowest Total Expenditure Cost	**PISTA® provides significantly reduced capital costs and much lower operation and maintenance than other systems**

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PISTA® Options

PISTA® PRO-PAK™: Weather & Freezing Protection

PISTA® PRO-PAK™ protects your **PISTA® TURBO™** Grit Pump against weather and freezing by mounting the critical grit removal system components inside of a retractable fiberglass enclosure. It is a cost-effective alternative to a building, while still offering freeze protection in harsh climates.



PISTA® WORKS™: All-in-One Skid Package

PISTA® WORKS™ features a complete headworks and grit removal scheme in a skid-mounted package. The all-in-one system features a screen and grit removal chamber, as well all grit handling components including grit pump, concentrator and washer. All components are constructed of durable stainless steel.



Steel Tank and/or Influent Ramp or Shelf

Stainless steel packages are available including for tankage, influent ramp or shelf. The steel components are manufactured in pieces and welded together onsite.



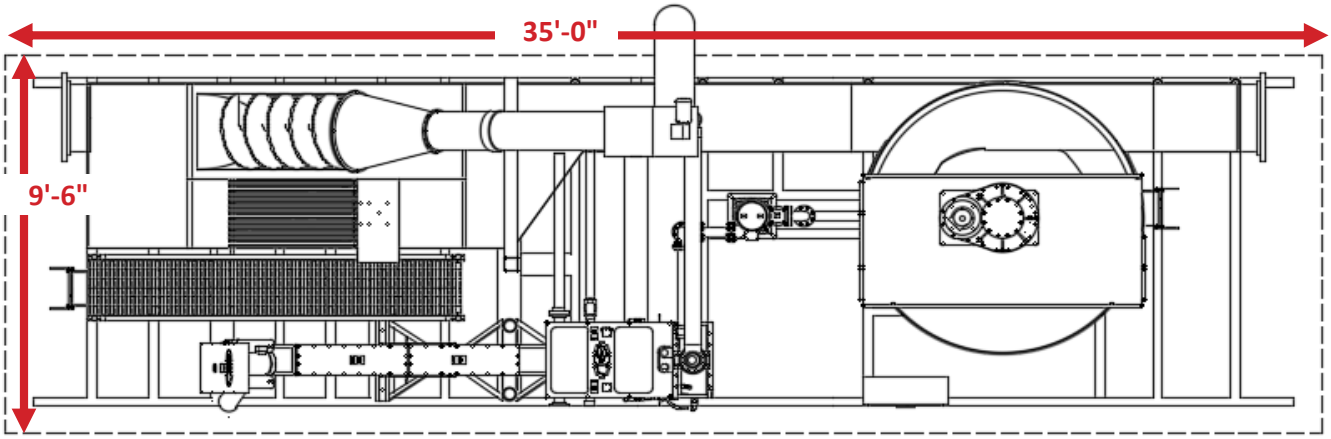
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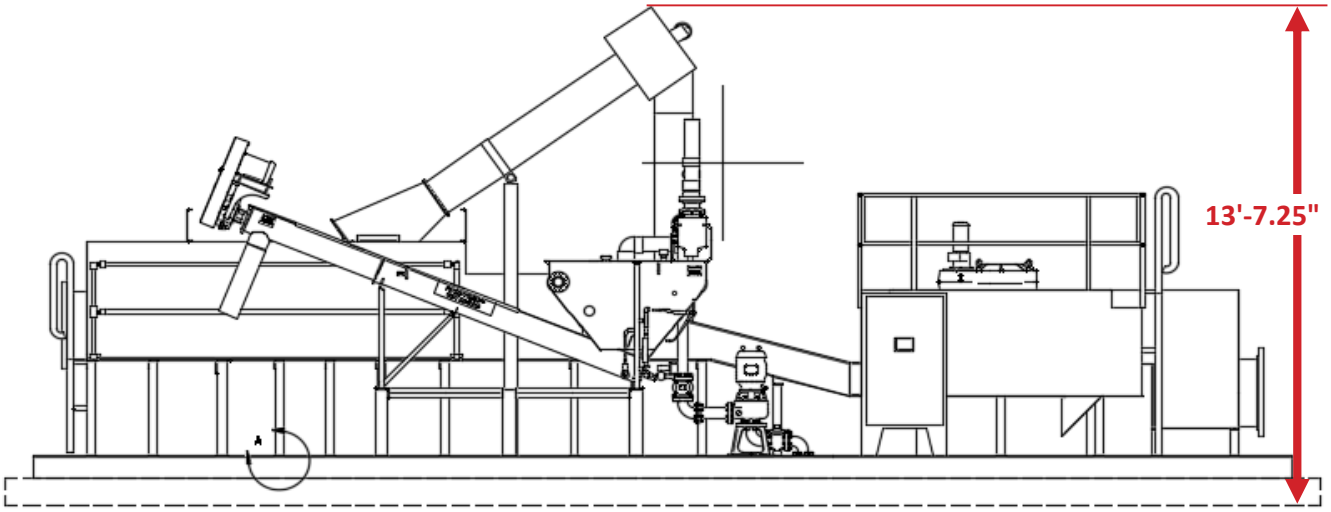
PISTAWORKS® Complete Screening and Grit Removal All-in-One Package

- Pre-assembled and shipped, virtually eliminating construction costs
- Complete system design and compact footprint

(Assumes non-classified area for system. Explosion proof motor, conduit, and remote mount panel optional.)

ESTIMATE VALID FOR 90 days (FOB Factory, Taxes Excluded)	
One (1) Model 2.5B PISTAWORKS	**$ 665,000**
One (1) 6 mm OBEX™ Spiral Fine Screen with manual bar screen bypass	Included
One (1) Grit Removal Chamber with V-Force Baffle for 95% of 105 micron	Included
One (1) PISTA Turbo Grit Pump, & One (1) 2-piece NiHard Grit Concentrator	Included
One (1) PISTA® TURBO Grit Washer	Included
One (1) NEMA 4X Control Panel with QuickSmart PLC	Included
All Items are 304SS or Aluminum (except epoxy coated carbon steel skid)	Included
Two (2) Trips for Start-Up and Training over Three (3) Days	Included
Freight	Included





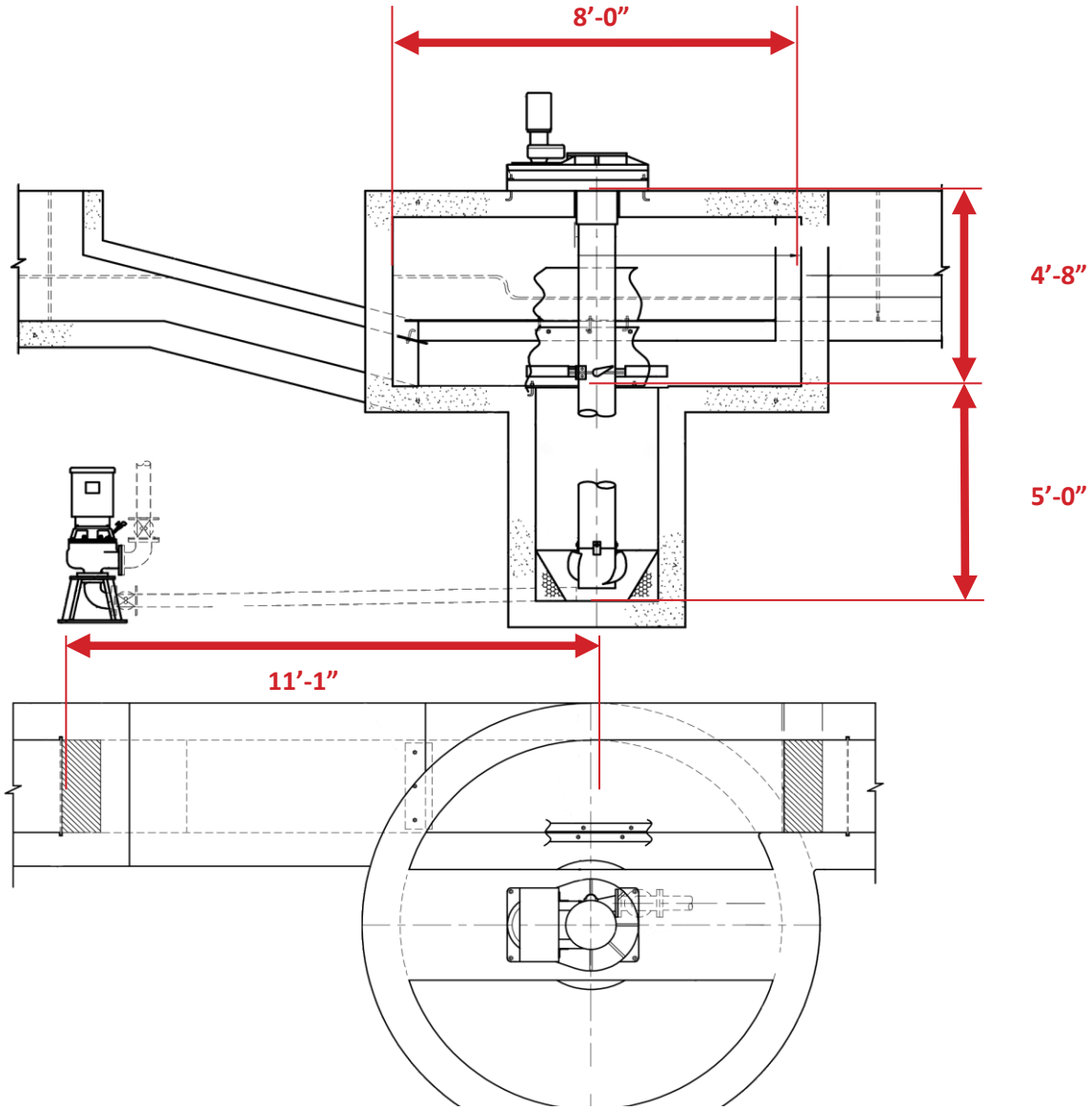
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PISTA V-Force Baffle Layout (3rd Generation Baffled Vortex)

Smith & Loveless offers both a top mounted vacuum prime grit pump and flooded suction grit pump. Both options have their pros and cons. Flooded suction grit pumps don't have priming cycles and duplex pumps for increased redudancy are possible. However, attention needs to be paid to the flushing of the suction lines prior to pumping.

The PISTA with V-Force Baffle offers a compact but fixed layout to achieve its industry leading grit removal.



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PISTA® TURBO™ Grit Pump for Maximum Grit Pumping Efficiency

Smith & Loveless offers a grit pump and is the only manufacturer that can have a single point of responsibility. It incorporates a number of features for improved durability and serviceability.

- S&L uses a vertical, direct coupled pump versus a belt driven horizontal pump. Operators like not having belts to maintain, and appreciate the vertical arrangement of the S&L design.
- Vertical pumps allow for grit slurries to remain inside the pump volute when having to access the impeller via removal of the rotating assembly. The horizontal grit pumps when split open, allows the grit slurry to spill over the working area and process piping needs to be taken apart.
- S&L grit pumps take less space than the horizontal.
- S&L grit pumps don't require shaft sleeves to the carbons steel shaft, nor do they require wear plates. The S&L design is driven by a solid stainless steel shaft with a diameter of either 1 -7/8” or 2-1/8”.
- Ni-Hard Impellers and Ni-Hard Volutes allow for long life in an abrasive applications.
- Vertical pump configuration allows flexibility of installing the grit pump in a flooded suction or top mounted vacuum primed arrangement.
- For top mounted applications, S&L is the only manufacturer to offer vacuum primed grit pumps instead of wastewater cast iron self-primer that is not design for grit slurry applications.





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PISTA® DURALYTE® Grit Concentrator or Hydrocyclone

Smith & Loveless offers a hydrocyclone that has the same removal efficiency as our PISTA chamber. It incorporates a number of features to retain the finest grit, while still separating organics and water.

- 2-piece Design for Improved Durability and Serviceability.
- **PISTA® DURALYTE®** with Polyurethane Lower Cone for Typical Grit Applications.
- **PISTA® DURALYTE®** with Ni-Hard lower cone for Heavy Grit Applications
- Rejects 95% of putrescible material and 93% of grit slurry water
- Large discharge opening prevent clogs
- Optimized for 250 GPM (4" piping) and 500 GPM (6" piping)
- When pin-hole leaks are visible in the lower cone, it is time to replace. Replacement time can be found below.
- Other hydrocyclones have liners that have to be checked and replace quarterly. Every year that is 12-18 man-hours to remove the hydrocyclone, take it apart, check liners, and put it all back together. If that maintenance is missed, the costly body of the hydrocyclone must be replaced.

PISTA® DURALYTE®
Polyurethane Bottom Cone
Replacement Time about 20 minutes
Typical Lifespan of 1-3 years



PISTA® DURALYTE®
Ni-Hard Bottom Cone
Replacement Time about 60 minutes
Typical Lifespan of 3-5 years



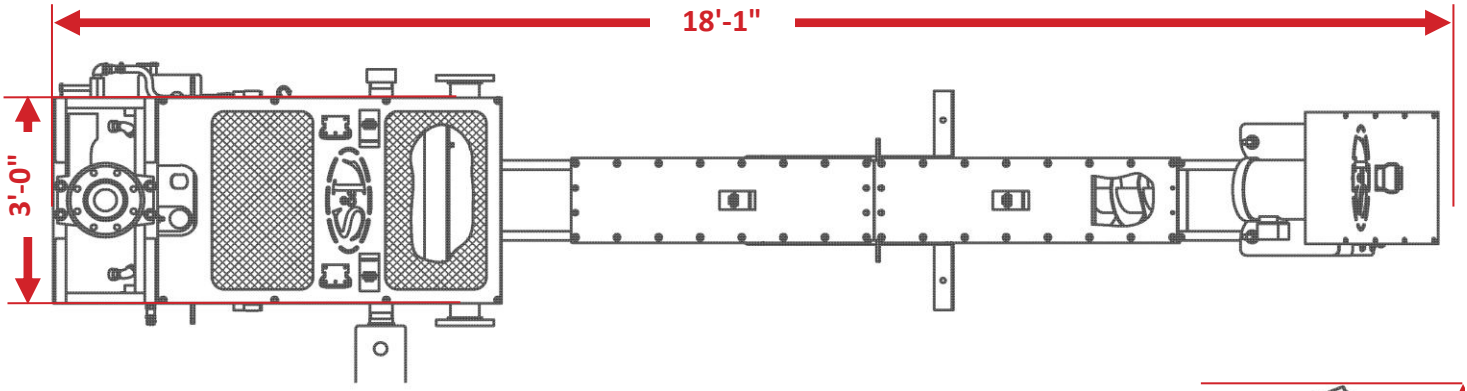
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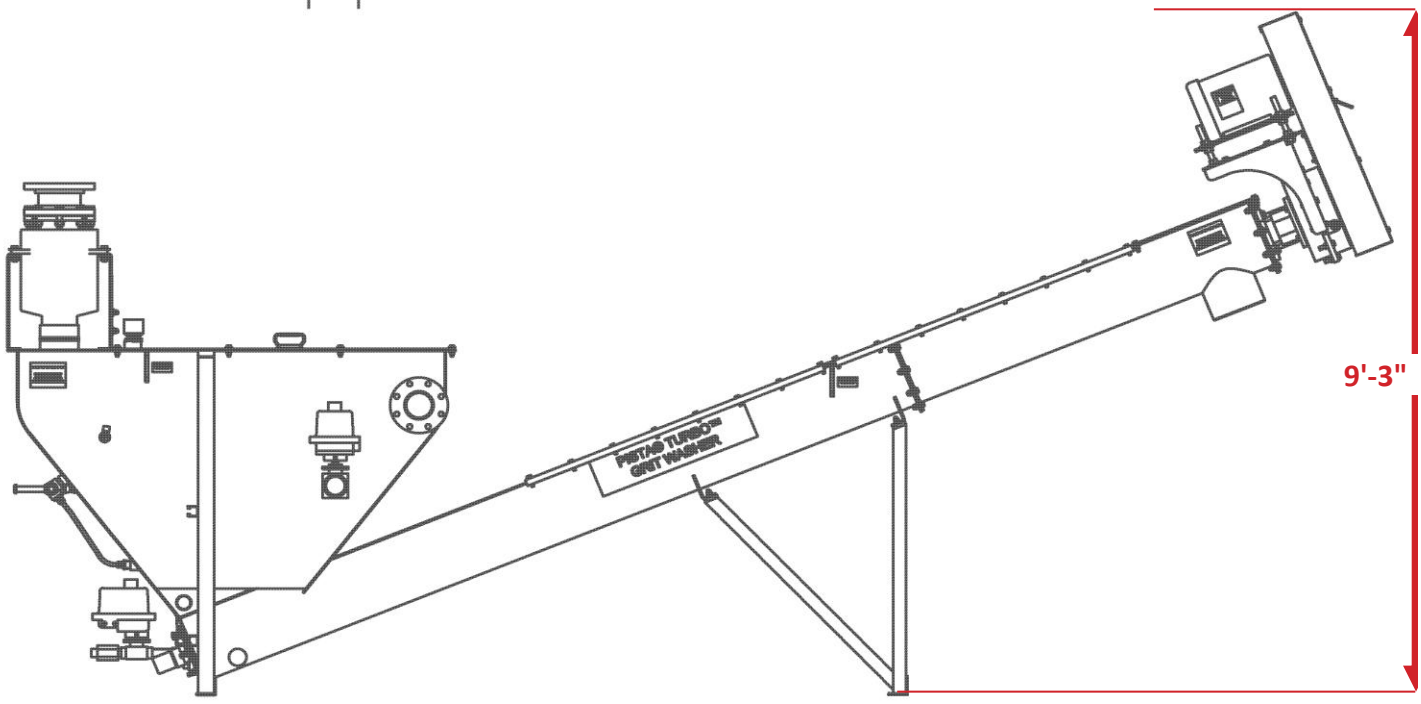
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Model 250 Grit Washer (In lieu of Dewatering Screw Conveyor)

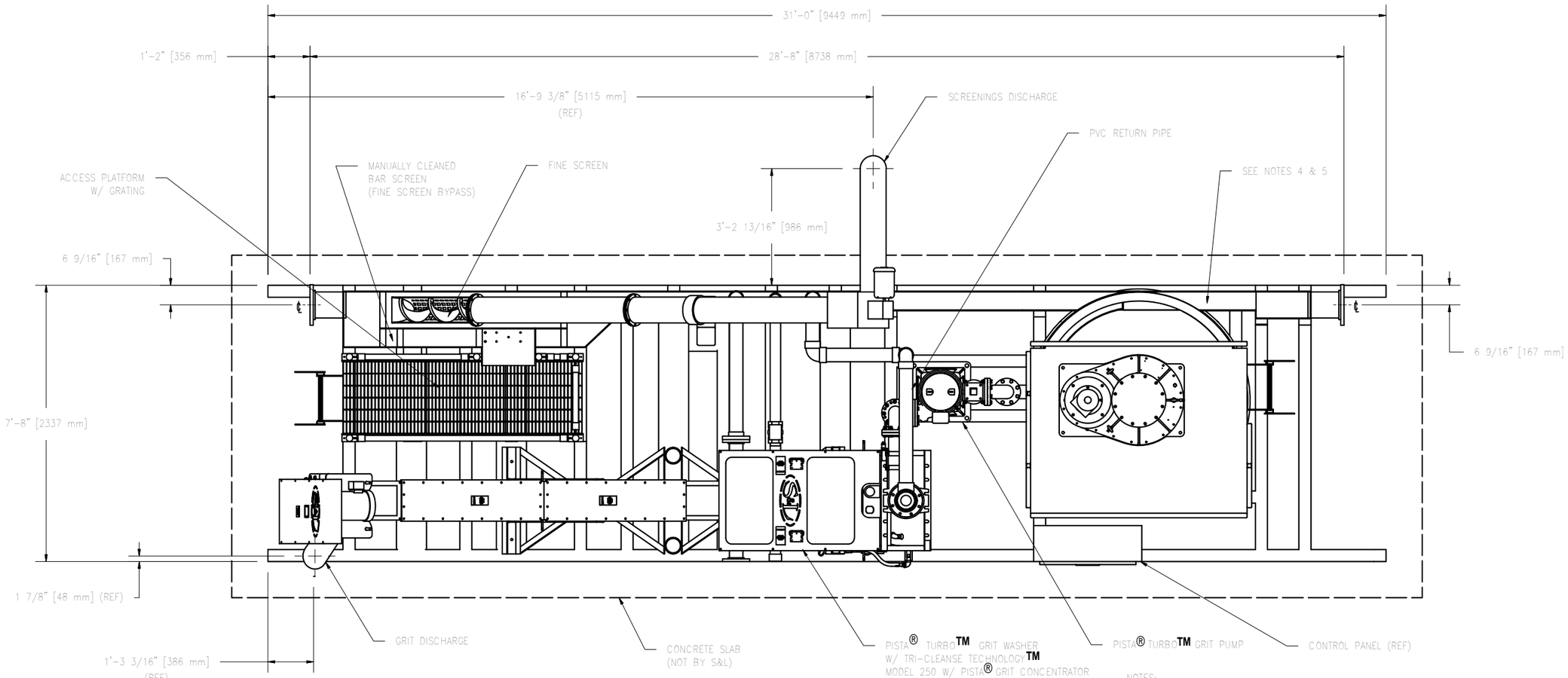
Smith & Loveless offers a grit washer that has the same removal efficiency as our PISTA chamber. It incorporates a number of features to retain the finest and cleanest grit, while still separating organics and water.

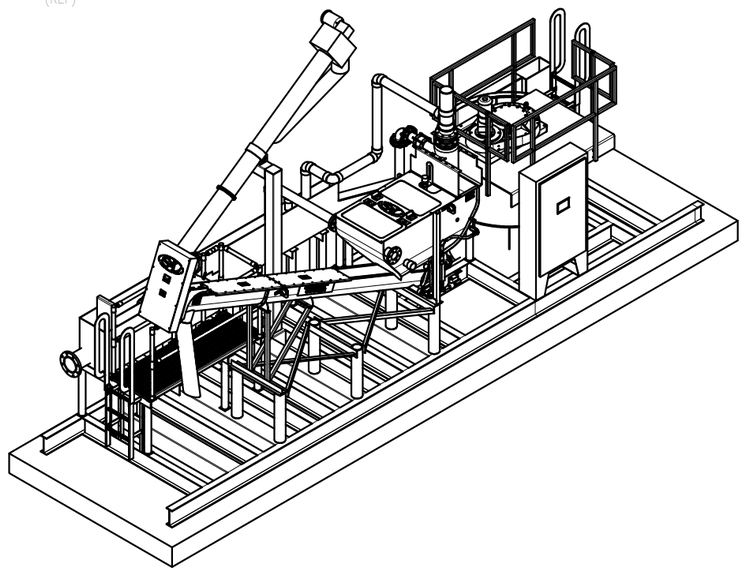
- **Less than 5% putrescible organic material in washed grit (typical values are 2.5%)**
- **Less than 10% water content in washed grit (typical values are 3%)**
- Agiatation provide by auger no separate mechcanism. Air floats off heavier organics.
- Lamella plates in the settling area retain fine grit while still floating off organics
- Screw and trough don't come into contact to highly reduce wear
  (wear shoes or liner aren't required or recommended)





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NOTES:

1. CONCRETE, REINFORCING, GROUT AND ANCHOR BOLTS NOT BY S&L.

2. RECEPTACLES FOR SCREENING AND GRIT WASHER DISCHARGES NOT BY S&L.

3. SEE NOTES ON DESIGN SECTION OF THE PISTA® CATALOG FOR HYDRAULIC REQUIREMENTS.

4. V-FORCE BAFFLES™ CONTROL VELOCITY BY CREATING HEAD LOSS. THE BAFFLES REQUIRE A FREE FLOWING FLUME IN THE OUTLET CHANNEL.

5. MAXIMUM WATER DEPTH IN OUTLET CHANNEL IS 5 1/4" [133 mm] AT 0.5 MGD [1.9 CMD].

6. DISCHARGE CHUTE DIMENSIONS ARE FOR REFERENCE ONLY AND WILL VARY BASED UPON THE LENGTH AND ANGLE OF THE CHUTE EXTENSION REQUIRED.

7. APPROXIMATE WEIGHT: 20,000 LBS [9071 kg].

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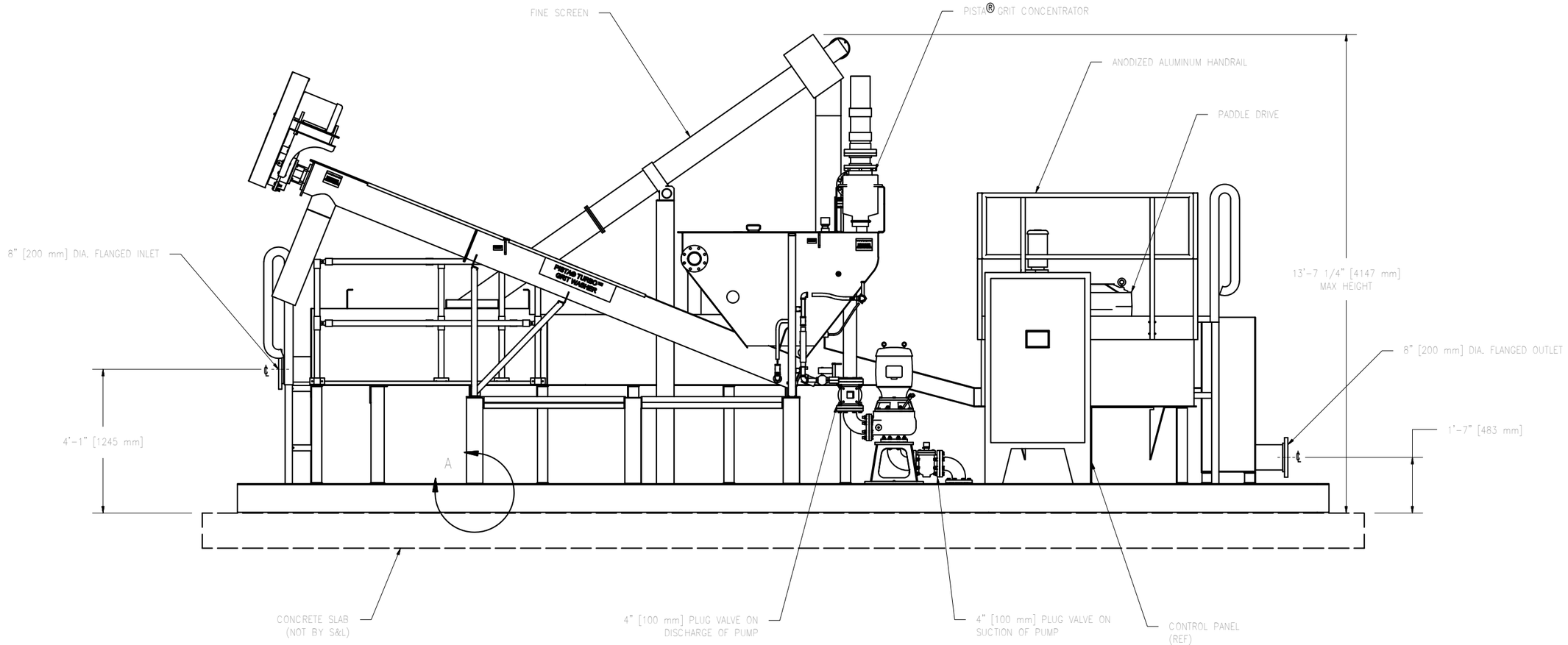
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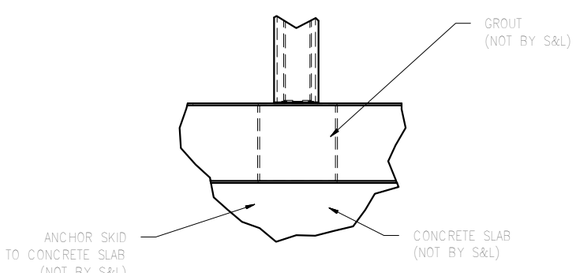
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DETAIL A

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				CHECKED BY: JD	DATE: 11/28/2011	FRACTIONS ~	PISTA® WORKS™ MODEL 0.5B STANDARD DRAWING
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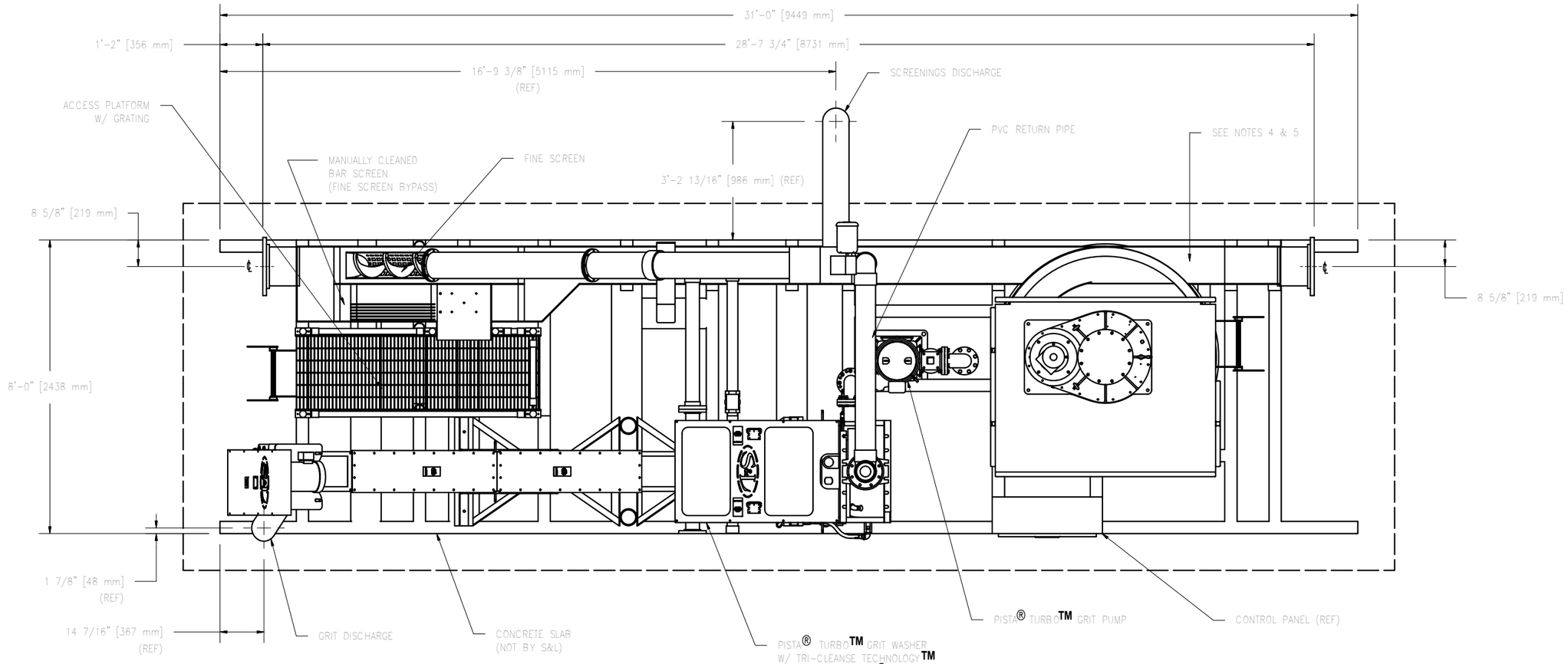
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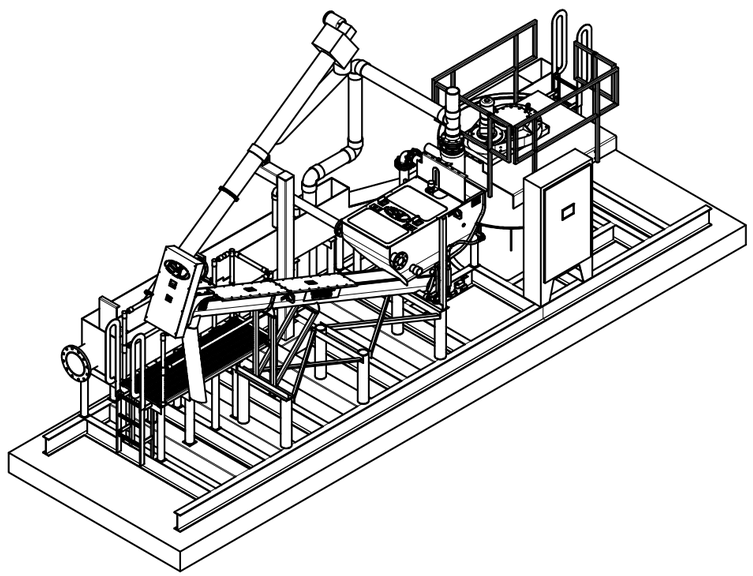
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SHEET 2 OF 2





NOTES:

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2. RECEPTACLES FOR SCREENING AND GRIT WASHER DISCHARGE NOT BY S&L.
3. SEE NOTES ON DESIGN SECTION OF THE PISTA® CATALOG FOR HYDRAULIC REQUIREMENTS.
4. V-FORCE BAFFLES™ CONTROL VELOCITY BY CREATING HEAD LOSS. THE BAFFLES REQUIRE A FREE FLOWING FLUME IN THE OUTLET CHANNEL.
5. MAXIMUM WATER DEPTH IN OUTLET CHANNEL IS 5 1/4" [133 mm] AT 1.0 MGD [3.8 CMD].
6. DISCHARGE CHUTE DIMENSIONS ARE FOR REFERENCE ONLY AND WILL VARY BASED UPON THE LENGTH AND ANGLE OF THE CHUTE EXTENSION REQUIRED.
7. APPROXIMATE WEIGHT: 20,000 LBS [9071 kg].
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LET	ECN NO	DATE	BY APPV'D
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A	N2013-52	2/2014	BTC RGD

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CHECKED BY: JD — DATE: 11/28/2011 — FRACTIONS ~
APPROVED BY: CGM — DATE: 4/12/2012 — DECIMALS ~
SCALE: NTS — CODE: — ANGLES ~

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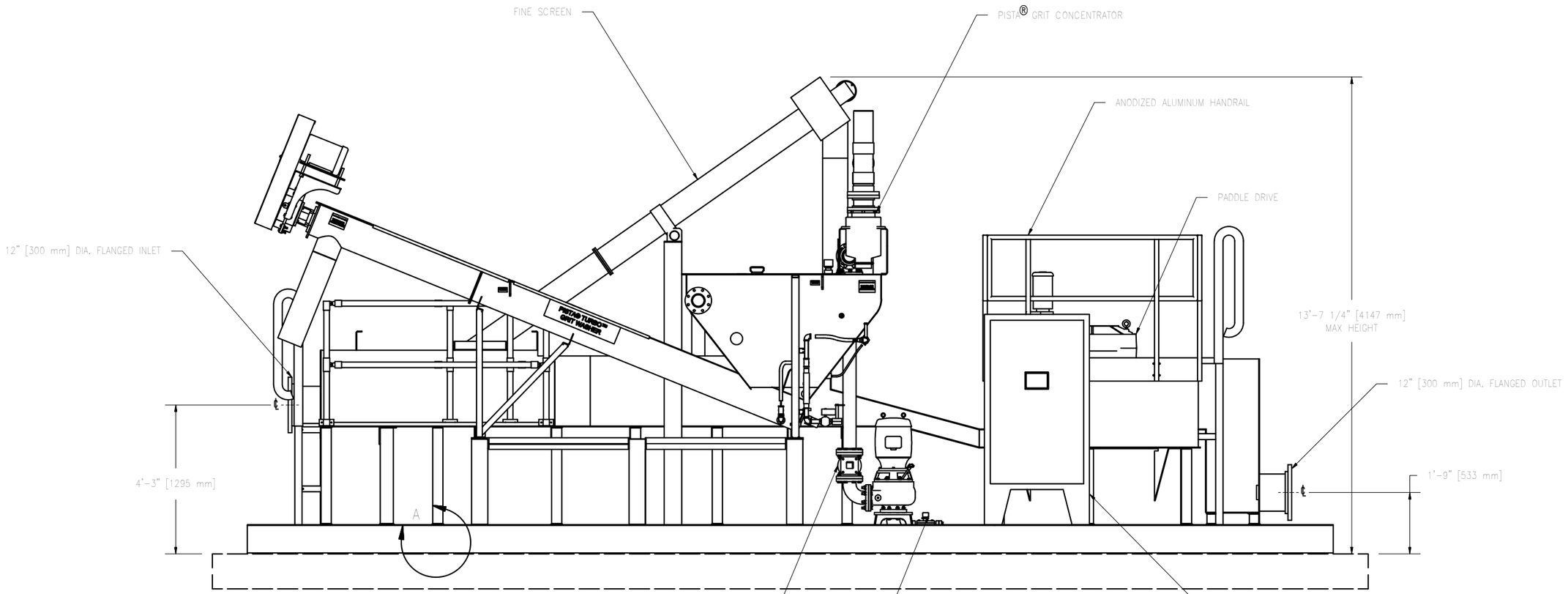
PISTA® WORKS™ MODEL 1.0B STANDARD DRAWING

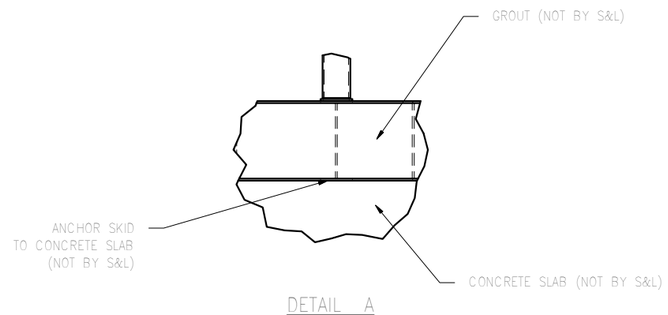
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SHEET 1 OF 2





DETAIL A

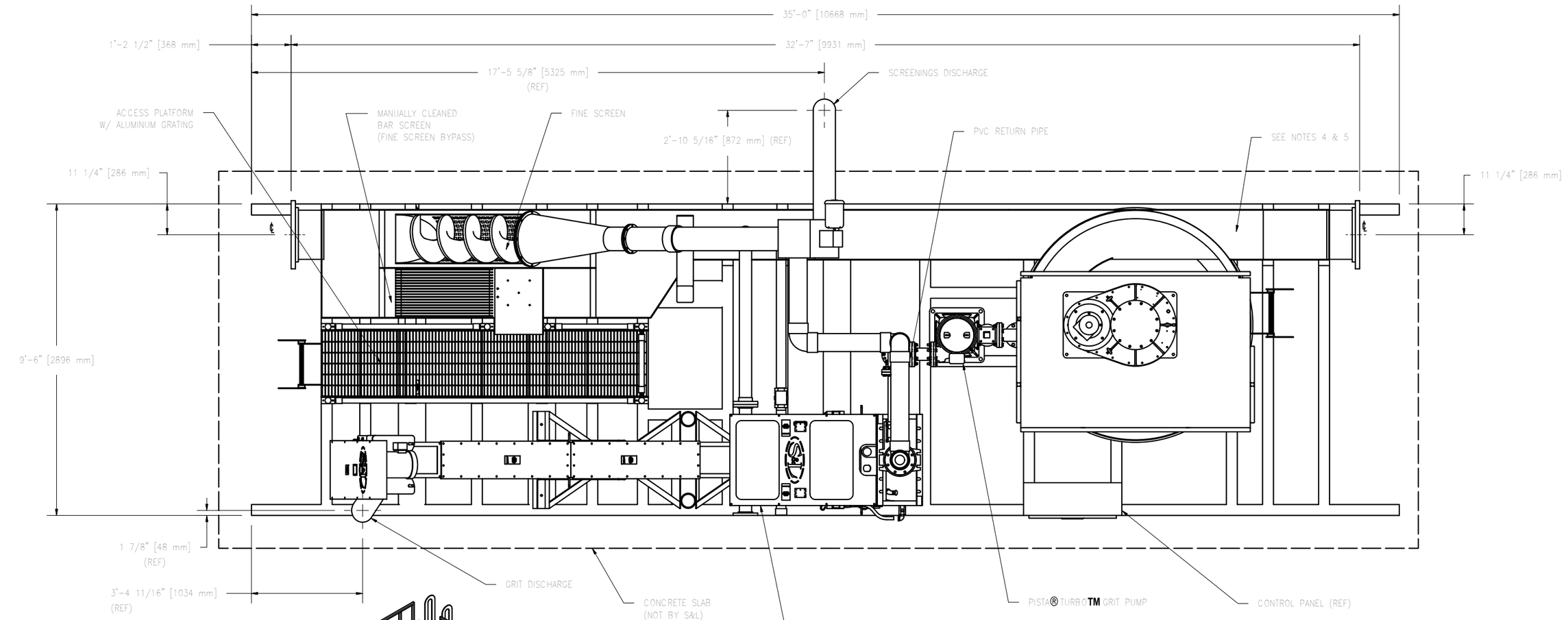
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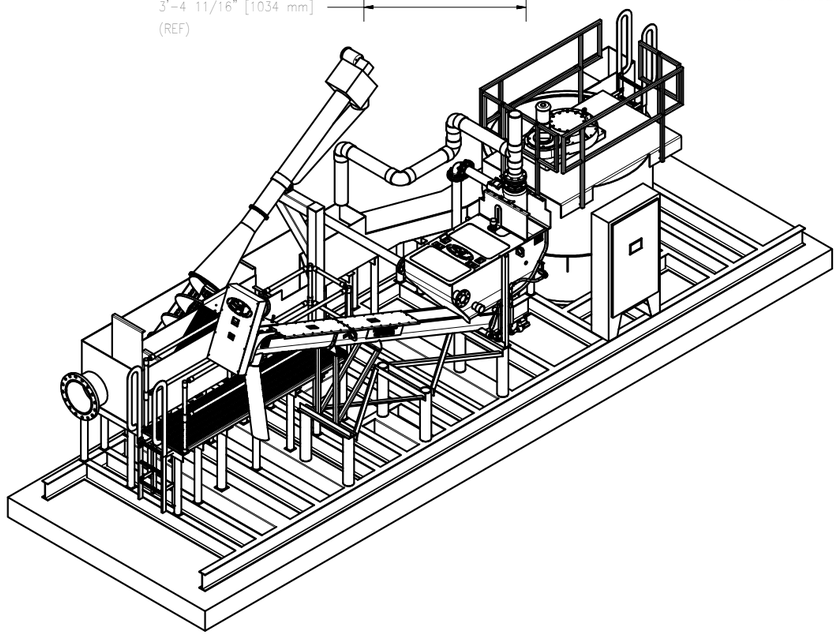
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B	N2014-43	11/2014	BTC JK	APPROVED BY: CGM	DATE: 4/12/2012	DECIMALS ~	
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ORIGINAL ISSUE	N2012-7			©Smith & Loveless, Inc, 2011, 14			SERIAL NO. DWG NO. 67B551 REV. B

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5. MAXIMUM WATER DEPTH IN OUTLET CHANNEL IS 7 1/4" [184 mm] AT 2.5 MGD [9.5 CMD].
6. DISCHARGE CHUTE DIMENSIONS ARE FOR REFERENCE ONLY AND WILL VARY BASED UPON THE LENGTH AND ANGLE OF THE CHUTE EXTENSION REQUIRED.
7. APPROXIMATE WEIGHT: 25,000 LBS [11339 kg].
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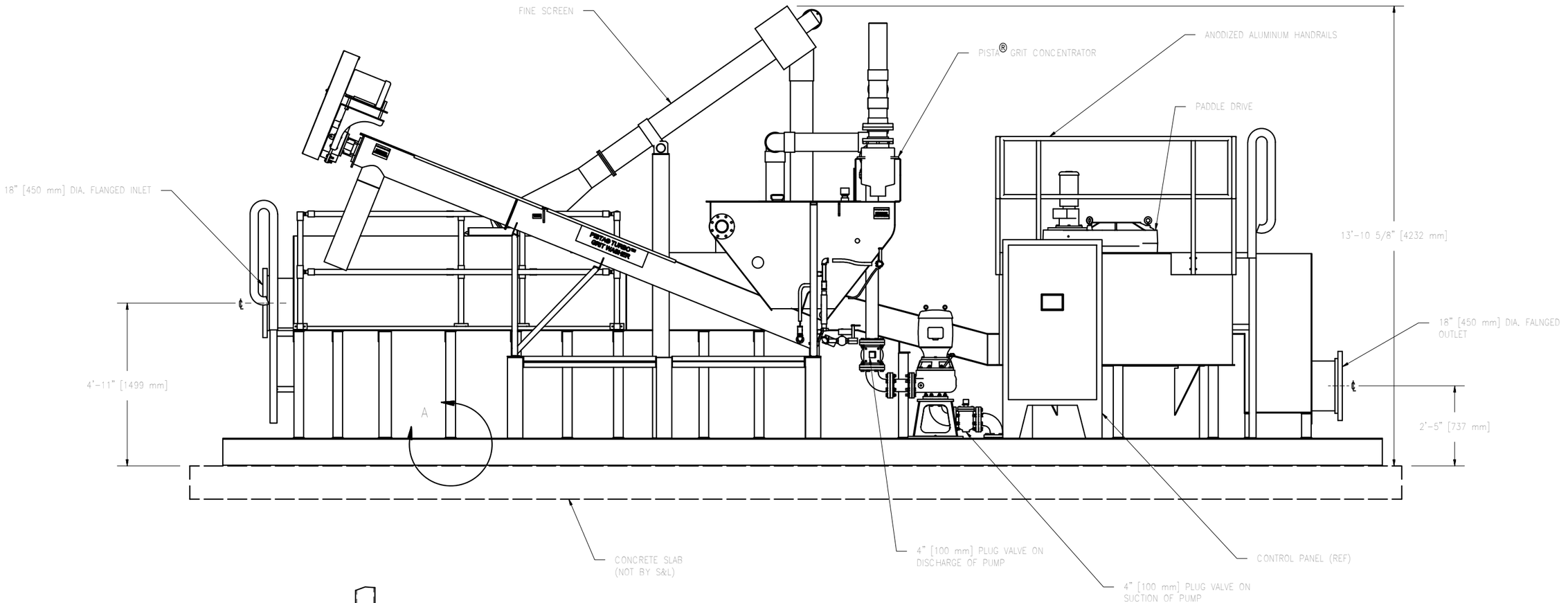
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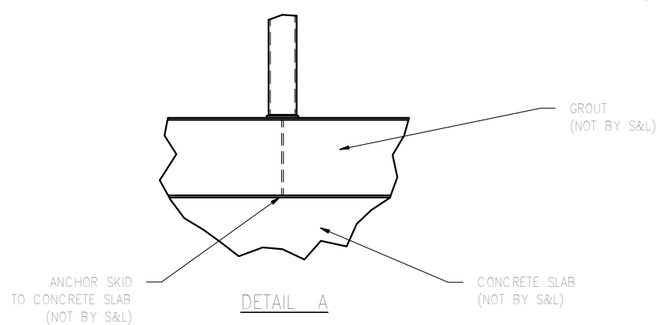
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ORIGINAL ISSUE: N2012-7				©Smith & Loveless, Inc. 2011, 14			SERIAL NO: / DWG NO: 67B552 / REV: A

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SHEET 1 OF 2





DETAIL A

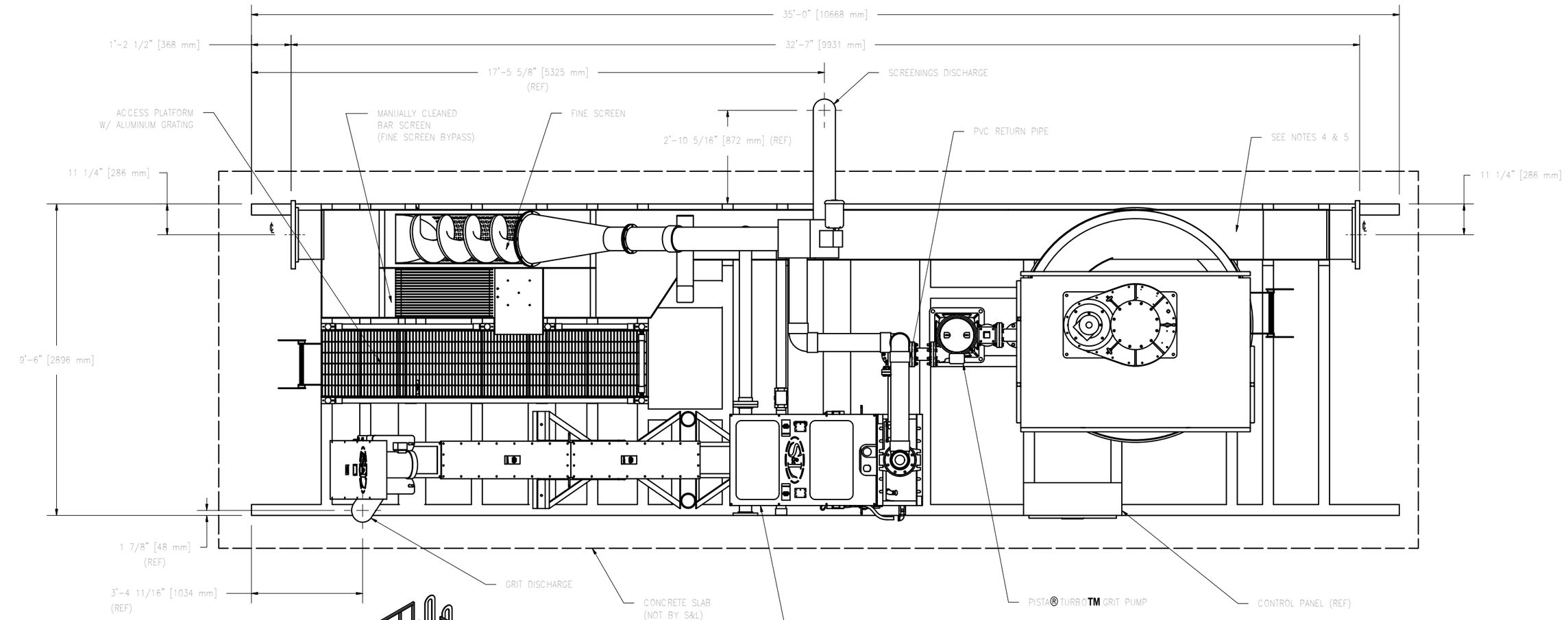
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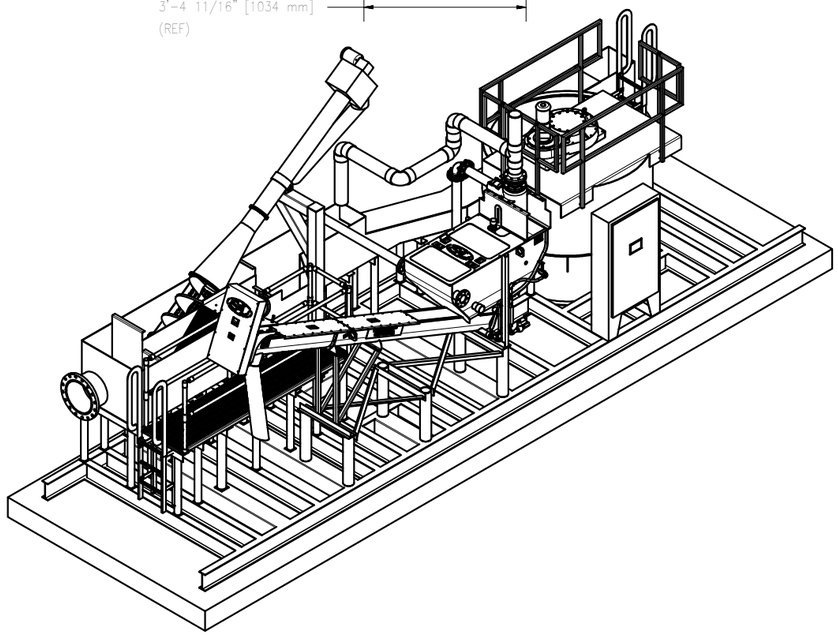
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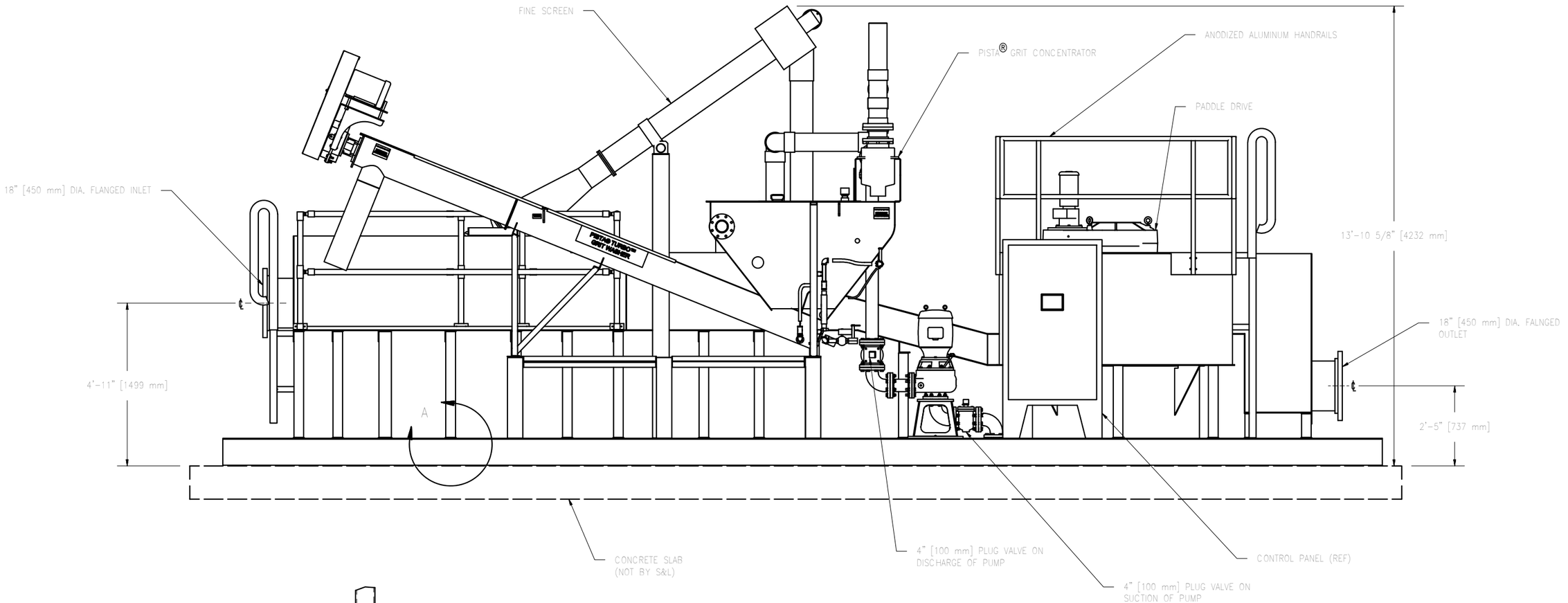
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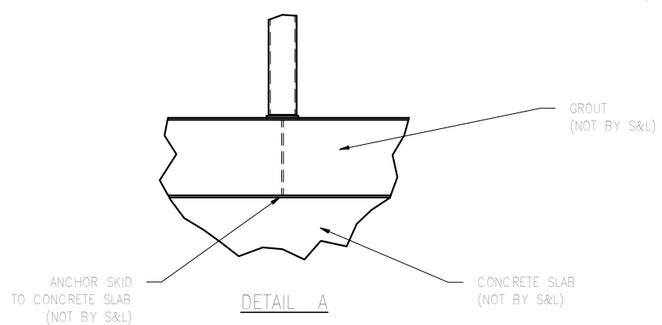
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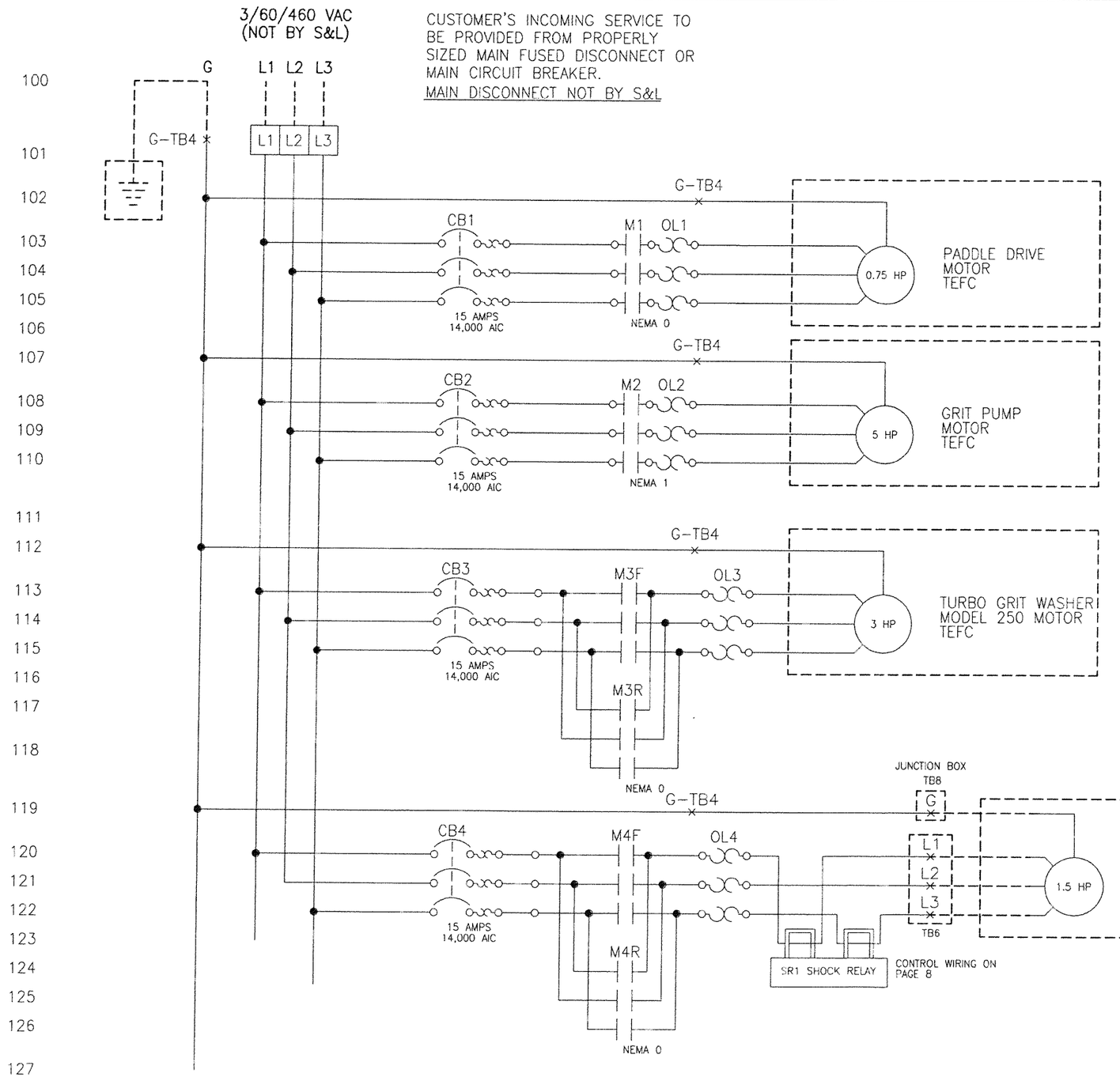
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SHEET 2 OF 2



SERVICE NOTES

1. ANY CUSTOMER SUPPLIED NEUTRAL MUST BE SOLIDLY GROUNDED AT THE SERVICE SWITCH
2. BEFORE CLOSING THE CONTROL BREAKER, VERIFY THAT THE VOLTAGE BETWEEN X AND N & Y AND N IS CORRECT.
3. THE UNIT MUST BE GROUNDED IN ACCORDANCE WITH NEC ARTICLE 250 AND TABLE 250.122 USING THE GROUNDING TERMINAL PROVIDED IN THE CONTROL PANEL.
4. WIRING THAT INTERLOCKS CONTROL CIRCUITS IN THE PANEL AND ARE ENERGIZED FROM AN EXTERNAL SOURCE ARE TO BE YELLOW IN COLOR.

WIRE NOTES

1. AC CONTROL WIRING IS RED AND TAGGED AS INDICATED.
2. POWER WIRING BOTH SINGLE PHASE & 3 PHASE IS BLACK AND NOT TAGGED.
3. NEUTRAL (N) IS WHITE.
4. GROUND (G) IS GREEN OR BARE COPPER.
5. DASHED ITEMS SIGNIFY FIELD CONNECTIONS.
6. ITEMS INSIDE RECTANGULAR BOXES DRAWN WITH DASHED LINES ARE OUTSIDE OF THE CONTROL PANEL.

7 — DEVICE TERMINAL CONNECTION

2144 — TERMINAL BLOCK CONNECTION (DENOTES CONDUCTOR ENTERING OR LEAVING ENCLOSURE.)

2 14 4 — WIRE NUMBERS ARE MADE UP OF
WIRE NUMBER
LINE NUMBER
PAGE NUMBER

FLA = 23.5 AMPS SCCR = 5 kAIC

LET	ECN NO	DATE	BY APP'D
D	ASBLT	12/18/12	SG / RJK
C	ENGR	12/9/12	SG / ZN
B	PROC	9/13/12	SG / ZN
A	ENGR	8/1/12	SG / RAG

ORIGINAL ISSUE

DRAWN BY: SG — DATE: 7/2/2012
CHECKED BY: ZN — DATE: 7/12/2012
APPROVED BY: FHA — DATE: 7/12/2012
SCALE: NTS — CODE:
ALLOWABLE TOLERANCES: FRACTIONS –; DECIMALS –; ANGLES –

FOR MINDEN, LA

PISTA® WORKS™ GRIT REMOVAL SYSTEM REMOTE MTD PUMP W/ GRIT WASHER WIRING DIAGRAM

SIZE | U/M | WT.
FILE NAME C0201004-300.dwg | PLOT SCALE 1=1

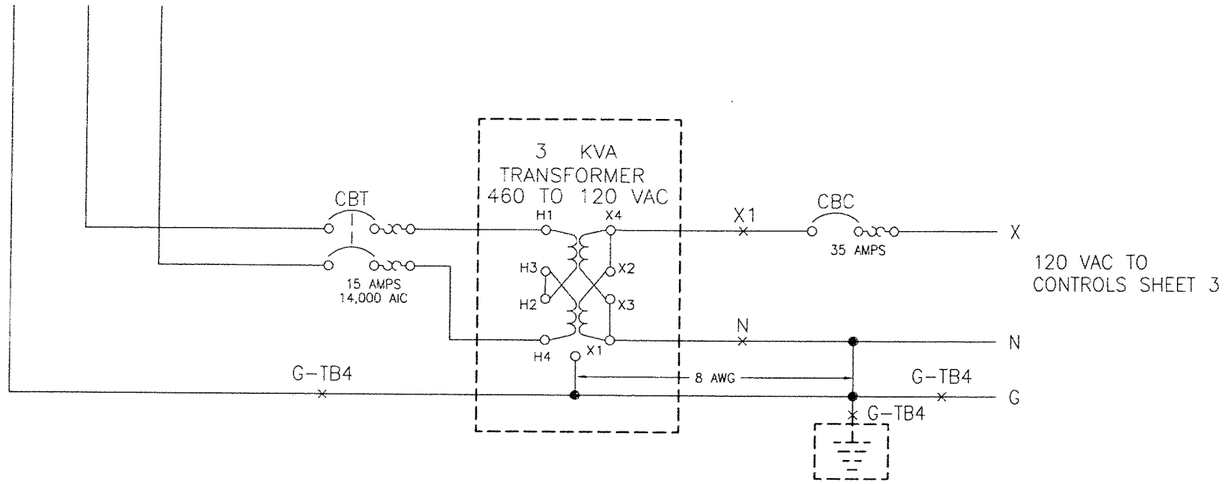
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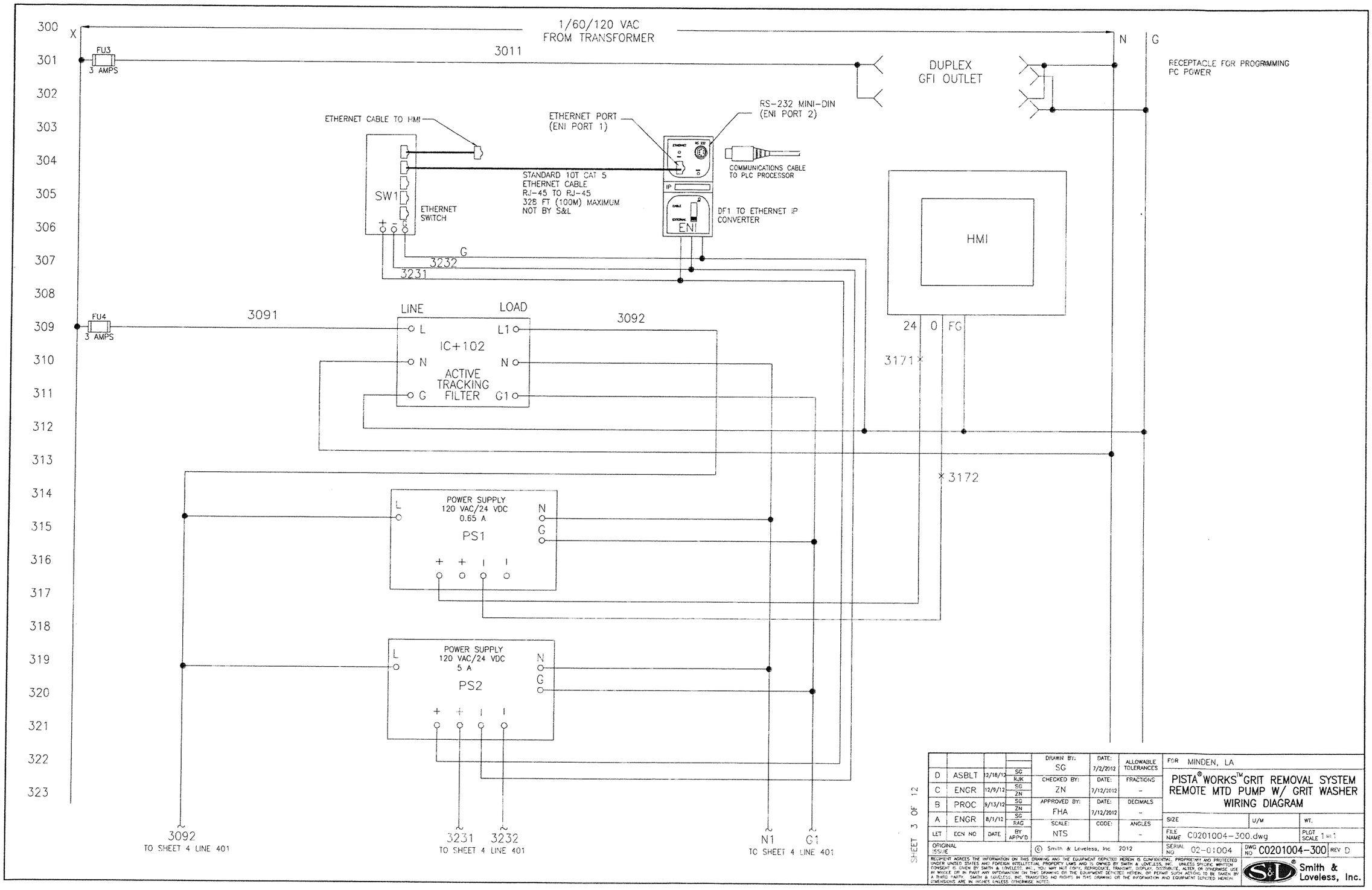


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B	PROC	9/13/12	SG	APPROVED BY: FHA	DATE: 7/12/2012	DECIMALS –	
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ORIGINAL ISSUE				© Smith & Loveless, Inc. 2012			SERIAL NO 02-01004 / DWG NO C0201004-300 REV D

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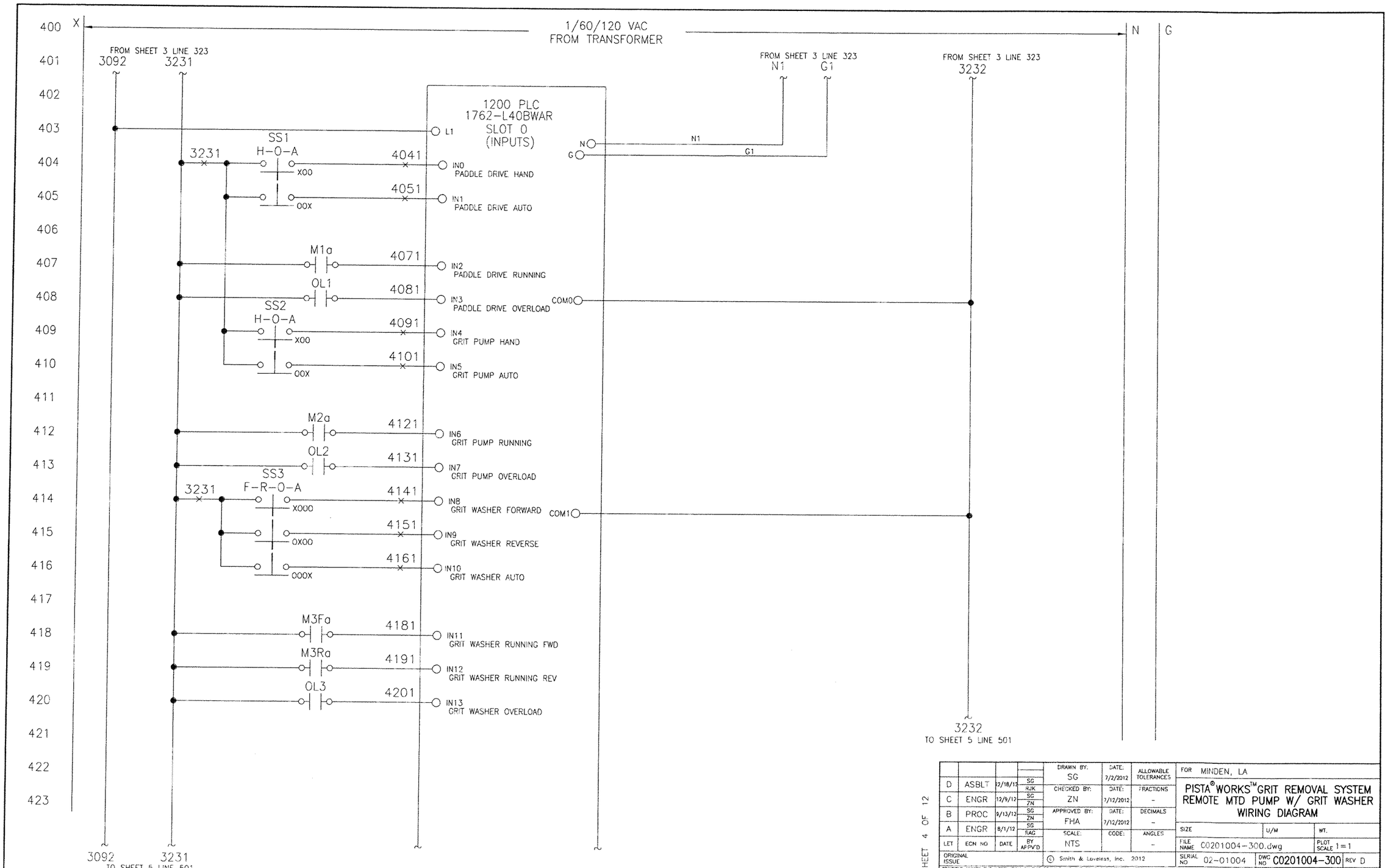
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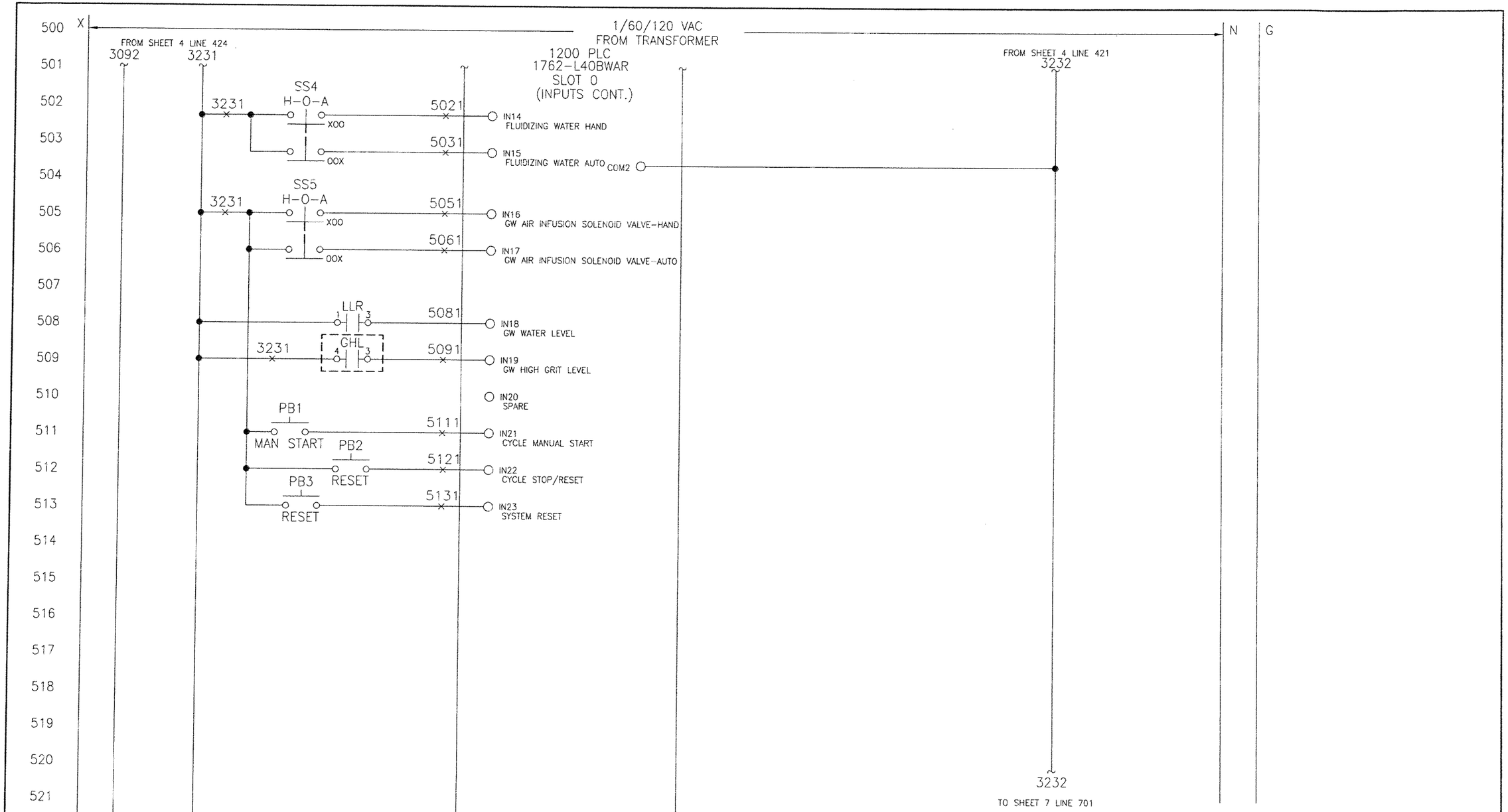
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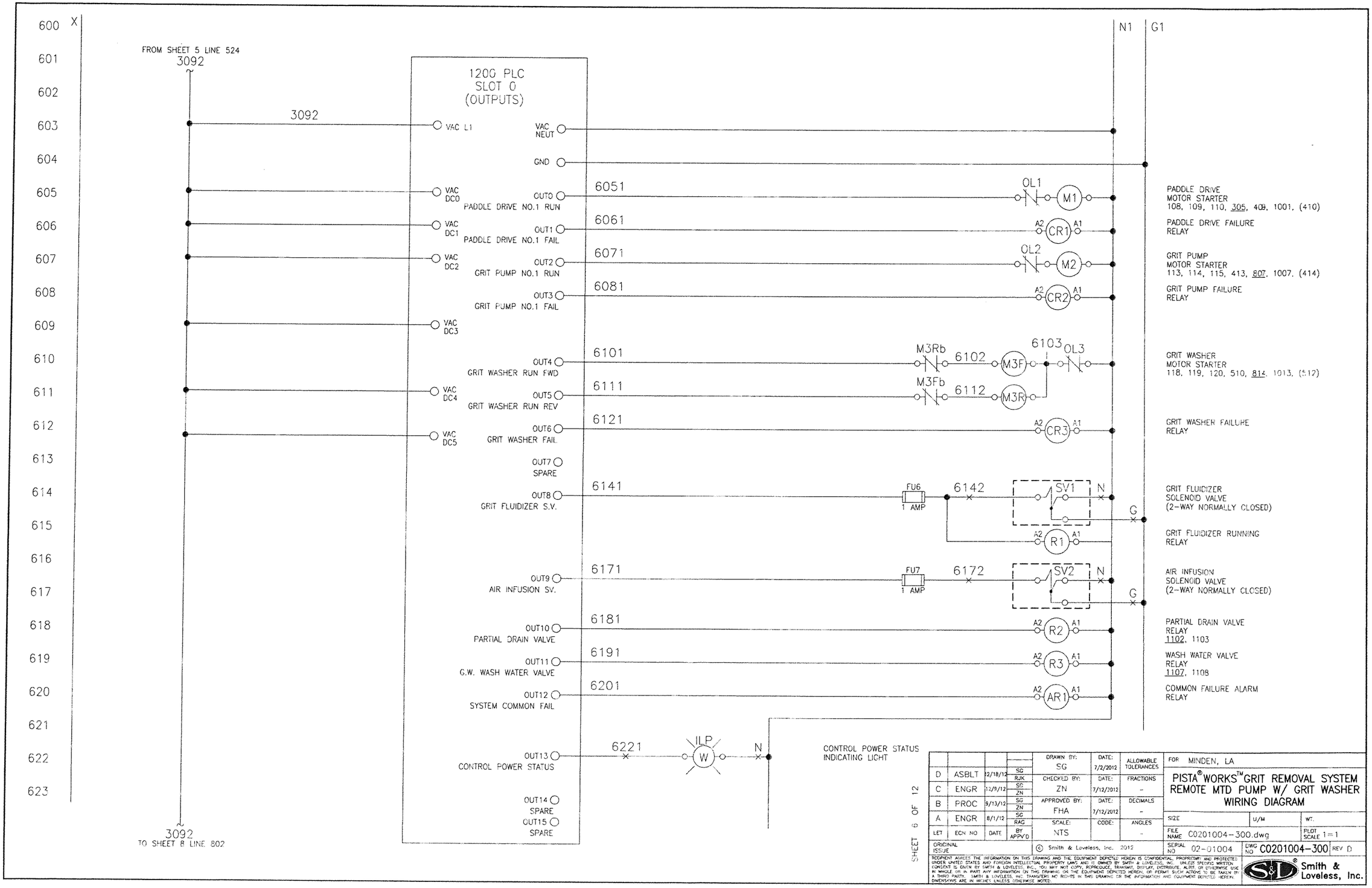
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SHEET 6 OF 12

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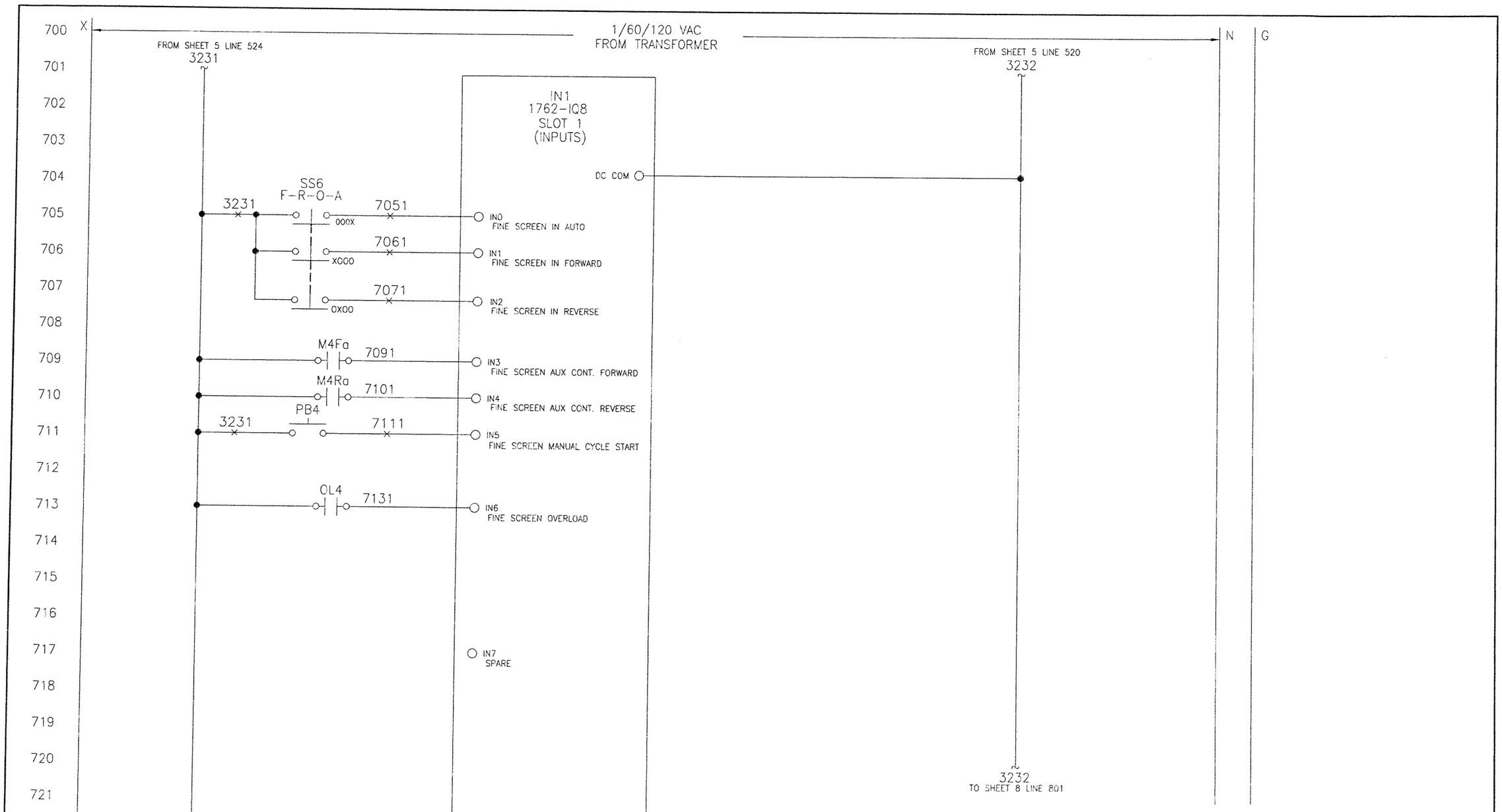
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SERIAL NO 02-01004 | DWG NO C0201004-300 | REV D

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SHEET 7 OF 12

				DRAWN BY: SG	DATE: 7/2/2012	ALLOWABLE TOLERANCES	FOR MINDEN, LA
D	ASBLT	12/18/12	SG				PISTA® WORKS™ GRIT REMOVAL SYSTEM REMOTE MTD PUMP W/ GRIT WASHER WIRING DIAGRAM
			RJK	CHECKED BY: ZN	DATE: 7/12/2012	FRACTIONS –	
C	ENGR	12/9/12	SG				
			ZN				
B	PROC	9/13/12	SG	APPROVED BY: FHA	DATE: 7/12/2012	DECIMALS –	
			ZN				
A	ENGR	8/1/12	SG				
			RAG	SCALE: NTS	CODE:	ANGLES –	
LET	ECN NO	DATE	BY APP'D				

SIZE | U/M | WT.

FILE NAME C0201004-300.dwg | PLOT SCALE 1=1

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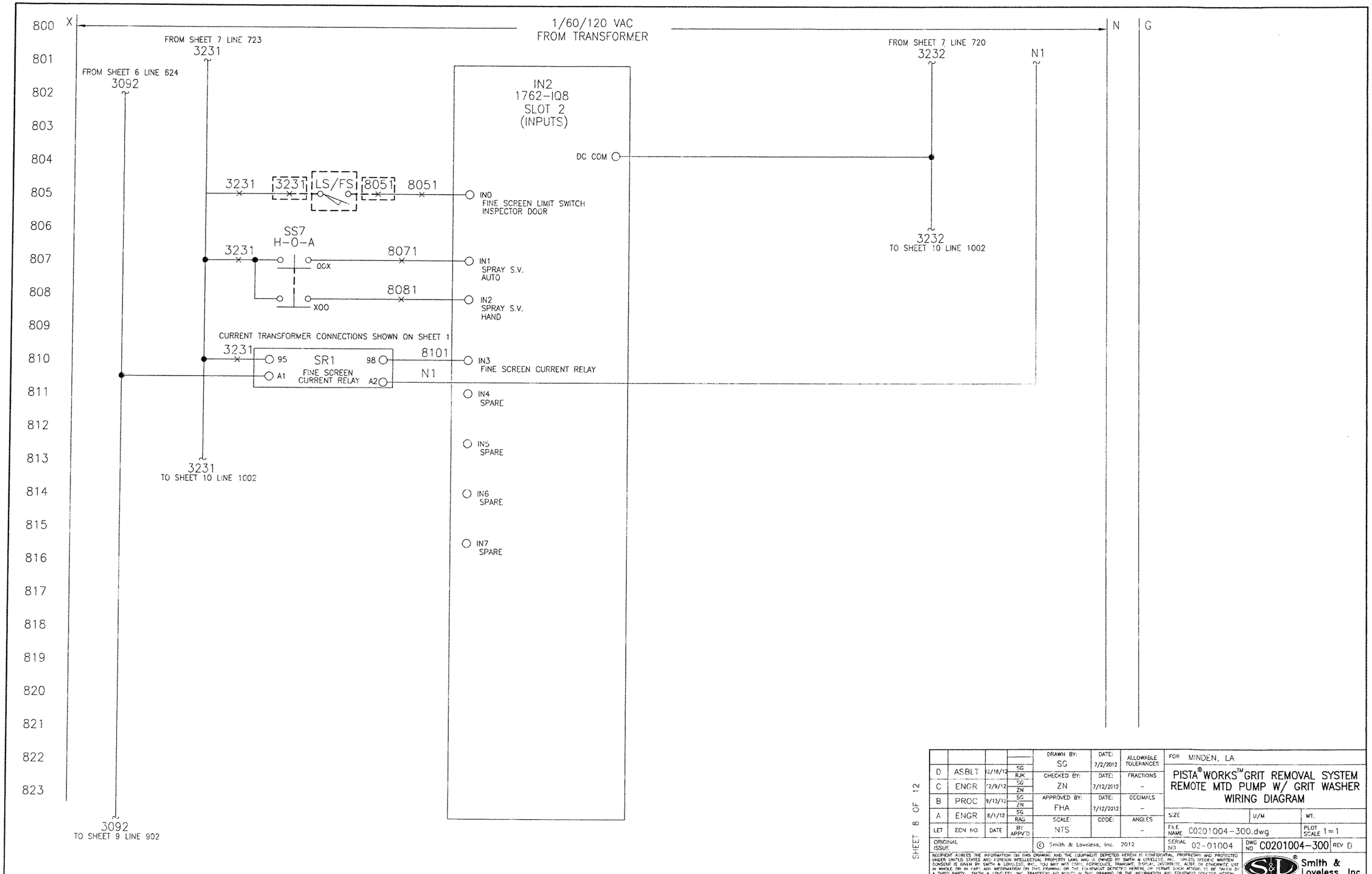
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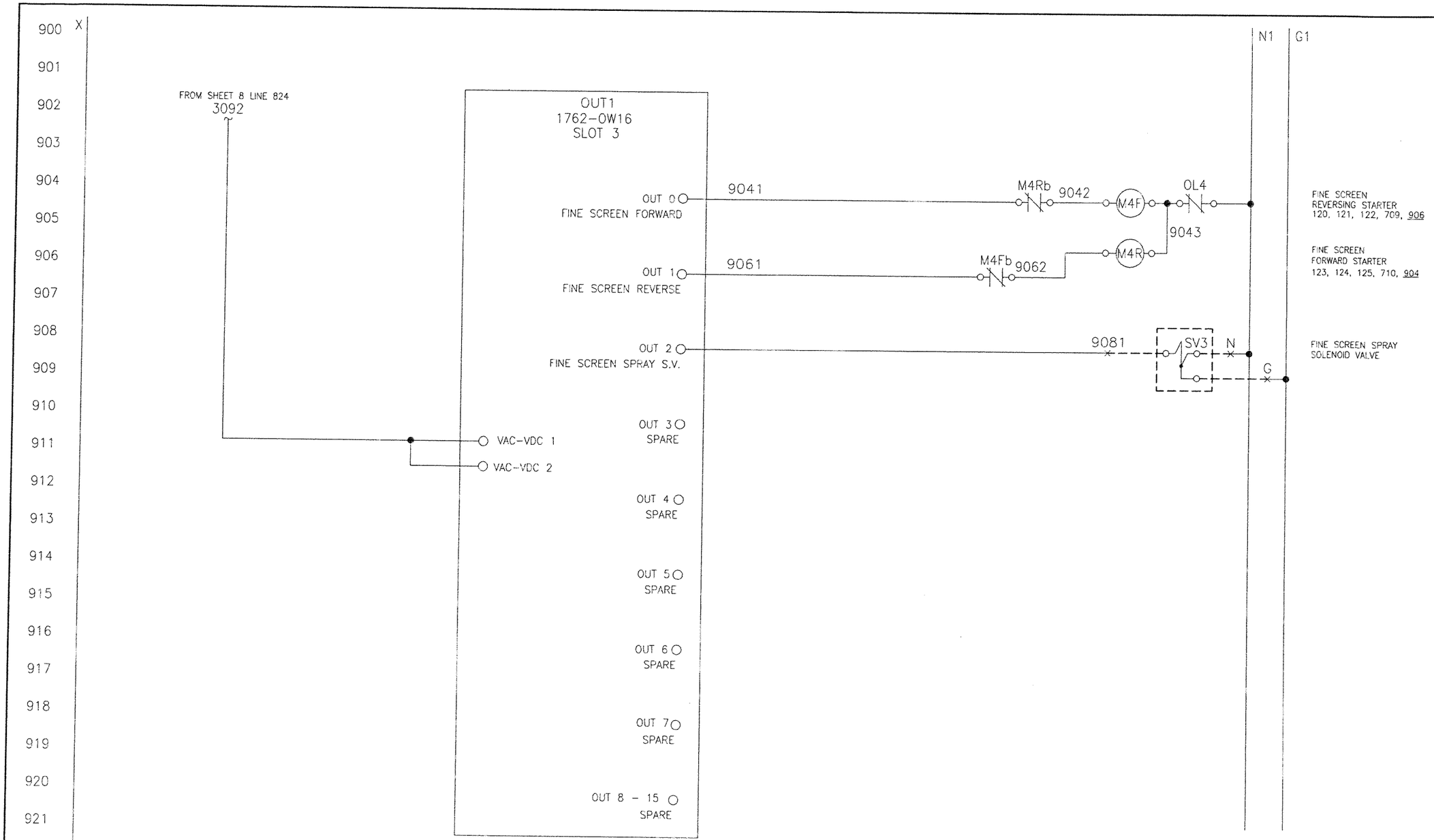
				DRAWN BY: SG	DATE: 7/2/2012	ALLOWABLE TOLERANCES	FOR MINDEN, LA
D	ASBLT	12/18/12	SG				PISTA® WORKS™ GRIT REMOVAL SYSTEM REMOTE MTD PUMP W/ GRIT WASHER WIRING DIAGRAM
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B	PROC	9/13/12	SG ZN	APPROVED BY: FHA	DATE: 7/12/2012	DECIMALS –	SIZE / U/M / WT.
A	ENGR	8/1/12	SG RAG	SCALE: NTS	CODE:	ANGLES –	FILE NAME C0201004-300.dwg / PLOT SCALE 1=1
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SHEET 9 OF 12

					DRAWN BY: SG	DATE: 7/2/2012	ALLOWABLE TOLERANCES	FOR MINDEN, LA
D	ASBLT	12/18/12	SC	RJK	CHECKED BY: ZN	DATE: 7/12/2012	FRACTIONS -	PISTA® WORKS™ GRIT REMOVAL SYSTEM REMOTE MTD PUMP W/ GRIT WASHER WIRING DIAGRAM
C	ENGR	12/9/12	SG	ZN				
B	PROC	9/13/12	SG	ZN	APPROVED BY: FHA	DATE: 7/12/2012	DECIMALS -	SIZE / U/M / WT.
A	ENGR	8/1/12	SG	RAG	SCALE: NTS	CODE:	ANGLES -	FILE NAME C0201004-300.dwg / PLOT SCALE 1=1
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1000 X

1001

1002

1003

1004

1005

1006

1007

1008

1009

1010

1011

1012

1013

1014

1015

1016

1017

1018

1019

1020

1021

1022

1023

1/60/120 VAC
FROM TRANSFORMER

N

G

FROM SHEET 8 LINE 813
3231

FROM SHEET 8 LINE 806
3232

AN1
A–B 1762–IF2OF2
SLOT 4
(ANALOG MODULE)

○ I IN 0 +

○ V/I IN 0 –

3231

RED

BLACK

10061

○ I IN 1 +

○ V/I IN 1 –

G

JUNCTION BOX
TB9

10111

10112

FINE SCREEN
ULTRASONIC
LIQUID LEVEL
TRANSMITTER

LL1

I OUT 0 ○

COM ○

I OUT 1 ○

COM ○

SHEET 10 OF 12

				DRAWN BY: SG	DATE: 7/2/2012	ALLOWABLE TOLERANCES	FOR MINDEN, LA
D	ASBLT	12/18/12	SG				PISTA® WORKS™ GRIT REMOVAL SYSTEM
C	ENGR	12/9/12	RJK SG ZN	CHECKED BY: ZN	DATE: 7/12/2012	FRACTIONS –	REMOTE MTD PUMP W/ GRIT WASHER
B	PROC	9/13/12	SG ZN	APPROVED BY: FHA	DATE: 7/12/2012	DECIMALS –	WIRING DIAGRAM
A	ENGR	8/1/12	SG RAG	SCALE: NTS	CODE:	ANGLES –	SIZE / U/M / WT.
LET	ECN NO	DATE	BY APP'D				FILE NAME C0201004-300.dwg / PLOT SCALE 1=1
ORIGINAL ISSUE				© Smith & Loveless, Inc. 2012			SERIAL NO 02-01004 / DWG NO C0201004-300 REV D

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1/60/120 VAC
FROM TRANSFORMER

X

N

G

CB5
15 AMPS

10011

FU8
2 A

11011

11011

HTR

EV01

7

CLOSE

11022

3

1

N

SS8
O-C-A

11021

00X

R2

11

12

14

OPEN

11031

2

11031

X00

ELECTRIC
VALVE
OPERATOR

0X0

FU9
2 A

11061

11061

HTR

EV02

7

SS9
O-C-A

11071

00X

R3

11

12

CLOSE

11072

3

1

N

14

OPEN

11081

2

11081

X00

ELECTRIC
VALVE
OPERATOR

0X0

FU11
1 A

11141

L1

GHL

N

N

SONIC GRIT START
HIGH LEVEL DETECTOR
610

G

MTD ON
GRIT WASHER

FU12
1/2 A

11161

SONIC START™

1

2

11162

7

LLR

2

GRIT WASHER SONIC START
LIQUID LEVEL RELAY
508

LL2

CONNECTIONS NOT BY S&L

THERMOSTAT
OPENS @ 52° F
CLOSES @ 37° F

ENCLOSURE HEATER
150 WATT, 120 VAC

FU13
15 AMP

11201

11201

CB6
15 AMPS

11202

T1

11203

HT1

N

N

11202

AIC

N

G

G-TB5

G

AIR INFUSION
COMPRESSOR
1/2 HP

INTERNAL THERMAL
PROTECTION WITH
AUTOMATIC RESET

AIR INFUSION PANEL

LET	ECN NO	DATE	BY, APP'D
D	ASBLT	12/18/12	SG, RJK
C	ENGR	12/9/12	SG, ZN
B	PROC	9/13/12	SG, ZN
A	ENGR	8/1/12	SC, RAG

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SCALE: NTS — CODE: —

ALLOWABLE TOLERANCES
FRACTIONS –
DECIMALS –
ANGLES –

FOR MINDEN, LA

PISTA® WORKS™ GRIT REMOVAL SYSTEM
REMOTE MTD PUMP W/ GRIT WASHER
WIRING DIAGRAM

SIZE | U/M | WT.
FILE NAME C0201004-300.dwg | PLOT SCALE 1=1
SERIAL NO 02-01004 | DWG NO C0201004-300 | REV D

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SHEET 11 OF 12

TERMINAL STRIP SCHEDULE

TB1

X1	N	N	N	N	N	N	N	N	N	G	G	G	G	G	G	3121	3171	3172	3231	3231	3231	3231	3231	3231	3231	3231	3231	3231	3231	3231	4041	4051	4091	4101	4141	4151	4161	5021	5031

TB1 – CONTINUED

5051	5061	5091	5111	5121	5131	6142	6172	6221	7051	7061	7071	7111	8051	8071	8081	9081	10062	11011	11011	11021	11022	11031	11031	11061	11061	11071	11072	11081	11081	11141	11161	11162	11201

TB2 – CONTROL CIRCUIT BREAKERS

X	X

TB4 – GROUND BUS

G	G	G	G	G	G	G	G

TB3 – AIR INFUSION PANEL

N	N	G	11201	11202	11202	11203

TB5 – GROUND BUS AIR INFUSION PANEL

G

JUNCTION BOX – FINE SCREEN MOTOR

TB6

L1	L2	L3

TB7

3231	3231	8051	S	S

TB8 – GROUND BUS

G	G

JUNCTION BOX – FINE SCREEN ULTRASONIC

TB9

10111	10112	S	S

LEGEND

AIC	AIR INFUSION COMPRESSOR
AN1	ANALOG MODULE; PLC ANALOG MODULE NO.1
AR1	RELAY: COMMON FAILURE ALARM
CB1	POWER BREAKER: PADDLE DRIVE MOTOR
CB2	POWER BREAKER: GRIT PUMP MOTOR
CB3	POWER BREAKER: GRIT WASHER
CB4	POWER BREAKER; FINE SCREEN ROTOR
CB5	CIRCUIT BREAKER: CONTROLS
CB6	CIRCUIT BREAKER: AIR INFUSION
CBC	CIRCUIT BREAKER: CONTROL MAIN
CBT	CIRCUIT BREAKER; TRANSFORMER
CR1	RELAY: PADDLE DRIVE FAILURE
CR2	RELAY: GRIT PUMP FAILURE
CR3	RELAY: GRIT WASHER FAILURE
ENI	COMMUNICATION CONVERTER
EV01	VALVE OPERATOR: PARTIAL DRAIN
EV02	VALVE OPERATOR: CONVEYOR WASH WATER
FU11	FUSE: SONIC GRIT START
FU12	FUSE: SONICSTART GRIT WASHER LIQUID LEVEL DET
FU13	FUSE: AIR INFUSION PANEL
FU3	FUSE; PROGRAMMING POWER
FU4	FUSE; CONTROL POWER
FU6	FUSE: GRIT FLUIDIZER
FU7	FUSE: AIR INFUSION
FU8	FUSE: PARTIAL DRAIN BALL VALVE OPERATOR
FU9	FUSE: WASH WATER BALL VALVE OPERATOR
GHL	SONIC GRIT START HIGH LEVEL DETECTOR
HMI	HUMAN MACHINE INTERFACE
HT1	PANEL HEATER: PRIME SYSTEM
IC+102	ACTIVE TRACKING FILTER
ILP	INDICATING LIGHT: CONTROL POWER STATUS
IN1	INPUT MODULE; PLC INPUT MODULE NO.1
IN2	INPUT MODULE; PLC INPUT MODULE NO.2
LL1	LIQUID SENSOR: ULTRASONIC
LL2	LIQUID SENSOR: GRIT WASHER
LLR	RELAY: SONIC START GRIT WASHER LIQUID LEVEL
LS/FS	LIMIT SWITCH: FINE SCREEN
M1	STARTER: PADDLE DRIVE
M2	STARTER: GRIT PUMP
M3R	REVERSING STARTER; GRIT WASHER (REVERSE)
M3F	REVERSING STARTER; GRIT WASHER (FORWARD)
M4R	REVERSING STARTER; FINE SCREEN (REVERSE)
M4F	REVERSING STARTER; FINE SCREEN (FORWARD)
OUT1	OUTPUT CARD; RELAY OUTPUT CARD
PB1	PUSHBUTTON: CYCLE START
PB2	PUSHBUTTON: CYCLE RESET
PB3	PUSHBUTTON: SYSTEM RESET
PB4	PUSH BUTTON: FINE SCREEN MANUAL CYCLE START
PS1	POWER SUPPLY 24VDC: HMI
PS2	POWER SUPPLY 24VDC: CONTROLS
R1	RELAY: GRIT FLUIDIZER RUNNING
R2	RELAY: PARTIAL DRAIN VALVE
R3	RELAY: WASH WATER VALVE
SR1	SHOCK RELAY; FINE SCREEN
SS1	SELECTOR SWITCH: PADDLE DRIVE HOA
SS2	SELECTOR SWITCH: GRIT PUMP HOA
SS3	SELECTOR SWITCH: GW CONVEYOR FROA
SS4	SELECTOR SWITCH: FLUIDIZING WATER HOA
SS5	SELECTOR SWITCH: GW AIR INFUSION SOLENOID VALVE
SS6	SELECTOR SWITCH; FINE ROTOR SCREEN F-R-O-A
SS7	SELECTOR SWITCH; SPRAY SOLENOID VALVE
SS8	SELECTOR SWITCH: CONVEYOR PARTIAL DRAIN OCA
SS9	SELECTOR SWITCH: CONVEYOR WASH OCA
SV1	SOLENOID VALVE: GRIT FLUIDIZER
SV2	SOLENOID VALVE: AIR INFUSION
SV3	SOLENOID VALVE: FINE SCREEN
SW1	SWITCH; ETHERNET
T1	THERMOSTAT: PRIME PANEL HEATER

				DRAWN BY: SG	DATE: 7/2/2012	ALLOWABLE TOLERANCES	FOR MINDEN, LA	
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Blowers

ROTARY LOBE BLOWER PACKAGES

DELTA BLOWER GENERATION 5

Intake volume flow from 20 cfm to 8,800 cfm

Quiet, Compact, Energy Efficient



Delta Blower 5 Generation

AERZEN

aerzenusa.com

Aerzen's Generation 5 Delta Blower

The 5th generation of Aerzen modular compact packages combines tradition and innovation.

1 Easy installation with forklift or pallet jack for placement



2 Room-saving, compact, side-by-side installation



3 Easy access to all components with one oil drain/oil fill point



4 Oil level can be observed from the outside



5 Automatic belt tension– No adjustment required



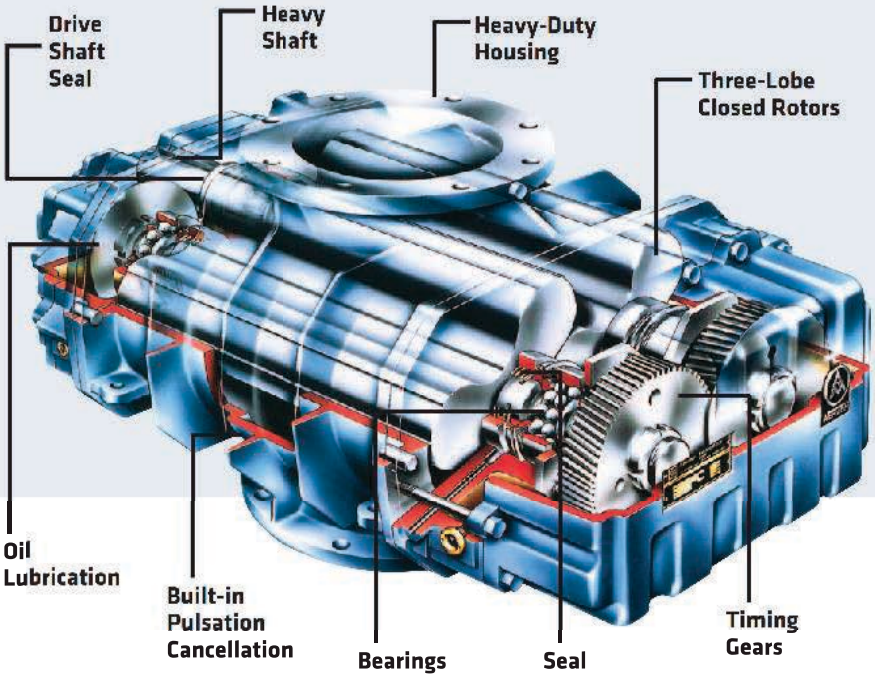
6 Typical machinery noise average SPL 75-80 dB(A) with acoustic hood



Aerzen Delta G5 Blower Stage

The details that set Aerzen Blowers apart.

Pulse Cancellation Built In, Active Noise Cancellation Built In



7 No need for additional electric motor and interlocks with shaft-mounted cooling fan for forced ventilation of the enclosure

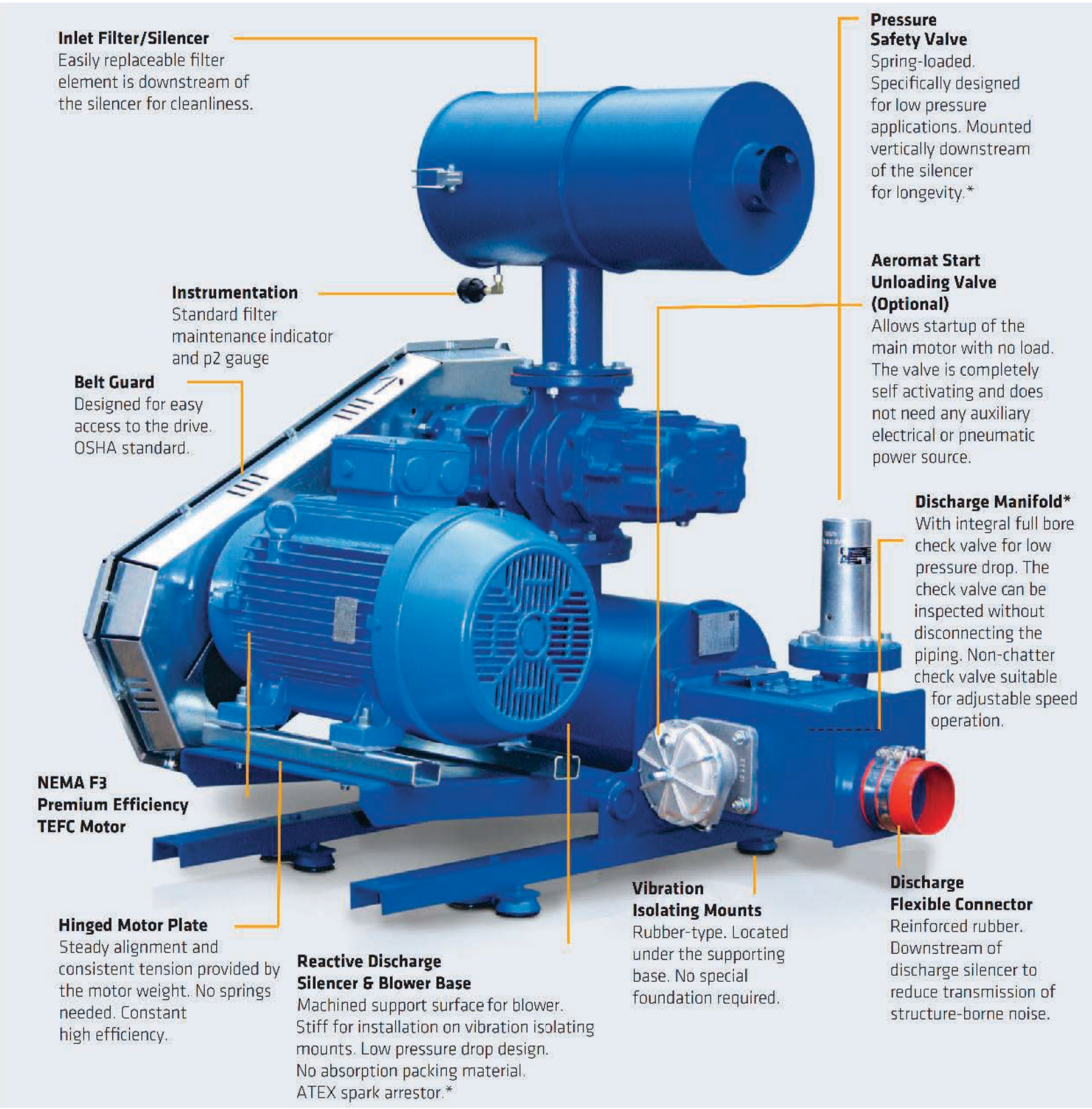


8 Reactive discharge silencer without internal absorption material



For more information, visit **www.aerzenusa.com**

The accessories that make the difference.



Inlet Filter/Silencer
Easily replaceable filter element is downstream of the silencer for cleanliness.

Pressure Safety Valve
Spring-loaded. Specifically designed for low pressure applications. Mounted vertically downstream of the silencer for longevity.*

Instrumentation
Standard filter maintenance indicator and p2 gauge

Aeromat Start Unloading Valve (Optional)
Allows startup of the main motor with no load. The valve is completely self activating and does not need any auxiliary electrical or pneumatic power source.

Belt Guard
Designed for easy access to the drive. OSHA standard.

Discharge Manifold*
With integral full bore check valve for low pressure drop. The check valve can be inspected without disconnecting the piping. Non-chatter check valve suitable for adjustable speed operation.

NEMA F3 Premium Efficiency TEFC Motor

Hinged Motor Plate
Steady alignment and consistent tension provided by the motor weight. No springs needed. Constant high efficiency.

Reactive Discharge Silencer & Blower Base
Machined support surface for blower. Stiff for installation on vibration isolating mounts. Low pressure drop design. No absorption packing material. ATEX spark arrestor.*

Vibration Isolating Mounts
Rubber-type. Located under the supporting base. No special foundation required.

Discharge Flexible Connector
Reinforced rubber. Downstream of discharge silencer to reduce transmission of structure-borne noise.



Instrumentation package:
AERtronic Control System includes pressure transmitters for intake, discharge and oil pressure, as well as resistance temperature detectors (RTD) discharge and oil temperature and operator interface.

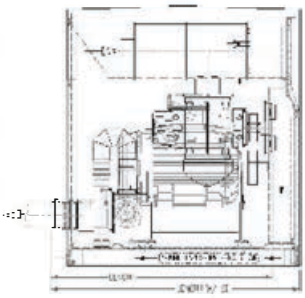
*PED compliant pressure vessel

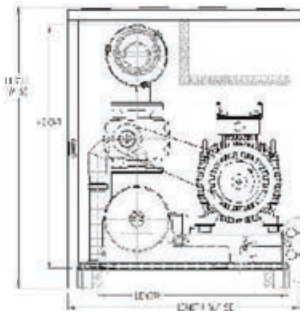
G5 Blower Dimensions

Aerzen Blower Model	Length (inches)	Width (inches)	Height (inches)	Weight (lbs)	Nominal Nozzle Size	Nominal Discharge Pipe Diam. (inches)	Max. Flow (icfm) at 10 psi rise	Pressure (psi)
GM 3S	31	33	43	485	DN-50	2	131	15
GM 4S	48	36	52	695	DN-80	3	184	15
GM 7L	48	36	52	706	DN-80	3	270	10
GM 10S	48	36	52	759	DN-80	3	339	15
GM 10S	55	51	61	1120	DN-100	4	385	15
GM 15L	55	51	61	1153	DN-100	4	576	10
GM 25S	59	55	61	1279	DN-125	5	823	15
GM 30L	80	73	78	2161	DN-150	6	1186	10
GM 35S	80	73	78	2293	DN-150	6	1370	15
GM 50L	80	73	78	2492	DN-150	6	1494	10
GM 50L	78	84	86	2889	DN-200	8	1896	10
GM 60S	78	84	86	3219	DN-200	8	2020	15
GM 80L	99	90	94	7872	DN-250	10	2828	10
GM 90S	99	90	94	8004	DN-250	10	3090	15
GM 130L	126	116	96	7111	DN-300	12	4449	9
GM 150S	126	116	96	7651	DN-300	12	5120	15
GM 240S	(depends on motor size)				DN-400	16	8800	12

Notes

1. *For informational use only. Dimensions shown are close estimates and are subject to change without notice. Contact Aerzen USA if certified dimensions are required. Dimensions are in inches, weights are in lbs.*
2. *Weight notes: motor not included.*
3. *Oversize/overweight motors may require hinge plate support; dimensions and weights may vary. Consult Aerzen USA with specific application.*
4. *Packages available w/o sound enclosure. Consult Aerzen USA.*





Aerzen means trouble-free compression.

Aerzen's modular blower packages have been offered since the 1960s. Aerzen Delta Blower packages have been in successful operation since the 1990s. They are just one of the offerings in our single stage positive displacement program. Whatever your application and installation requirements, be sure to consider Aerzen.

Delta Care Maintenance Agreement

Warranty: 5 years optional with our Care Maintenance Agreement

For Pressure

- Up to 15 psi: G5 Blower packages
- Delta Hybrid up to 22 psi
- 10 to 51 psi: Oil-free and air-cooled VM and VML screw compressors

For Vacuum (Dry)

- Up to 15″ Hg: G5 Blower packages
- Hybrid up to 20″ Hg
- Up to 25″ Hg: G5 Blower packages with pre-inlet cooling
- Up to 25.5″ Hg: Oil-free and air-cooled VM screw compressors at same flow (30% more efficient than PD blowers)
- Vacuum boosters to 10-3 mbar absolute

For Extended Pressure/Vacuum

- Up to 40,000 cfm available
- For other gases, higher pressure/vacuum consult factory

Aerzen USA
108 Independence Way, Coatesville, PA 19320
Phone: (610) 380-0244 • Fax: (610) 380-0278
Service Hotline: (800) 444-1692
www.aerzenusa.com
Email: inquiries@aerzenusa.com
Atlanta: (770) 951-7035
Houston: (281) 980-6651

Aerzen Canada
Phone: (450) 424-3966
www.aerzen.ca
E-mail: info@aerzen.ca

Aerzen Mexico
Phone: +52 722-235-9400
E-mail: info@aerzen.com.mx

AERZEN
EXPECT PERFORMANCE

© 2017 Aerzen USA | G5 Delta Blower | 500 | 3.2017

Project

4/14/2026

Aerzen Rotary Lobe Blower		GM 90 S		
Medium		Air		
Volume flow at inlet	cfm	2545.4		
Volume flow at inlet	cfh	152725.9		
Volume flow @ Normal conditions	scfm (ASME)	2294.0		
Intake pressure (abs.)	psi	14.20		
Intake temperature	F	90.0		
Specific weight at intake conditions	lb/ft³	0.069		
Pressure difference	psi	8.301	RFDruck	75 %
Discharge pressure (abs.)	psi	22.5		
Discharge temperature	F	196		
Blower speed	RPM	1970		
Motor speed	RPM	1780		
Required power at blower shaft	BHP	116	Toleranzen für Drehzahl und Volumenstrom +/-5%	
Motor rating	HP	150		

Sound pressure level of complete package with Sch.40 customer piping --- (not including exhaust noise in vacuum applications)

without hood	dB(A)	102	measured in free field at 1 m distance from the outline of the unit (tol. ± 2dB(A) in accordance with DIN 45 635
with hood	dB(A)	81	

Scope of supply

1 Aerzen Rotary Lobe Blower GM 90 S, LU 43.01
drawing: 3ZG-7924
Nominal pipe size discharge side: DN 10"
Weight: 3916 lb

"Aerzen 10" CombiMount base with integrated silencer exempt of absorption material
Hinged motor support as automatic belt tensioning device
Set of vibration isolating mounts
Narrow V-belt drive with guard
Intake filter silencer
Pressure safety relief valve, Configuration B
Manifold with integral check valve
and connecting flanges for pressure safety relief valve and start-unloading valve
Flexible sleeve with clamps for discharge side nominal size (ISO) DN 10"

1 Driving motor per NEMA-standard, design B, TEFC,
150.0 HP, 1780 rpm, 60 Hz, 460 V, size: 445T
weight: 1892 lb

1 Motor installation

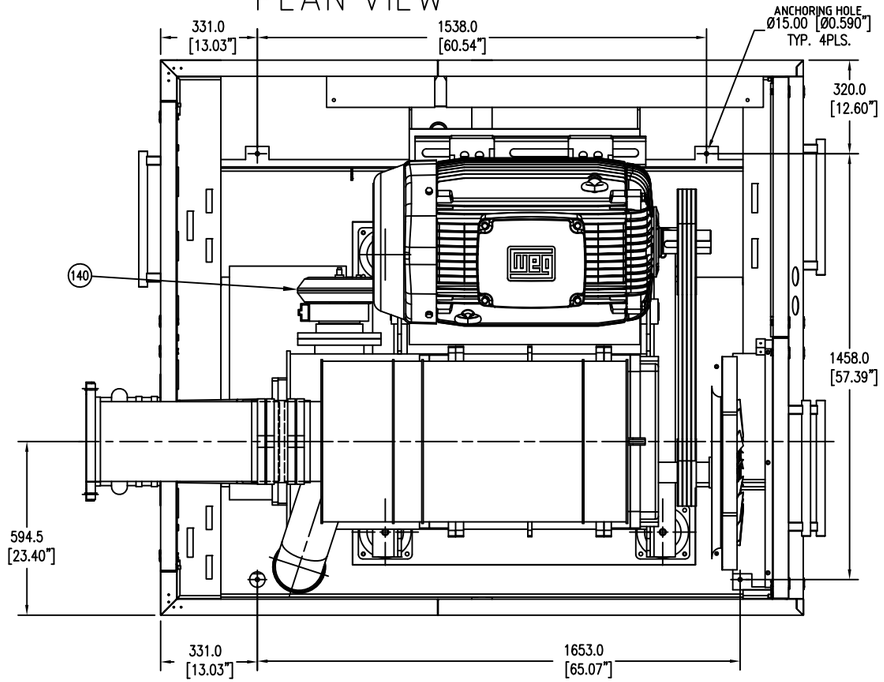
2 Pneumatic start-unloading valve type: Aeromat 5"

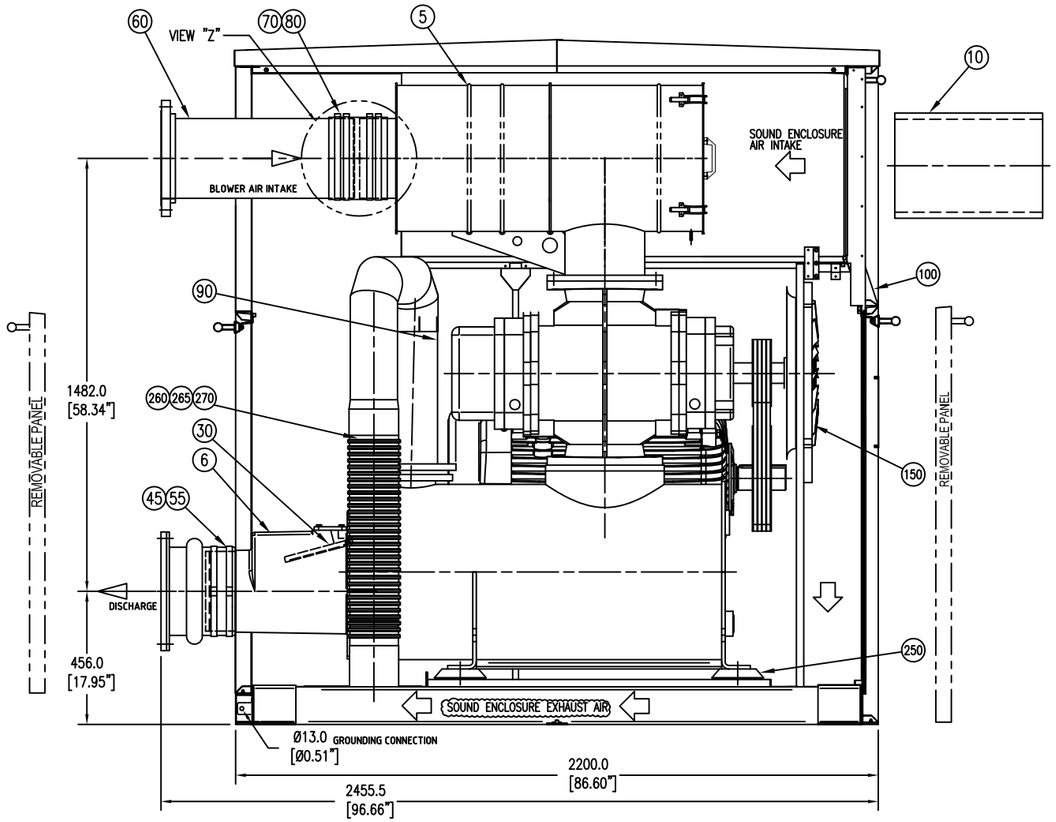
1 Pressure gauge 63 mm (2.5") ø with connection pieces

1 Filter maintenance indicator

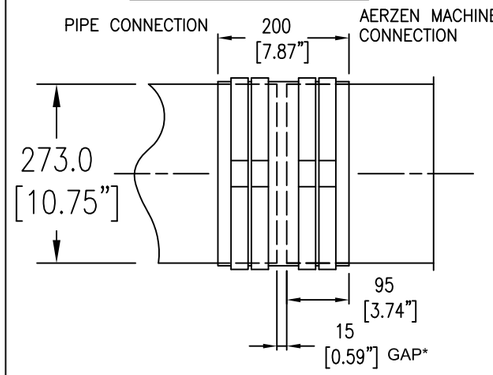
1 Oil filling (12.5 US qt), included in the service kit

PLAN VIEW





PIPE CONNECTION DETAIL

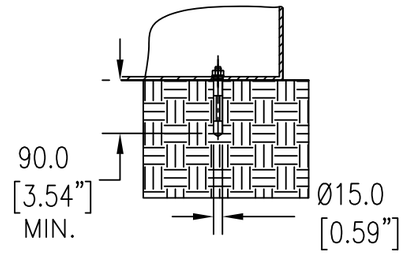


* PIPE ENGAGEMENT IN FLEX CONNECTION LEAVES .6" GAP

VIEW "Z"

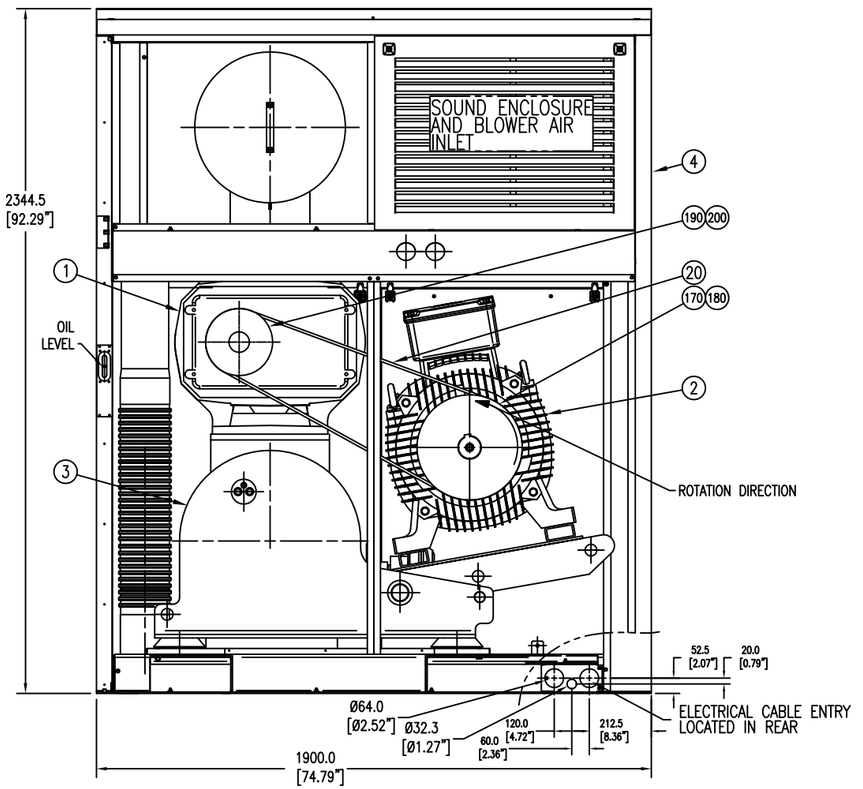
RECOMMENDED SOUND ENCLOSURE ANCHORING

SHOWN WITH OPTIONAL LIEBIG #AB 15/15
AERZEN P/N 120835



ITEM	QTY.	DESCRIPTION
1	1	BLOWER
2	1	MOTOR (SEE JOB SPECIFIC DATA)
3	1	BASE FRAME
4	1	SOUND ENCLOSURE (S.E.)
5	1	INLET FILTER/SILENCER ASSEMBLY
6	1	DISCHARGE HOUSING
10	1	INLET FILTER ELEMENT (SHOWN REMOVED)
20	–	DRIVE BELTS (SEE JOB SPECIFIC DATA)
30	1	ONE–WAY VALVE
45	1	EXPANSION JOINT – 10" 150# ANSI FLANGE
55	2	CLAMPS FOR EXPANSION JOINT
60	1	STUB PIPE W/ 10"–150# ANSI FLANGE (INTAKE)
70	1	FLEXIBLE CONNECTOR (INTAKE)
80	4	CLAMPS FOR INTAKE FLEX CONNECTOR
90	1	SAFETY RELIEF VALVE
100	–	INSTRUMENTATION (SEE JOB SPECIFIC DATA)
140	1	UNLOADING VALVE (OPTIONAL)
150	1	S.E. VENTILATION FAN (MOUNTED ON BLOWER SHAFT)
170	1	MOTOR SHEAVE BUSHING
180	1	MOTOR SHEAVE
190	1	BLOWER SHEAVE BUSHING
200	1	BLOWER SHEAVE
250	4	VIBRATION ISOLATORS
260	1	SAFETY RELIEF VALVE HOSE
265	1	SAFETY RELIEF VALVE TUBE
270	3	SAFETY RELIEF VALVE HOSE CLAMPS

FRONT VIEW –
SHOWN W/O REMOVEABLE PANELS



NOTES

1. TOLERANCE ON DIMENSIONS = ±12mm [0.5"]
2. WEIGHT: BLOWER PACKAGE WEIGHT 2340 Kg. (5148 Lbs.)
   MOTOR WEIGHT Kg. (Lbs.)
   TOTAL Kg. (Lbs.)
3. REMOVABLE PANEL WEIGHT:
   PANELS DO NOT EXCEED APPROX. 20 Kg (45 Lbs)
4. CUSTOMER PIPING TO BE INDEPENDENTLY SUPPORTED
5. LIFTING OF PACKAGE: AFTER REMOVING FRONT & REAR DOORS, FROM FRONT SIDE THROUGH FORK LIFT POCKET IN BASE
6. FREE SPACE FOR MAINTENANCE WORK AT FRONT AND REAR SIDE OF UNIT APPROX. 800mm [32"]
7. FOR ADDITIONAL INFORMATION SEE:
   JOB SPECIFIC DATA PACKAGE

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AERZEN USA CORP.
108 Independence Way, COATESVILLE PA 19320
(610) 380–0244 PH, (610) 380–0278 FX

TITLE
GM 90S - GENERATION 5
DN-250 PRESSURE w/ S.E.
ANSI INLET & DISCHARGE CONN. (F3 MOTOR)

DATE	DRAWN BY:	CHECKED BY:	P.M. APPROVAL	SCALE:
12/28/2010	JPS	DLM	---	MODEL SPACE 1 :1

DRAWING NO:	REVISION NO:	SHEET:
GB-005919	–	1/2

Mixers

Product description

SULZER

Pos.no	Description	Item no.	Qty.
	Mixer selection: Blending and suspension		
1.1	RW 3021		1

Submersible mixer type ABS RW 3021

Compact, versatile submersible mixers
The RW is Sulzer's standard range of submersible mixers, economical without compromising on reliable design. These compact, versatile submersible mixers are ideal for agitating, blending, mixing, dissolving, and suspension of solids in municipal treatment plants, industry, and agriculture. The RW mixers can easily be fitted to existing guiderails and lifting devices without modification, using our wide range of brackets and adapters.

MIXER DATA

Type:	RW 3021
Propeller diameter:	11.81 inch
Propeller speed:	1111 rpm

MOTOR DATA

Motor:	A17/6 60HZ
Series:	3~ motor
Nominal power:	2.28 hp
Nominal efficiency:	71.42 %
Frequency:	60 Hz

Mixer Selection System

Blending and suspension

Printout for Mixer

RW 3021 - A17/6 60HZ



Calculation for

Customer name	Manchester, Maryland WWTP ENR Upgra
Project name	Untitled project 2026-04-09 15:39:35.591
Project no	
Project note	Pre-Anoxic tank 1 and 2

Tank data

Tank shape	rectangular
Liquid depth	18 ft
Length	25 ft
Width	13 ft
Volume	165700 l

Fluid data

Type of Fluid	Activated Sludge - Anoxic (Screening < 5 mm (0,2 inch) - with Pre-Sedimentation)
MLSS / DMC	0.5 %
SVI	2.002 ft³/lb
Density	62.43 lb/ft³
Viscosity	10 cP
Temperature	77 °F

Process description

Application	Denitrification
Mixing process	Solid Suspension

Mixer data

Mixer	RW 3021 - A17/6 60HZ
Frequency	60 Hz
No of Mixer	1
Rated Motor Power (P2)	2.28 hp
Propeller diameter	11.81 inch
Propeller speed	1111 rpm
Mixing capacity	2314 US g.p.m.
Application factor	
Note	
Thrust	400 N

Calculation data

Speed correction	No
Motor duty point (P1)	2.1 hp
Motor duty point (P2)	1.475 hp
Total power P1 (all mixers)	2.1 hp
Specific power density (P1)	0.009455 kW/m³
Specific power density (P2)	0.00664 kW/m³
Mixing grade	2.5
Required performance indicator (ID Figure)	406
Performance indicator (ID Figure)	500

Energy cost

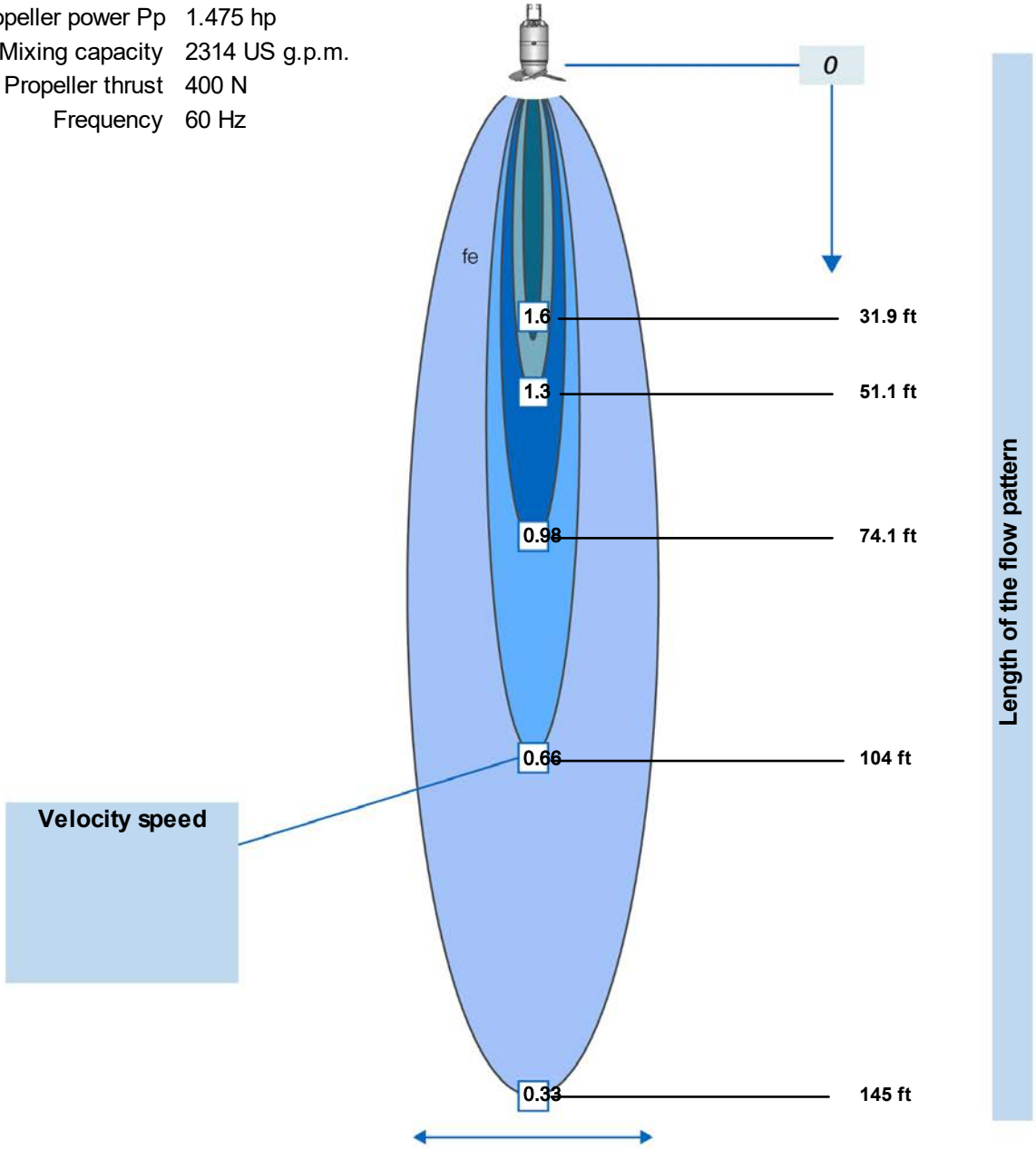
Cost per KW/h	0.32 EUR/kWh
Operating hours per day	17.21 h/d
Operating days per year	365 d/a
Power Consumption	9836 kWh
Total energy cost per day	8.623 EUR
Total energy cost per year	3148 EUR

Sulzer reserves the right to change any data and dimensions without prior notice
and can not be held responsible for the use of information contained in this software.

Velocity diagram

RW 3021

Propeller diameter	11.81 inch
Propeller speed	1111 rpm
Propeller power Pp	1.475 hp
Mixing capacity	2314 US g.p.m.
Propeller thrust	400 N
Frequency	60 Hz



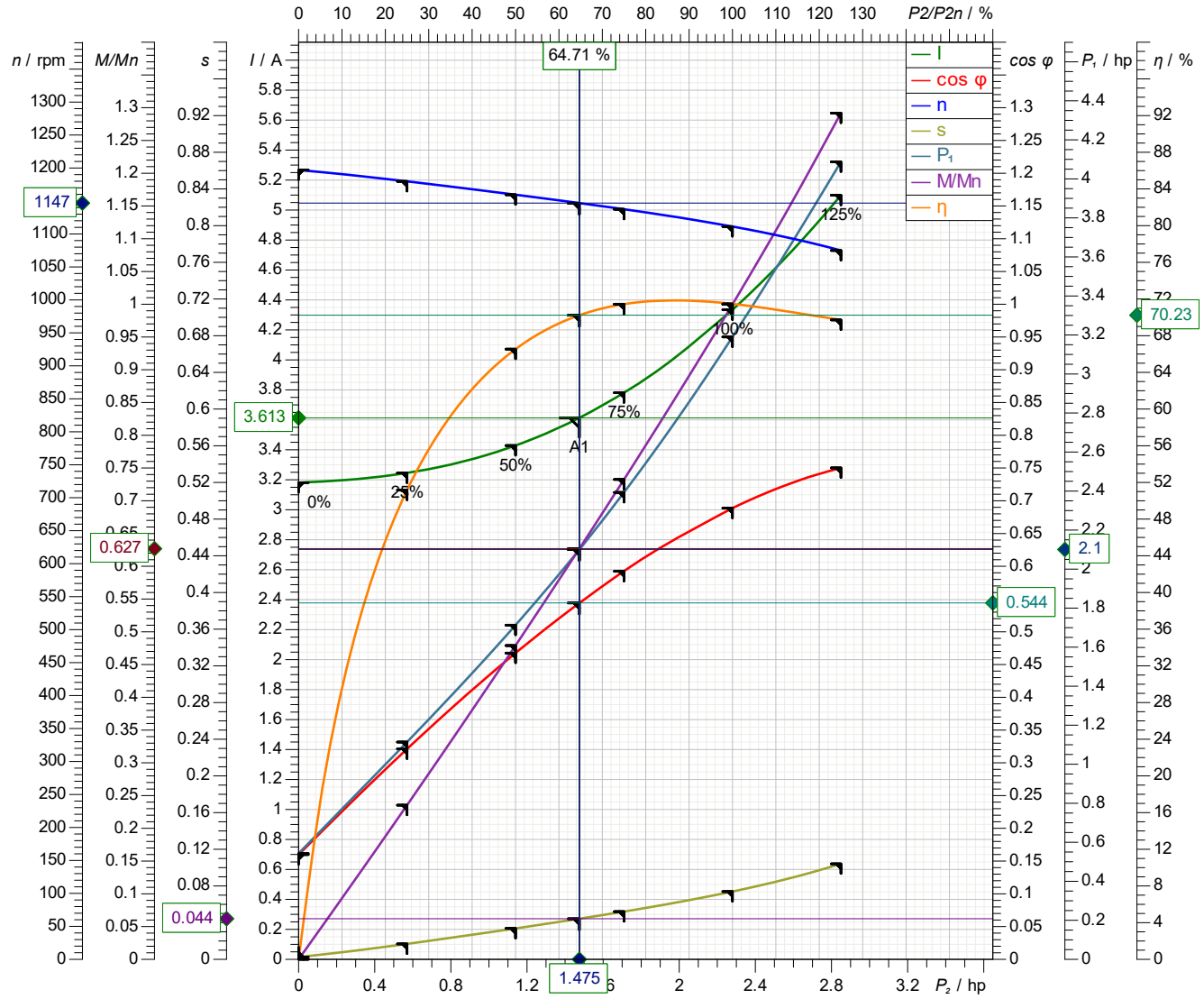
Width of the flow pattern

1.6 ft/s	4.9 ft
1.3 ft/s	6.2 ft
0.98 ft/s	8.2 ft
0.66 ft/s	12 ft
0.33 ft/s	25 ft

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and can not be held responsible for the use of information contained in this software.

Frequency		Motor performance curve	SULZER
60 Hz		A17/6 60HZ	

Rated power	Service factor	Nominal Speed	Number of poles	Rated voltage	Date
2.28 hp	1	1111 rpm	6	460 V	2026-04-09



Symbol	No load	25 %	50 %	75 %	100 %	125 %
P_2 / hp	0	0.5699	1.14	1.71	2.28	2.85
P_1 / hp	0.543	1.114	1.713	2.393	3.19	4.087
I / A	3.181	3.246	3.429	3.781	4.334	5.099
cos φ	0.1598	0.3212	0.4676	0.5924	0.6888	0.7502
n / rpm	1197	1180	1160	1137	1111	1075
s / %	0.2457	1.688	3.374	5.21	7.395	10.42
M / lbf ft	0	2.537	5.163	7.895	10.78	13.92
η / %	0	51.17	66.54	71.44	71.47	69.72

Tolerance according to VDE 0530 T1 12.84 for rated power

Starting current	Starting torque	Moment of inertia	No. starts per hour
15.5 A	22.8 lbf ft	0.0783 lb ft²	15

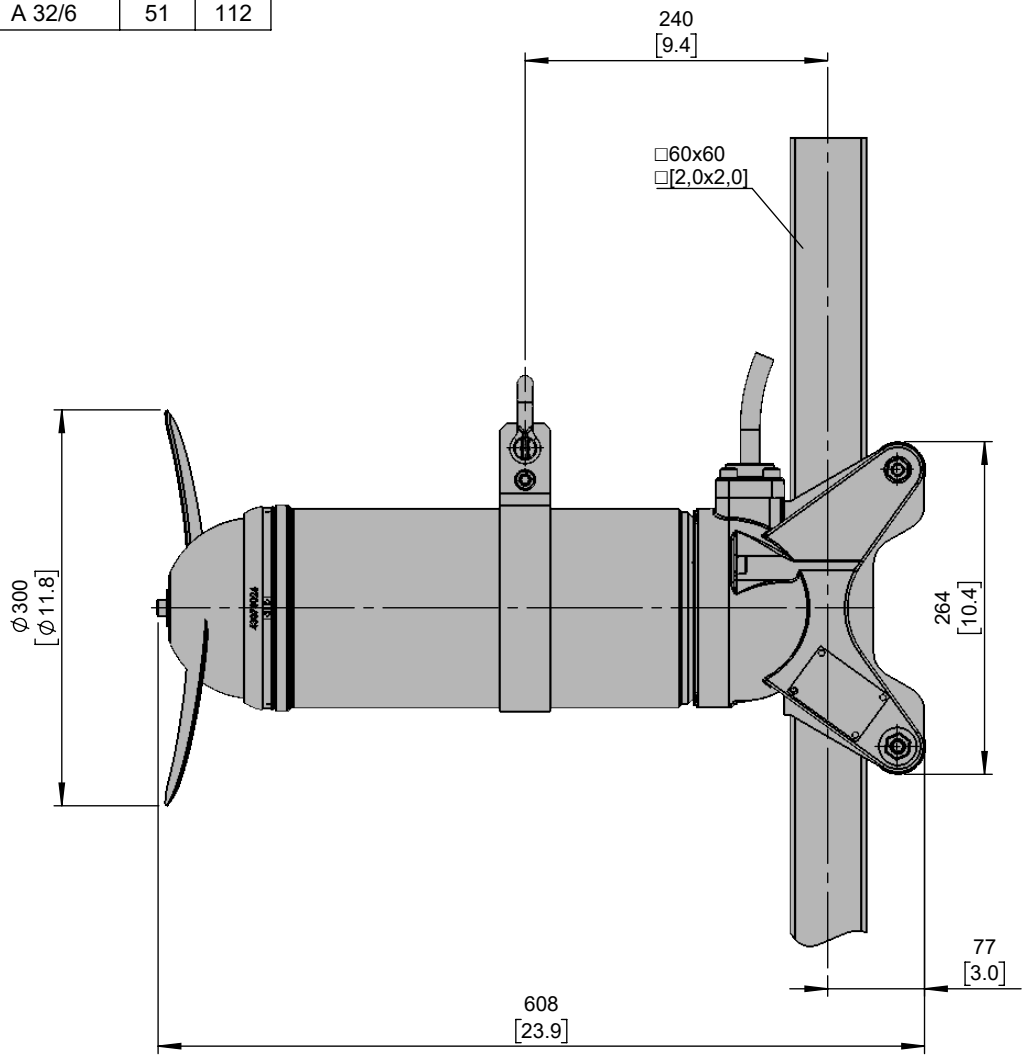
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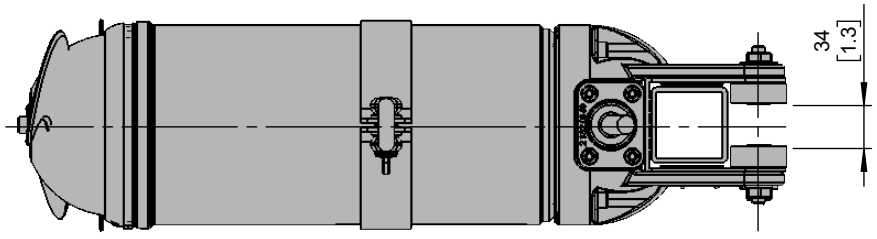
No: AN-M.14.147 - 04	**RW300**
Dat/Nam.:25.07.1995 / D. Whelan	Dimension sheet RW300 □60
Cad Code: AN-M.14.147	Maßblatt RW300 □60
Technical changes reserved Änderungen vorbehalten Sous réserve de modifications	Plan d'encombrement RW300 □60

SULZER

Type Typ Type 50Hz	Type Typ Type 60Hz	Weight Gewicht Poids	
		(~kg)	(~lb)
A 15/6	A 17/6	47	104
A 28/6	A 32/6	51	112

Weight: Includes pump, slider bracket and 10m cable
Gewicht: Beinhaltet Pumpe, Halterung und 10m Kabel
Poids: Pompe, coulisseau et 10m de câble





[mm [inch]]

* Guidline value: Minimum submergence can be lower
Richtwert: Die Mindestüberdeckung kann geringer sein
Valeur indiquée: la submergence minimale peut s'avérer inférieure en pratique

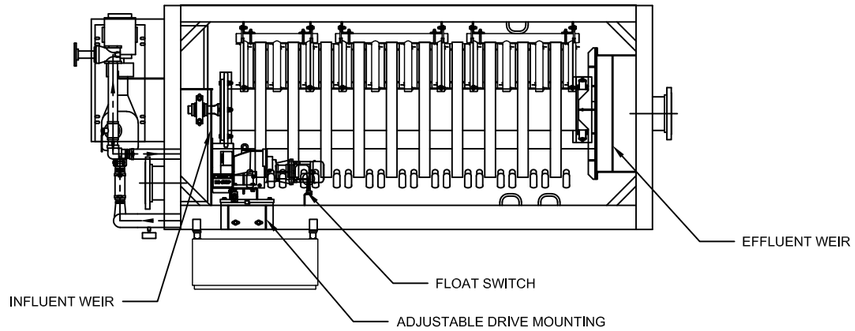
Cloth Media Filter

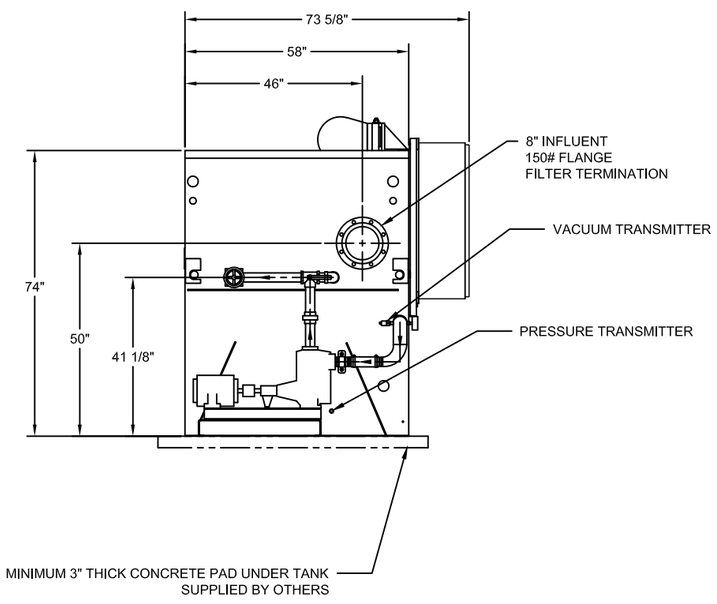
1. IF FREEZING IS A CONCERN AQUA-AEROBIC SYSTEMS RECOMMENDS THE FILTERS BE PLACED IN A HEATED BUILDING. IF A BUILDING IS NOT PROVIDED, ANY NECESSARY PROTECTION, INCLUDING BUT NOT LIMITED TO, HEAT TRACING AND INSULATION OF PUMPS AND PIPING, AS WELL AS PROTECTION AGAINST INTERNAL TANK FREEZING, SHALL BE PROVIDED BY THE INSTALLING CONTRACTOR.

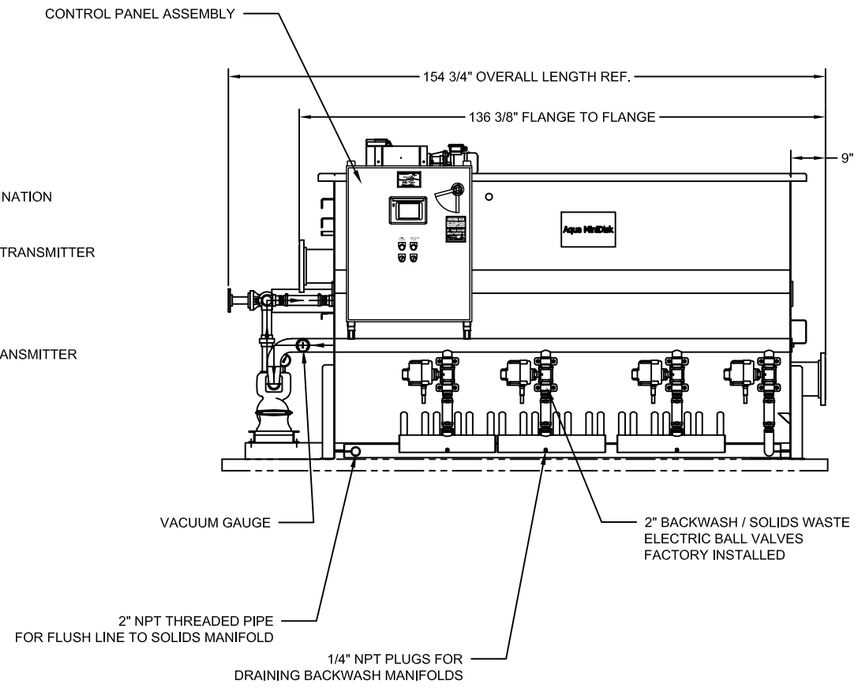
2. THE FILTER CONTROL PANEL IS SHOWN IN THE STANDARD LOCATION. IF THE FILTER IS LOCATED OUTSIDE, THE CONTROL PANEL SHOULD FACE NORTH, TO LIMIT EXPOSING THE H.M.I. TO DIRECT SUNLIGHT.

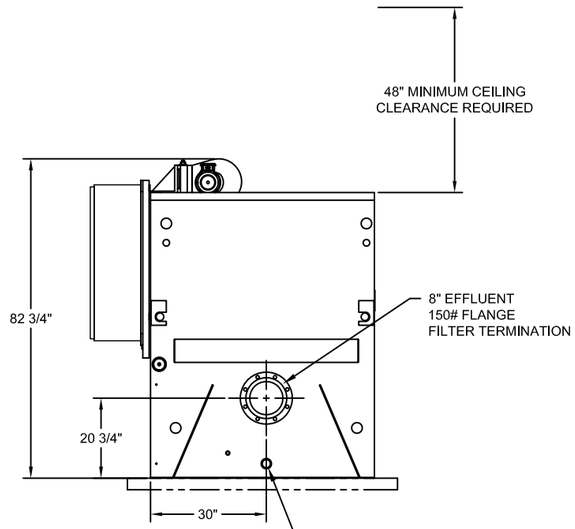
3. THE GRAPHIC ELEMENTS OF THIS COMPUTER GENERATED DRAWING ARE DRAWN FULL SIZE. THE DIMENSIONS ARE ASSOCIATIVE. IF THE SIZE OF THE GRAPHIC ELEMENTS IS CHANGED THE DIMENSIONS WILL NOT BE CORRECT.

4. AN INFLUENT VALVE IS REQUIRED FOR ISOLATION / MAINTENANCE OF THE FILTER UNIT. THE INFLUENT VALVE SHALL BE PROVIDED BY OTHERS AND INSTALLED BY OTHERS.









DRY WT (LBS)	OPER. WT. (LBS)
4,850	14,750

NOT FOR CONSTRUCTION

JOB NAME:
JOB LOCATION:

AQUA-AEROBIC SYSTEMS, INC.

DO NOT SCALE DRAWING

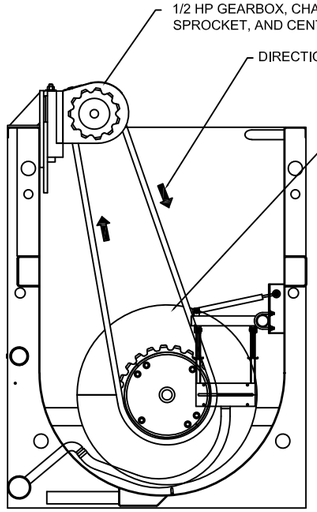
UNLESS OTHERWISE SPECIFIED
FRACTIONAL DIMENSIONS +/- 1/16
ALL TWO PLACE DECIMALS +/- 0.010
ALL THREE PLACE DECIMALS +/- 0.005
ALL ANGLES +/- 1/2°
ANSI

MATERIAL:
SIMILAR TO:
TYPE:
DRAWN BY: SLT DATE: 2012-03-28
CHECKED BY: DATE:
WEIGHT: SHEET: 1 OF 4

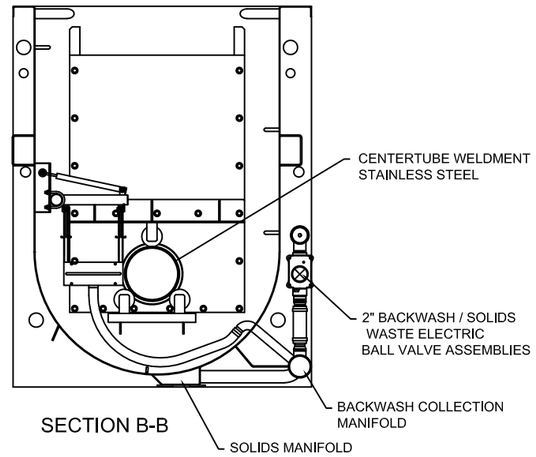
REV.	ERN / ECO	DATE	BY	REVISION DESCRIPTION

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DRAWING NUMBER: 2801994
SCALE:
SIZE: D

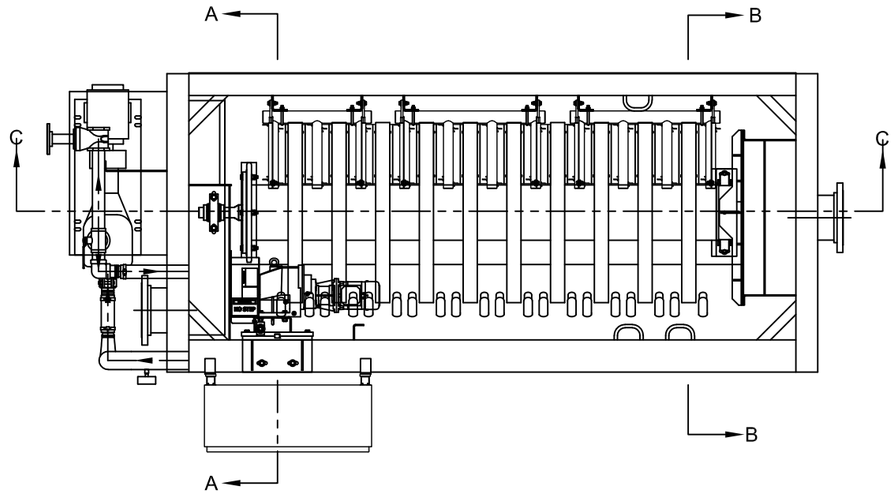
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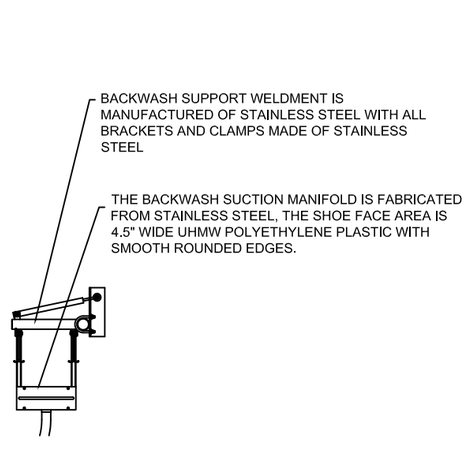


SECTION A-A

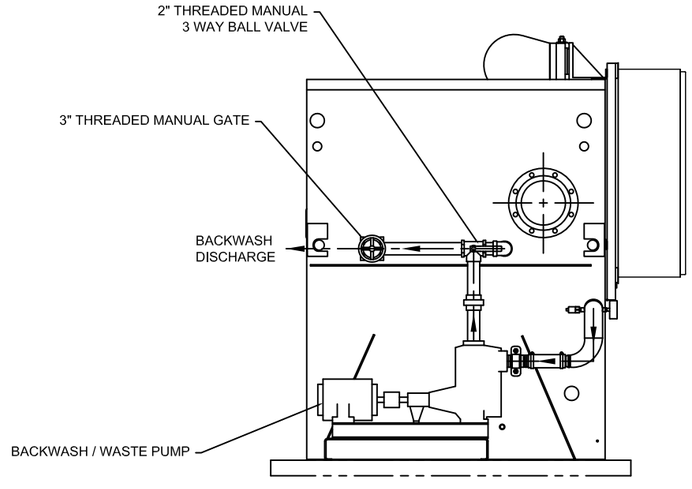


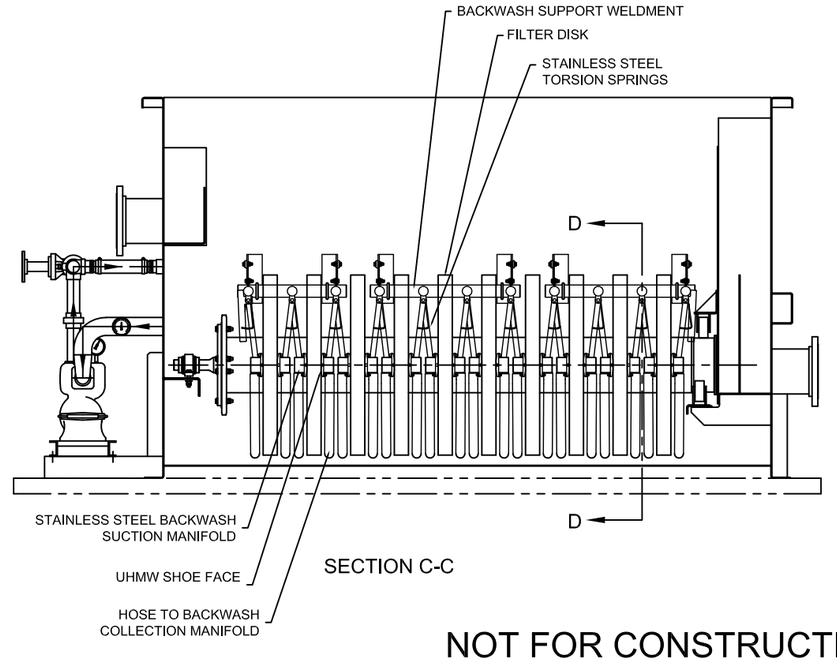
SECTION B-B





SECTION D-D





SECTION C-C

[1] THE BACKWASH / WASTE PUMP CAPABILITIES ARE AS FOLLOWS:

- HORSEPOWER: 2 HP
- FLOW: 113.75 gpm
- TOTAL DYNAMIC HEAD: 26.2 ft
- ALLOWABLE DISCHARGE HEAD, AFTER FILTER LOSSES: 15.2 ft

FOR INSTALLATIONS THAT REQUIRE MORE DISCHARGE HEAD, ALTERNATIVE PUMPS ARE AVAILABLE. PLEASE CONSULT ENGINEERING TO VERIFY THE SUITABILITY OF THE DISCHARGE PIPING OR FOR SPECIAL PUMP REQUIREMENTS.

NOT FOR CONSTRUCTION

REV	ERN / ECO	DATE	BY	REVISION DESCRIPTION

JOB NAME:
JOB LOCATION:

AQUA-AEROBIC SYSTEMS, INC.

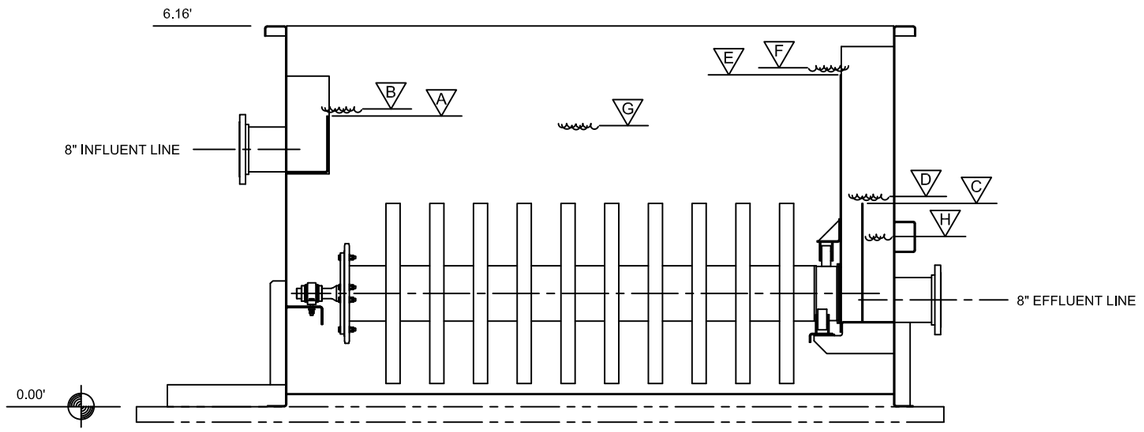
DO NOT SCALE DRAWING

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FRACTIONAL DIMENSIONS +/- 1/16
ALL TWO PLACE DECIMALS +/- 0.010
ALL THREE PLACE DECIMALS +/- 0.005
ALL ANGLES +/- 1/2°
ANSI

MATERIAL:
SIMILAR TO:
TYPE:
DRAWN BY: SLT
DATE: 2012-03-28
CHECKED BY:
DATE:
WEIGHT:
SHEET: 2 OF 4

DRAWING NAME: AQUADISK FILTER MODEL ADFSP-11 X 10E-PC-RH
DRAWING NUMBER: 2801994
SCALE:
SIZE: D

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ELEVATION

A	4.71'	INFLUENT WEIR ELEVATION
B	4.91'	NAPPE OVER INFLUENT WEIR AVERAGE FLOW
	5.04'	NAPPE OVER INFLUENT WEIR MAXIMUM FLOW
C	3.29'	EFFLUENT WEIR ELEVATION
D	3.50'	NAPPE OVER EFFLUENT WEIR AVERAGE FLOW
	3.62'	NAPPE OVER EFFLUENT WEIR MAXIMUM FLOW
E	5.35'	OVERFLOW WEIR ELEVATION
F	5.56'	NAPPE OVER OVERFLOW WEIR AVERAGE FLOW
	5.68'	NAPPE OVER OVERFLOW WEIR MAXIMUM FLOW
G	4.67'	BACKWASH INITIATE LEVEL
H	2.79'	MAXIMUM AVAILABLE LIQUID LEVEL FOR EFFLUENT CONVEYANCE

HYDRAULIC PROFILE

BASED UPON AVERAGE FLOW RATE OF 3.25 GPM PER SQUARE FOOT (.5 MGD)
BASED UPON MAXIMUM FLOW RATE OF 6.5 GPM PER SQUARE FOOT (1.0 MGD)

WEIR LENGTHS

INFLUENT = 2.50'
EFFLUENT = 2.50'
OVERFLOW = 2.50'

NOT FOR CONSTRUCTION

JOB NAME:
JOB LOCATION:

AQUA-AEROBIC SYSTEMS, INC.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED
FRACTIONAL DIMENSIONS +/- 1/16
ALL TWO PLACE DECIMALS +/- 0.010
ALL THREE PLACE DECIMALS +/- 0.005
ALL ANGLES +/- 1/2°
ANSI

MATERIAL:
SIMILAR TO:
TYPE:
DRAWN BY: SLT
DATE: 2012-03-28
CHECKED BY:
DATE:
WEIGHT:
SHEET: 3 OF 4

REV	ERN / ECO	DATE	BY	REVISION DESCRIPTION

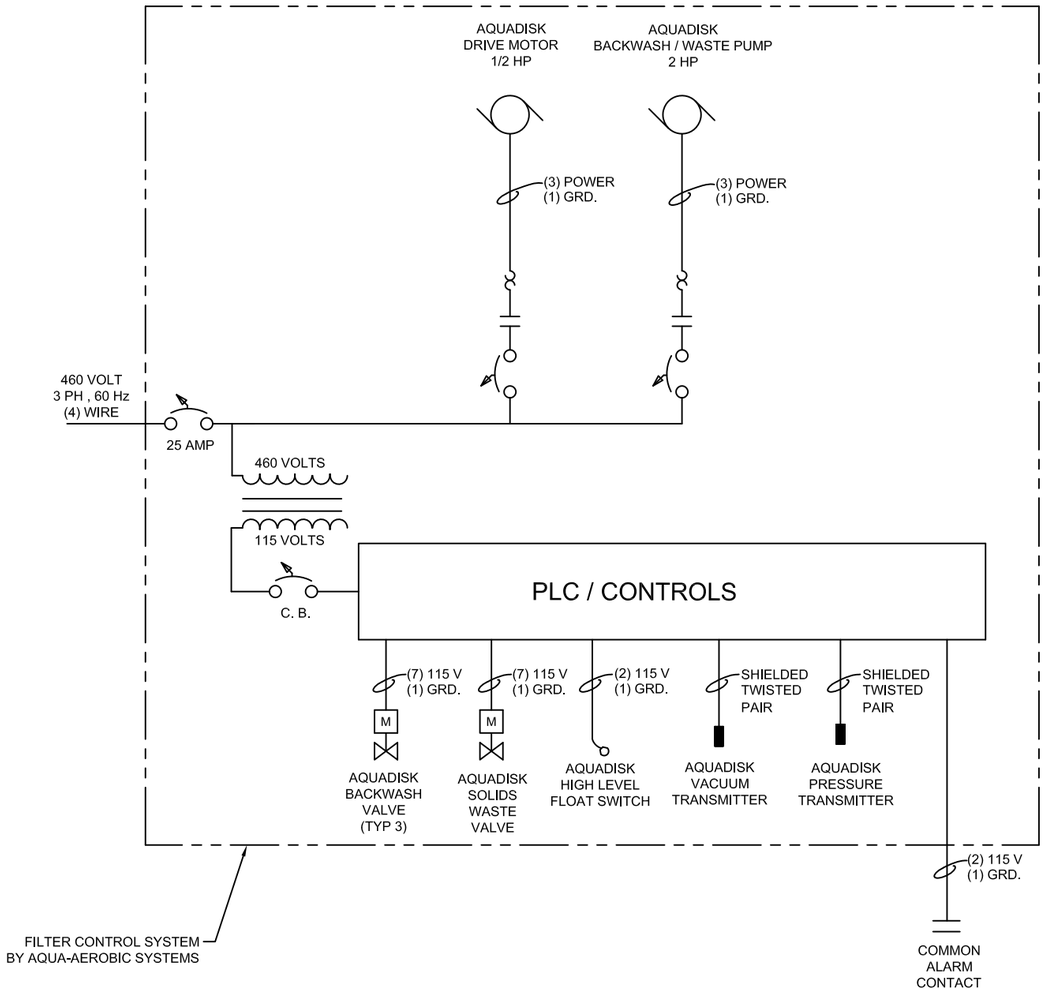
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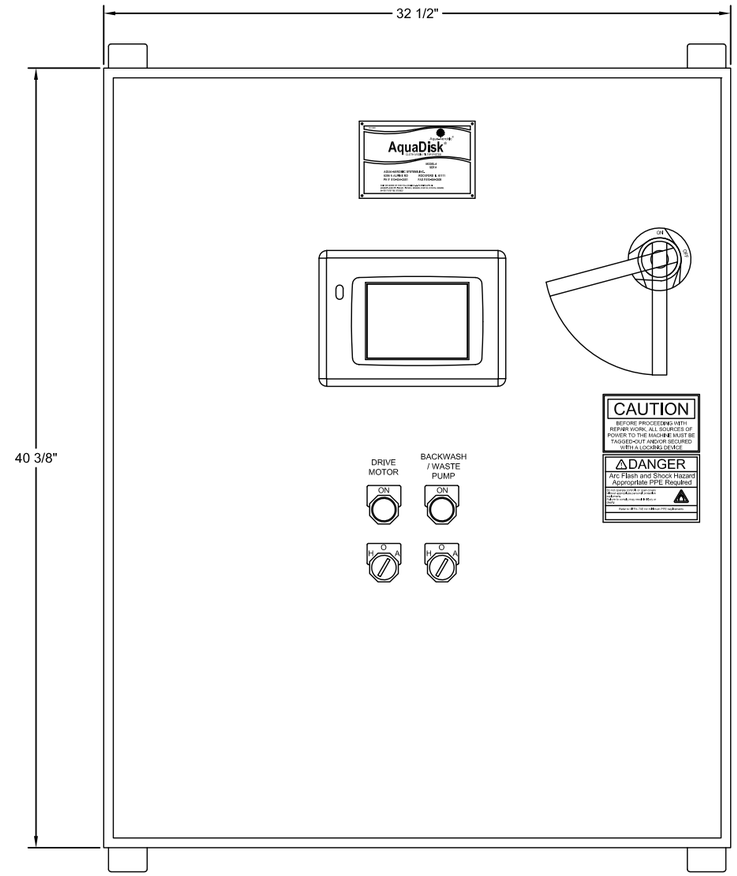
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SYMBOL KEY

	MOTOR		CIRCUIT BREAKER		ELECTRICAL DISCONNECT	VFD	VARIABLE FREQUENCY DRIVE		TRANSDUCER		STARTER CONTACTOR
M	MOTOR OPERATED VALVE		TRANSFORMER		MOTOR OVERLOAD	P	PNEUMATIC OPERATED VALVE		FUSE		FLOAT SWITCH

NOTE: SOME SYMBOLS MAY NOT BE APPLICABLE





1 CONTROL PANEL
ENCLOSURE NEMA 4X WALL MOUNTED TYPE FIBERGLASS
FACTORY ASSEMBLED AND SHIPPED LOOSE. INSTALLED BY OTHERS.
MUST BE LOCATED WITHIN 50 FEET OF THE PRESSURE TRANSMITTER.
FACING NORTH TO LIMIT THE H.M.I. EXPOSURE TO DIRECT SUNLIGHT.
FLOOR MOUNTING IS AVAILABLE WITH STEEL OR STAINLESS STEEL ENCLOSURES.

2 STANDARD CONTROL PANEL SIZE
40" HEIGHT X 32" WIDE X 12" DEEP

NOT FOR CONSTRUCTION

REV	ERN / ECO	DATE	BY	REVISION DESCRIPTION

JOB NAME:
JOB LOCATION:

AQUA-AEROBIC SYSTEMS, INC.

DO NOT SCALE DRAWING

UNLESS OTHERWISE SPECIFIED
FRACTIONAL DIMENSIONS +/- 1/16
ALL TWO PLACE DECIMALS +/- 0.010
ALL THREE PLACE DECIMALS +/- 0.005
ALL ANGLES +/- 1/2°
ANSI

MATERIAL:
SIMILAR TO:
TYPE:
DRAWN BY: SLT
DATE: 2012-03-28
CHECKED BY:
DATE:
WEIGHT:
SHEET: 4 OF 4

DRAWING NAME: AQUADISK FILTER MODEL ADFSP-11 X 10E-PC-RH
DRAWING NUMBER: 2801994
SCALE:
SIZE: D

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20-YEAR O&M ESTIMATE

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

COLLEGE STUDENT PROJECTS

Design#: 182914

Option: Preliminary Northeastern University Filter Design

Designed By Kayla Donahoe on Monday, March 30, 2026

Prepared By Kayla Donahoe on Monday, March 30, 2026

The enclosed information is based on preliminary data which we have received from you. There may be factors unknown to us which would alter the enclosed recommendation. These recommendations are based on models and assumptions widely used in the industry. While we attempt to keep these current, Aqua-Aerobic Systems, Inc. assumes no responsibility for their validity or any risks associated with their use. Also, because of the various factors stated above, Aqua-Aerobic Systems, Inc. assumes no responsibility for any liability resulting from any use made by you of the enclosed recommendations.

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O&M Notes

The cloth media filter has been designed to handle the maximum design flow while maintaining one unit out of service.

* The actual cloth media life may be more or less than 7 years depending on site specific conditions.

** The values listed are for estimating purposes only. The actual amount of operator attention provided will be dependent upon local requirements and the size of the staff available for testing.

All estimates are based upon equipment maintenance and operation in accordance with the O & M instructions provided by Aqua-Aerobic Systems. They are based on typical AquaDisk installations with a normal preventative maintenance schedule for the equipment. The actual maintenance man hours required for each project will vary depending upon site and climate conditions, which may alter the frequency of the maintenance schedule.

AquaDisk®: Estimated Operation & Maintenance Costs

Design# 182914

Project: COLLEGE STUDENT PROJECTS

Option: Preliminary Northeastern University Filter Design

Designed By Kayla Donahoe on Monday, March 30, 2026

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

I. EQUIPMENT MAINTENANCE AND REPLACEMENT ESTIMATE

Qty	Unit	Service Required	Replacement Interval (Years)	Material Cost	20-Year Total
	AquaDisk Filter				
2	Main "V-Ring" Seal	Parts Replacement	10	$382	$1,528
2	Filter Media Cloths/Disk	Parts Replacement	7*	$255	$20,400

INTERVAL TOTALS:

7-Year	10-Year
$10,200	$764

20-Year Estimated Total: **$21,928**

II. LUBRICATION REQUIREMENTS ESTIMATE

Estimated General Operation & Maintenance **	**# of Units**		**Minutes/Unit**		**Times/Year**	**Hours/Year**	
Backwash / Solids Waste Pump - Routine Lubrication	2	**x**	5	**x**	12	**/ 60 =**	2.00
Backwash / Solids Waste Pump - Drain and Refill	2	**x**	30	**x**	1	**/ 60 =**	1.00
Drive Gear Box Lubrication	2	**x**	30	**x**	0.25	**/ 60 =**	0.25
Drive Motor Lubrication	2	**x**	5	**x**	0.25	**/ 60 =**	0.04

TOTAL LABOR REQUIREMENTS: 3.29

III. POWER CONSUMPTION ESTIMATE

Power Costs of All Equipment as Proposed

Backwash / Solids Waste Pump	1,711.6	(kWh/Year)
Disk Drive Motor	248.8	(kWh/Year)
Power Control Panel	2,800.0	(kWh/Year)
Total:	4,760.40	(kWh/Year)
Estimated $/kWh:	$0.08	
Total Annual Power Cost:	$381	

20-Year Estimated Power Cost: **$7,617**

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

Process Design Report

COLLEGE STUDENT PROJECTS

Design# 182914

Option: Preliminary Northeastern University Filter Design

Aqua MiniDisk®

Cloth Media Filter



March 30, 2026

Designed By: Kayla Donahoe

6306 N. Alpine Rd Loves Park, IL 61111
(815) 654-2501 www.aqua-aerobic.com

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Process/Site

- The following parameters have been assumed, as displayed on the design (engineer to verify): Influent TSS and influent Total P.

- Chemical addition for coagulation/flocculation must be added upstream of the filter. In addition, rapid mixing and a flocculation tank with at least 5 minutes retention time must be provided. The chemical dosage should be flow-paced and controlled to avoid over-dosing.

- To achieve the effluent monthly average total phosphorus limit, the biological process, chemical feed systems, and Cloth Media Filters need to be designed to facilitate optimum performance.

- A minimum of twelve (12) daily composite samples per month (both influent and effluent) shall be obtained for total phosphorus analysis.

- Secondary effluent phosphorus shall be in a reactive phosphate form and/or a filterable particulate form.

- Chemical addition (i.e. metal salts, and/or polymer) shall be furnished prior to the filter. Adequate rapid mixing must be provided as part of the chemical feed system. The chemical dosage should be flow-paced and controlled to avoid overdosing. Jar testing with various metal salts and polymers is recommended to determine the most effective metal salt and polymer as well as the optimum dosages of each, and to estimate the degree of phosphorus removal that can be achieved. In addition, a pilot study may be required to verify the actual performance capability.

- pH monitoring and control in a range of 6.8-7.2 of the biological reactor is required when adding metal salts.

- The cloth media filter will only remove TP that is associated with the TSS removed by the filter. Since only insoluble, particle-associated phosphorous is capable of being removed by filtration, phosphorous speciation shall be provided by the owner to substantiate the concentrations of soluble and insoluble phosphorous in the filter influent. If the proportions of soluble (unfilterable) and insoluble phosphorous are such that removal to achieve the desired effluent limit is not practical, the owner will provide for proper conditioning of the wastewater, upstream of the filter system, to allow for the required removal.

- The average and maximum design flow and loading conditions, shown within the report, are based on maximum month average and maximum day conditions, respectively.

Filtration

- The cloth media filter recommendation and anticipated effluent quality are based upon influent water quality conditions as shown under "Design Parameters" of this Process Design Report.

- The filter influent should be free of algae and other solids that are not filterable through the specified media. Provisions to treat algae and condition the solids to be filterable are the responsibility of others.

- The cloth media filter has been designed to handle the maximum design flow while maintaining one unit out of service.

Equipment

- Scope of supply includes freight, installation supervision and start-up services.

- Equipment selection is based upon the use of Aqua-Aerobic Systems' standard materials of construction and electrical components, suitable for non-classified electrical environments.

- Aqua-Aerobic Systems, Inc. is familiar with various “Buy American” Acts (i.e. BABA, AIS, ARRA, Federal FAR 52.225, EXIM Bank, USAid, PA Steel Products Act, etc.). As the project develops Aqua-Aerobic Systems can work with you to ensure full compliance of our goods with various Buy American provisions if they are applicable/required for the project. When applicable, please provide us with the specifics of the project’s “Buy American” provisions.

- If the cloth media filter will be offline for extended periods of time, protection from sunlight is required.

AquaDisk® Tertiary Filtration - Design Summary

Design#: 182914

Project: COLLEGE STUDENT PROJECTS

Option: Preliminary Northeastern University Filter Design

Designed by Kayla Donahoe on Monday, March 30, 2026

AQUA-AEROBIC SYSTEMS, INC.
A Metawater Company

DESIGN INFLUENT CONDITIONS

Pre-Filter Treatment: Secondary

Avg. Design Flow	= 0.50 MGD	= 347.22 gpm	= 1892.71 m³/day
Max Design Flow	= 0.66 MGD	= 458.33 gpm	= 2498.37 m³/day

DESIGN PARAMETERS	Influent	mg/l	Effluent Required	<= mg/l	Effluent Anticipated	<= mg/l
Avg. Total Suspended Solids:	TSSa	10	--	--	TSSa	5
Max. Total Suspended Solids:	TSSm	15	--	--	--	--
Phosphorus:	Total P	0.80	Total P	0.30	Total P	0.30
***Turbidity:**	--	--	NTU	2	NTU	2

*Note: Tubidity represented in Nephelometric Turbidity Units (NTU's) in lieu of mg/l.

AquaDisk FILTER RECOMMENDATION

Qty Of Filter Units Recommended	= 2
Number Of Disks Per Unit	= 10
Total Number Of Disks Recommended	= 20
Total Filter Area Provided	= 216.0 ft² = (20.07 m²)
Filter Model Recommended	= AquaDisk Package: Model ADFSP-11-10E-PC
Filter Media Cloth Type	= OptiFiber PES-14®

AquaDisk FILTER CALCULATIONS

Filter Type:

Vertically Mounted Cloth Media Disks featuring automatically operated vacuum backwash . Tank shall include a rounded bottom and solids removal system.

Average Flow Conditions:

Average Hydraulic Loading
= Avg. Design Flow (gpm) / Recommended Filter Area (ft²)
= 347.2 / 216 ft²
= 1.61 gpm/ft² (3.93 m/hr) at Avg. Flow

Maximum Flow Conditions:

Maximum Hydraulic Loading
= Max. Design Flow (gpm) / Recommended Filter Area (ft²)
= 458.3 / 216 ft²
= 2.12 gpm/ft² (5.19 m/hr) at Max. Flow

Solids Loading:

Solids Loading Rate
= (lbs TSS/day at max flow and max TSS loading) / Recommended Filter Area (ft²)
= 82.6 lbs/day / 216 ft²
= 0.38 lbs. TSS /day/ft² (1.86 kg. TSS/day/m²)

The above recommendation is based upon the provision to maintain a satisfactory hydraulic surface loading with (1) unit out of service. The resultant hydraulic loading rate at the Maximum Design Flow is: 4.2 gpm / ft² = (10.4 m/hr)

Cloth Media Filters

AquaDisk Tanks/Basins

2 AquaDisk Model # ADFSP-11x10E-PC Package Filter Painted Steel Tank(s) consisting of:

- 10 Disk painted steel tank(s).
- 2" ball valve(s).

AquaDisk Centertube Assemblies

2 Cloth set(s) will have the following feature:

- Cloth will be OptiFiber PES-14.

2 Centertube(s) consisting of:

- 304 stainless steel centertube weldment(s).
- Centertube driven sprocket(s).
- Dual wheel assembly(ies).
- Rider wheel bracket assembly(ies).
- Centertube bearing kit(s).
- Effluent centertube lip seal.
- Pile cloth media and non-corrosive support frame assemblies.
- 304 Stainless steel frame top plate(s),
- Media sealing gaskets.
- Disk segment 304 stainless steel support rods.

AquaDisk Drive Assemblies

2 Drive System(s) consisting of:

- Gearbox with motor.
- Drive sprocket(s).
- Drive chain(s) with pins.
- Stationary drive bracket weldment(s).
- Adjustable drive bracket weldment(s).
- Chain guard weldment(s).
- Warning label(s).

AquaDisk Backwash/Sludge Assemblies

2 Backwash System(s) consisting of:

- Backwash shoe assemblies.
- Includes enhanced backwash shoe design.
- Backwash shoe support weldment(s).
- 1 1/2" flexible hose.
- Stainless steel backwash shoe springs.
- Hose clamps.

2 Backwash/Solids Waste Pump(s) consisting of:

- Backwash/waste pump(s).
- 0 to 15 psi pressure gauge(s).
- Absolute pressure gauge(s).).
- Throttling gate valve(s).
- 2" bronze 3 way ball valve(s).

AquaDisk Instrumentation

2 Pressure Transmitter(s) consisting of:

- Level transmitter(s).

2 Float Switch(es) consisting of:

- Float switch(es).

2 Vacuum Transmitter(s) consisting of:

- Vacuum transmitter(s).

AquaDisk Valves

2 Solids Waste Valve(s) consisting of:

- 2" full port, three piece, stainless steel body ball valve(s), grooved end connections with single phase electric actuator(s). Valve / actuator combination shall be TCI / RCI (RCI, a division of Rotork).
- 2" flexible hose.
- Victaulic coupler(s).

2 Set(s) of Backwash Valves consisting of:

- 2" full port, three piece, stainless steel body ball valve(s), grooved end connections with single phase electric actuator(s). Valve / actuator combination shall be TCI / RCI (RCI, a division of Rotork).
- 2" flexible hose.
- Victaulic coupler(s).

AquaDisk Controls w/Starters

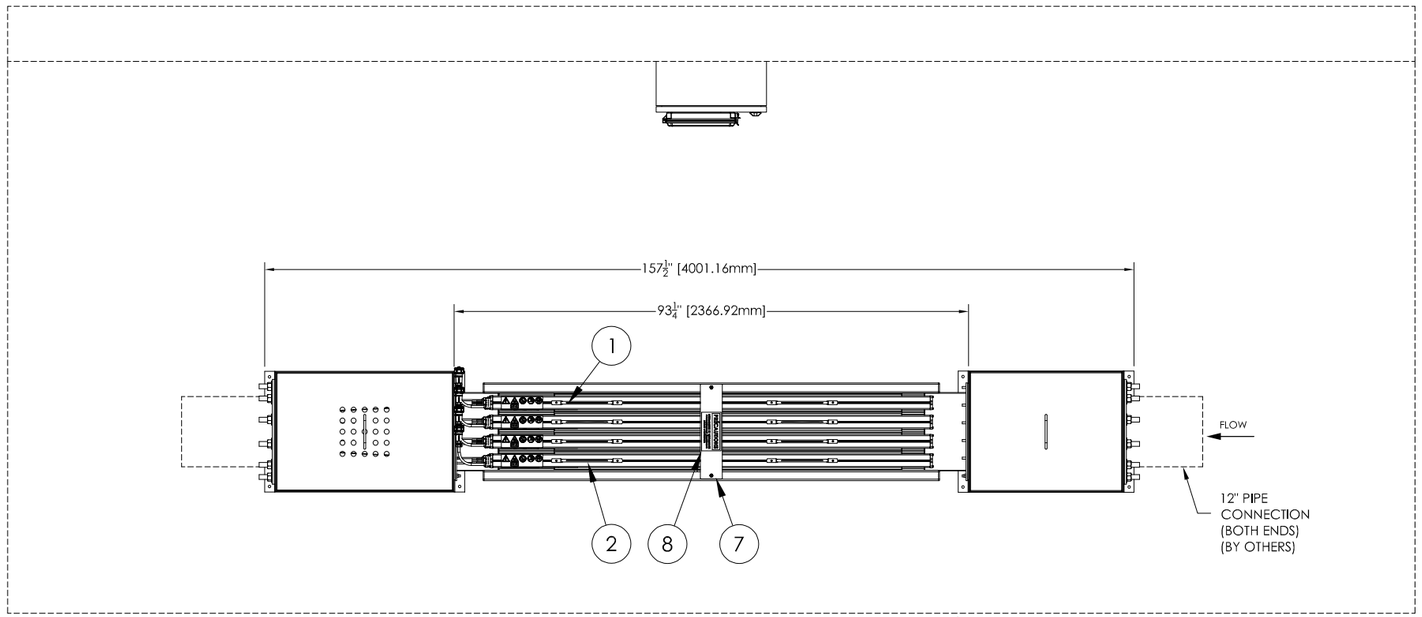
2 Control Panel(s) consisting of:

- NEMA 4X fiberglass enclosure(s).
- Circuit breaker with handle.
- Transformer(s).
- Fuses and fuse blocks.
- Line filter(s).
- GFI convenience outlet(s).
- Control relay(s).
- Selector switch(es).
- Pilot light(s).
- Compactlogix Processor.
- Power supply(s).
- Input card(s)
- Output card(s).
- Analog input card(s).
- Ethernet switch(es).
- Operator interface(s).
- Power supply(ies).
- Motor starter(s).
- Terminal blocks.
- UL label(s).

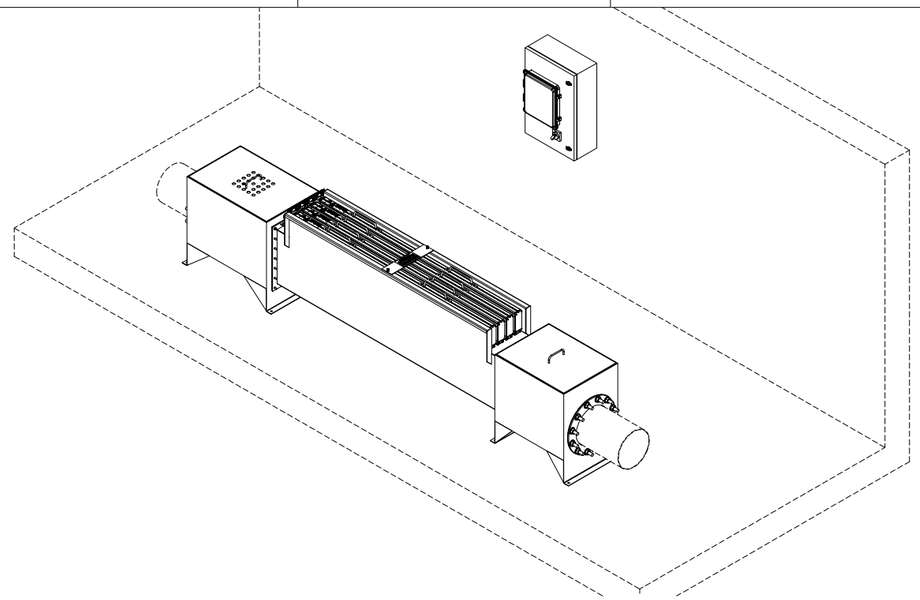
2 Conduit Installation(s) consisting of:

- PVC conduit and fittings.

Ultraviolet Disinfection



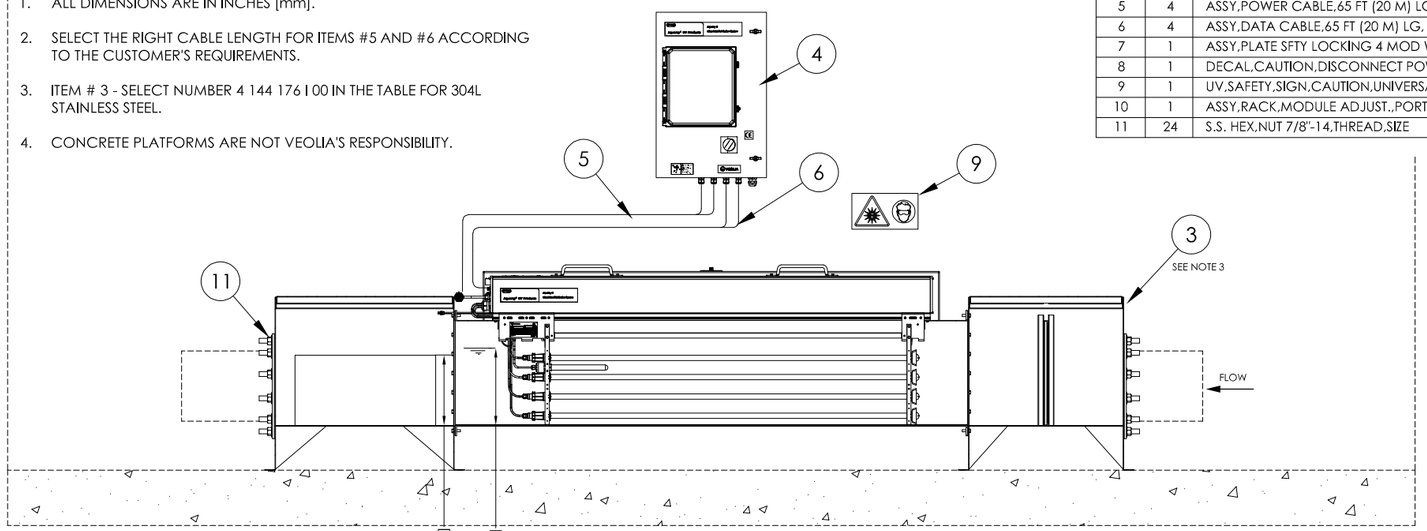
PLAN LAYOUT



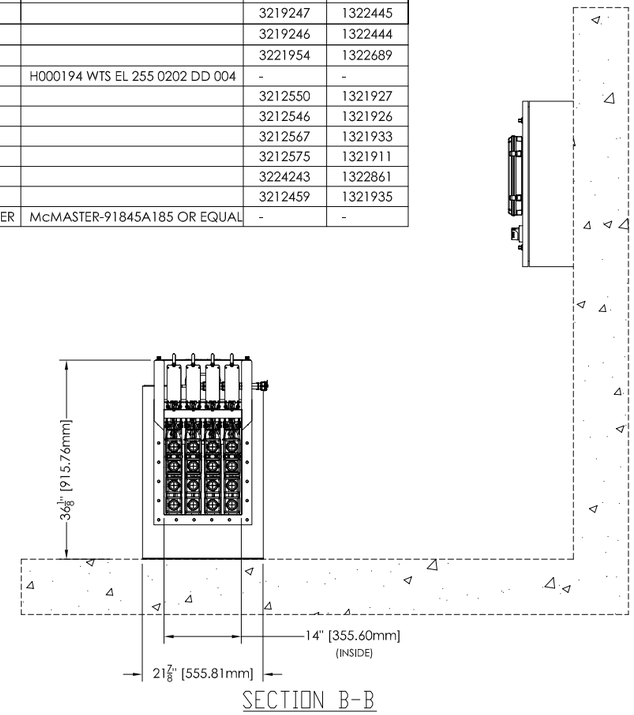
BILL OF MATERIAL						
ITEM#	QTY	DESCRIPTION	MANUF/SUPPL	CFO#	MM#	DM#
1	1	ASSY,MODULE,4-LAMP 04SC1, AQ.S	VEOLIA		3219247	1322445
2	3	ASSY,MODULE,4-LAMP 040C1, AQ.S	VEOLIA		3219246	1322444
3	1	ASSY,PREFAB,CH,O-ALL,4MX4L-AQ.S	VEOLIA		3221954	1322689
4	1	PDDC (4M x 4L) (208V)	VEOLIA	H000194 WTS EL 255 0202 DD 004	-	-
5	4	ASSY,POWER CABLE,65 FT (20 M) LG, AQ.S	VEOLIA		3212550	1321927
6	4	ASSY,DATA CABLE,65 FT (20 M) LG, AQ.S	VEOLIA		3212546	1321926
7	1	ASSY,PLATE SFTY LOCKING 4 MOD WIDE AQ.S	VEOLIA		3212567	1321933
8	1	DECAL,CAUTION,DISCONNECT POWER, AQ.S	VEOLIA		3212575	1321911
9	1	UV,SAFETY,SIGN,CAUTION,UNIVERSAL	VEOLIA		3224243	1322861
10	1	ASSY,RACK,MODULE ADJUST.,PORTABLE, AQ.S	VEOLIA		3212459	1321935
11	24	S.S. HEX,NUT 7/8"-14,THREAD,SIZE	VEOLIA/McMASTER	McMASTER-91845A185 OR EQUAL	-	-

NOTES:

1. ALL DIMENSIONS ARE IN INCHES [mm].
2. SELECT THE RIGHT CABLE LENGTH FOR ITEMS #5 AND #6 ACCORDING TO THE CUSTOMER'S REQUIREMENTS.
3. ITEM # 3 - SELECT NUMBER 4 144 176 I 00 IN THE TABLE FOR 304L STAINLESS STEEL.
4. CONCRETE PLATFORMS ARE NOT VEOLIA'S RESPONSIBILITY.



SECTION A-A



SECTION B-B

REV	DESCRIPTION	ECO	DWN	APPR	APPR	DATE
A	INITIAL ISSUE		MDL	MDL		02/12/25

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TOLERANCES UNLESS NOTED
DECIMALS .X .XX .XXX
ANGLES
FRAC

VEOLIA

CUSTOMER INFORMATION

4M x 4L SYSTEM (STANDARD) NAM

PLAN & SECTION LAYOUT

Aquaray® S (HORIZONTAL UV)

DRAWING NUMBER: H000194 WTS ME 255 7700 DD 005
REVISION: A
REF.: -
DOC. OWNER: -
PROJECT NO.
PART/MATERIAL NO.
SCALE: NONE
SIZE: D
SHEET: 1 OF 1
LAST SAVED: Thursday, August 14, 2025 10:51:07 AM

FILE LOCATION: C:\Users\VGE304\Documents\Back Up File 1-14-14 Manny\Research and Development\UV PRODUCTS\Aquaray S\Channel\System Layout NAM\No Wiper Prefab Channel\H000194 WTS ME 255 7700 DD 005.dwg

SECTION _____ – HORIZONTAL LP HO ULTRAVIOLET DISINFECTION SYSTEMS

1 General

The Contractor/Owner shall provide all labor, equipment, and material necessary to install and test one (1) ultraviolet (UV) system for the disinfection of wastewater, complete in place, as shown on the drawings and specified herein and approved by the owner and the engineer.

1.1 Manufacturer

The process design and equipment layout specified and as shown on the contract drawings, is based on the Aquaray S model 4M x 4L as manufactured by Veolia Water Technologies of Leonia, NJ.

If an alternate UV system manufacturer is proposed, the contractor is responsible for all costs associated with the system evaluation and redesign including all electrical, mechanical, structural, and civil aspects of installation.

No alternate will be considered unless it is pre-approved by the owner/engineer 14 days prior to bid opening. The contractor shall also be responsible for the difference in present worth cost calculations if the 20 yr O&M is higher than the basis of design due to increased parts prices, labor and modifications to accommodate the alternate design.

1.2 Qualification of manufacturer

Products used in the work of this section shall be produced by manufacturers regularly engaged in the manufacture of UV disinfection with a history of five (5) years and a minimum of 10 successful installations.

Bioassay UV dose calculations shall be based on the outcome of a comprehensive third-party bioassay validation test using both MS2 and T1UV virus phage as biodosimeters. The bioassay methods must be in accordance with the UV Disinfection Guidance Manual (UVDGM) as part of the Long Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), published by the United States Environmental Protection Agency (USEPA, 2006), the IUVA Uniform Protocol for Wastewater UV Validation Applications (IUVA Uniform Protocol, July 2011) and Section 3 of the UV Disinfection for Wastewater - Low-Dose Applications Guidance for Secondary and Tertiary Discharges (IUVA/WEF, 2015).

2 Warranty and Remedies

Seller warrants that Equipment shall be delivered free from defects in material, workmanship and title and that Services shall be performed in a competent, diligent manner in accordance with any mutually agreed specifications for one (1) year from start-up or eighteen (18) months from shipment, whichever occurs first. Seller's warranty does not cover the results of improper handling, storage, installation, commissioning, operation or maintenance of the Equipment by Buyer or third parties, repairs or alterations made by Buyer without Seller's written consent or fair wear and tear.

3 Design criteria and performance

3.1 Design criteria

The UV system will be able to disinfect the water with the following minimum quality characteristics:

Parameter	Configuration
Peak flow	0.5 MGD
Suspended solids	< 30 mg/L
Maximum particle size	30 microns
UV transmittance	65%
Effluent requirement	< 126 MPN/100 ml e. coli

3.2 UV system performance

A. The UV system shall be designed to provide a minimum dosage of 30 millijoules per square centimeter (mJ/cm^2) at the peak flow, with 90% lamp life (at 9,000 hours). 65% UV transmittance with 1 bank in service.

B. The dosage listed shall reduce the e. coli count to less than 126 MPN e. coli per 100 mL geometric mean for any 30-day period.

C. The maximum ambient air temperature should not exceed 40°C (104°F).

D. The water level past the fixed weirs must be always below the tip of the weirs during operation of the UV system (e.g., 5.75 inches for 2-lamp modules, 12.75 inches for 4-lamp modules and 19.75 inches for 6-lamp modules). For prefabricated channels, the gravity flow capacity from the UV system effluent piping must be greater than the UV system peak design flow.

4 Ultraviolet disinfection system components

4.1 General construction

A. All materials of construction used in the design of the UV system shall be corrosion resistant, suited for outdoor, corrosive service.

B. All materials directly exposed to UV light shall be stainless steel, concrete, Type 214 GE quartz or equivalent, UV-C resistant plastics, and Teflon®.

4.2 Open channel for horizontal system

A. The UV disinfection unit shall be designed to be a self-contained system requiring minimal construction to place into service.

B. The prefabricated stainless-steel channel provided by Veolia shall have the following components and dimensions:

Parameter	Configuration
Channel total length (including effluent weir box)	157.5 inches
Channel total height (including support legs)	36 1/8 inches
Channel maximum width	21 7/8 inches
Channel internal width at the modules	14.0 inches

B. The UV system shall have the following layout:

Parameter	Configuration
Number of channels	One (1)
Total number of banks	One (1)
Number of duty banks	One (1)
Number of spare banks	Zero (0)
Number of lamps/module	Four (4)
Total number of UV lamps	Sixteen (16)

C. The UV system shall have the following components:

Parameter	Configuration
Number of regular 4-lamp modules	Three (3)
Number of sensor 4-lamp modules	One (1)
Number of power bars	Four (4)
Number of UV intensity sensors	One (1)
Number of PDDCs	One (1)
Number of ACCs	Zero (0)

4.3 Prefabricated stainless steel channel details

A. All wetted and structural metal parts shall be made of Type 304L stainless steel.

B. Influent wastewater shall be conveyed to the channel through an 12-inch diameter sch10 pipe.

C. The channel shall have a minimum three (3) times the inlet pipe diameter as inlet clearance before wastewater reaches the modules.

D. The module section of the channel shall be equipped with a one-inch drain for channel cleanout.

E. The channel weir shall be contained inside an effluent weir box that bolts down to the effluent side of the modules channel.

F. The channel weir shall be 12.75 inches high and 220 inches long to keep the water crest at or below 1.25 inches under peak design flow condition.

G. The channel weir box shall be equipped with a one-inch drain on the outlet side of the weir for cleanout.

H. The channel floor shall be at the same elevation throughout the total length of the channel and supported above the ground by proper load-bearing stainless steel legs.

I. Channels equipped with influent and effluent box positioned at a lower elevation than the module section of the channel shall not be permitted.

J. The inlet and outlet sections of the channel shall be covered with eye shields to prevent UV light from escaping the channel during operation.

K. The inlet section of the channel shall have a removable strainer to retain large objects and algae before they reach the UV modules.

4.4 Module frame

A. Each module frame shall be constructed of type 316L stainless steel.

B. The UV lamps shall be supported at each end by openings designed to firmly hold each lamp in a specific location relative to the other lamps throughout the bank.

C. The lamp spacing shall not be more than 3.5 inches horizontally and vertically, within each bank.

4.5 Module assembly

A. Each module shall have four (4) lamps.

B. The FLA for a four (4) -lamp module is up to 3.2 amps.

C. Each lamp shall be protected from direct contact with water inside a waterproof quartz sleeve.

D. Each sleeve shall be sealed from water using easy to install waterproof plastic fittings.

E. Wiper-enabled modules shall be fitted with a pneumatic double-acting cylinder to actuate the wiper plate.

F. Wiper-enabled modules shall use a wiper plate equipped with UV and heat-resistant wiper brushes.

G. Each module shall have the option to be fitted with a UV intensity sensor without changing the module design and electrical connections.

H. The UV intensity sensor shall fit inside a sleeve that protrudes no more than 20 inches from one end of the module.

I. A wiper-enable module shall wipe the UV intensity sensor sleeve when applicable.

J. Each lamp of the module shall be equipped with a flow redirecting baffle to optimize hydraulics and improve disinfection.

K. All components of the UV module shall be rated IP 68 (NEMA 6P) and shall be completely watertight.

L. Each module shall be completely field serviceable. They shall have a waterproof CE compliant power bar that runs the lamps as commanded by the Power Distribution and Data Center (PDDC).

M. Each module shall have a local IN-SERVICE pushbutton. The lamps must not be able to come on if the module is not set to IN-SERVICE.

N. All wiring between the module power bar, the lamps, and the optional UV intensity sensor shall not degrade after prolonged exposure to UV light.

O. Each module shall have top handles for ease of removal and maintenance by the plant operators without the need for special tools.

4.6 Ultraviolet lamps

A. The UV lamps shall be non-amalgam low pressure high output UV lamps.

B. UV lamps shall produce UV light with > 95% of the UV emission at a 253.7 nm wavelength.

C. The UV system manufactured shall warrant that the UV lamp output be no less than 90% of a new lamp after 9,000 hours of operation (following a 100-hour burn in).

D. Amalgam lamps and lamps that produce ozone shall not be used.

4.7 Quartz sleeve

A. Quartz sleeves shall be made of 99.9% pure silicon dioxide, type 214 GE quartz or equivalent.

B. The sleeve shall have a bead or dimple of equal outside diameter all around the circumference of the sleeve and within one (1) inch of the open end of the sleeve.

C. Quartz sleeves shall allow a minimum of 90% transmittance through the quartz wall at 253.7 nm.

4.8 Module power bar

A. The power bar shall be rated IP 68 (NEMA 6P) and be made of extruded aluminum for enhanced cooling under harsh conditions.

B. The power bar shall contain a control card and ballast cards interconnected for proper operation and monitoring of the lamps.

C. The power bar shall be equipped with additional filtering for compliance with the CE EMC directive.

D. EMC filtering inside the Power Distribution and Data Center (PDDC) is not permitted.

E. The power bar shall be equipped with front LED light indicators to give the plant operators a visual indication of the module statuses as follows:

   a. LAMP 1 ON/OFF

   b. LAMP 2 ON/OFF

   c. LAMP 3 ON/OFF

   d. LAMP 4 ON/OFF

   e. LAMP 5 ON/OFF

   f. LAMP 6 ON/OFF

   g. IN-SERVICE / OUT-OF-SERVICE

h. GFI fault active/inactive

i. Over-temperature fault active/inactive

j. WIPER ON

k. PDDC power bar communication status.

F. The power bar shall be internally designed such that replacing a key failed component only requires replacement of that component.

G. The power bar front end plate shall be easily removed to access the control card and ballast cards within the power bar for troubleshooting.

H. The power bar internal control card and ballast cards shall be rail mounted to enable easy removal and installation for troubleshooting.

I. The card rail shall slide the cards back inside the power bar such that proper cooling of the cards is not impacted.

J. The power bar shall connect to the PDDC with an AC mains cable and a data cable in lengths of up to 50 feet.

K. The power bar for wiper-enabled modules shall connect to the Air Control Center (ACC) with a solenoid cable in lengths of up to 50 feet.

L. The power bar shall be auto tunable to AC mains voltages between 120 and 277 VAC single phase 50 or 60 Hz.

M. The power bar shall function with either a PLC PDDC or a manual controls PDDC.

N. The power bar shall automatically detect the absence of a PLC inside the PDDC and adjust itself to manual controls (non-PLC PDDC) accordingly.

O. The power bar shall turn on all lamps 300 seconds after a loss of communication with the PLC (this is not valid for a non-PLC PDDC).

4.9 PLC Power Distribution and Data Center (PDDC)

A. Each UV system shall have a UL508 labeled PDDC.

B. The PDDC shall be made of 304L type stainless steel for a NEMA 4X rating.

C. The power supply to the PDDC shall be 208 VAC 3-phase Delta 50/60 Hz with an equipment ground that is properly bonded to earth according to NEC 250.

D. Each module shall be powered by its own UL489 breaker.

E. The PLC PDDC shall have a conductive level relay for optional LOW- and HIGH- level probes for each channel.

F. The PDDC shall have a PLC and an HMI.

G. The PDDC HMI shall be protected under a transparent lockable cover to protect it from direct sunlight and the weather elements.

H. The PLC PDDC HMI shall have at least the following pages with proper graphics rendering:

a. UV PLANT OVERVIEW

b. Individual CHANNEL CONTROL

C. BANK MANAGEMENT

d. Individual BANK CONTROL
e. Individual MODULE OVERVIEW
F. ALARMS SUMMARY
g. ALARMS HISTORY
h. UV SYSTEM SETTINGS
i. CONFIGURATION
j. INSTRUMENT SETTINGS.

I. The PLC PDDC shall provide an Ethernet TCP/IP Modbus connection to SCADA for remote control and status of the UV system.

J. SCADA remote control shall include a REMOTE (vs LOCAL) setting in the PLANT page and a remote design dose setpoint.

K. SCADA remote status shall consist of each channel delivered dose and high priority alarms.

L. The PLC PDDC HMI shall have HOAs for the plant, individual channels, and individual banks.

M. The PLC PDDC HMI shall display each channel-delivered dose in real time.

N. The PLC PDDC HMI shall display each bank UV intensity reading in real time.

O. The PLC PDDC HMI shall display each module power bar hot-spot temperature in real time.

P. The PLC PDDC HMI shall allow the operator to assign a UV intensity sensor to any module as needed.

Q. With wiper-enable modules, the PLC PDDC shall have an AUTO-CLEAN feature for each channel.

R. With wiper-enable modules, the PLC PDDC shall have a MANUAL-CLEAN feature for each bank.

S. The PLC PDDC HMI shall display each and all lamp hours and cycles as logged by the PLC.

T. The PLC PDDC HMI shall enable zeroing lamp hours and cycles under a password protected elevated login.

U. The PLC PDDC shall not turn off banks of UV modules for at least six (6) hours once they are turned on.

V. The PLC PDDC shall automatically turn on an additional bank of modules (if available) when a maximum number of LAMPs OUT ($L_{OUT,MAX}$) in a running bank is exceeded.

W. While $L_{OUT,MAX}$ is not reached, the PLC PDDC shall automatically derate the delivered dose of a bank by the ratio of LAMP ON to lamps faults.

X. The PLC PDDC shall generate and display at the HMI the following alarms:

a. FLOW LOW-LOW, LOW, HIGH, HIGH-HIGH and O/R
b. UVT LOW-LOW, LOW, HIGH, HIGH-HIGH and O/R (if applicable)
c. BANK LOW-LOW INTENSITY
d. BANK LOW INTENSITY
e. BANK INTENSITY FAIL
f. LAMP FAULT
g. BANK ADJACENT LAMP FAULTS

h. BANK MULTI-LAMP FAULT
i. MODULE GFI
j. MODULE OVER-TEMPERATURE SHUTDOWN (OTSD)
k. MODULE DATA OUT OF RANGE
l. MODULE COM LOSS
m. MODULE OUT OF SERVICE.

Y. The PLC PDDC shall provide a BANK (HOURS) MANAGEMENT control feature for UV systems having two (2) or more banks in a channel.

4.9 Manual Control Power Distribution and Data Center (PDDC)

A. Each UV system shall have a UL508 labeled PDDC per bank of modules.
B. The PDDC shall be made of 304L type stainless steel for a NEMA 4X rating.
C. The power supply to the PDDC shall be 208 VAC 3-phase Delta 50/60 Hz with an equipment ground that is properly bonded to earth according to NEC 250.
D. Each module shall be powered by its own UL489 breaker.
E. The bank PDDC shall have the following features:
   a. individual 4-20 mA DC display for the UV intensity sensor enabled module
   b. a current switch with a minimum current trip level that detects the lamps turning on inside the modules of a bank
   c. individual hours counter that is non-resettable
   d. a POWER ON annunciating light for the entire PDDC
   e. a BANK ON annunciating light
   f. a BANK OFF annunciating light
   g. a two-position front selector switch to turn the bank lamps on and off
   h. an ALARMS RESET pushbutton to reset the power bar GFI and OTSD ALARMs when applicable
   i. with a wiper-enabled bank, the selector switch comes with two (2) additional settings to drive the bank wiper plates forward or backward (WIPE ON and WIPE OFF).
F. The PDDC sensor intensity display must change colors as follows:
   a. GREEN – INTENSITY SAFE
   b. AMBER – LOW INTENSITY
   c. RED – SENSOR FAULT.
G. The PDDC POWER ON light, hours counter and remote ON status shall be connected to the current switch contact to activate only when the module or modules inside the bank are running.
H. The PDDC shall provide remote status monitoring features for SCADA as follows:
   a. single pole single throw (SPST) NO relay output for BANK ON or OFF
   b. single pole single throw (SPST) NC relay output for INTENSITY SAFE

c. single pole single throw (SPST) NC relay output for LOW INTENSITY

d. single pole single throw (SPST) NC relay output for SENSOR FAULT

e. 4-20 mA DC output for the bank UV intensity readings.

I. Controls and alarm indications from the PDDC shall be completely visible to the operators through the weatherproof, UV resistant, polycarbonate window.

4.10 UV intensity sensor

A. The UV intensity sensor shall have a 360º angle of view.

B. The UV intensity sensor shall be protected from direct contact with water inside a waterproof quartz sleeve assembly.

C. The UV intensity sensor shall read in the wavelength range of 220 to 280 nm.

D. UV intensity sensors that expand into the visible light wavelength spectrum shall not be allowed.

E. The UV intensity sensor shall read between 0 and 150 W/m^2 with clean sleeves and new lamps.

F. The UV intensity sensor reading shall have a tunable GAIN at the PDDC.

G. The UV intensity sensor shall be positioned between the two (2) top lamps of the module.

H. For wiper-enabled modules, the UV intensity sensor shall be wiped alongside the UV lamp sleeves.

4.11 Air Control Center (ACC)

NOTE *This section only applies to UV systems with wiper-enabled modules.*

A. The ACC shall have an air pressure regulator to reduce the compressed air pressure from 150 to 200 psig down to 100 psig.

B. The ACC shall have a normally open (NO) 5/2-way valves, one for each module.

C. Without 24 VDC applied, the 5/2-way valve shall stay open and the wiper plate stays parked.

D. When 24 VDC is applied to the 5/2-way valve, the wiper plate shall travel to the opposite end of the module.

E. Once the wiper plate has reached the end of the module and the 24 VDC is removed, the solenoid valve shall open, and the wiper plate travels back to the parked position.

F. The 5/2-way valves shall be installed on manifolds with a common air inlet and common air exhausts.

G. The ACC shall have two (2) bleed valves on the common exhausts of all the 5/2-way valves to manually adjust the air pressure. This is to adjust the forward and backward speed of the wiper plates.

H. The ACC shall have pressure gauges for each backward and forward air tubing to quickly identify when a particular tubing leaks air.

I. The ACC shall have quick-disconnect connectors for 1/4 inch trade size OD tubing.

5 Spare parts

The following spare parts shall be provided:

- four (4) UV lamps
- four (4) quartz sleeves
- one (1) UV intensity sensor
- four (4) sleeve fittings
- one (1) operator kit (face shield, gloves, cleaning pads, cleaning powder, and UV warning sign).

6 Field service

- Installation and Start-Up Services shall include a minimum of two (2) eight-hour days in one (1) trip. Training for Plant Operators and maintenance staff will be coordinated between the Owner, Contractor and UV supplier to ensure maximum effectiveness.
- Service personnel shall be fully qualified and full-time employees of the UV system manufacturer.
- Performance testing of the UV system, if required, will be the Contractor's responsibility.
- The UV supplier shall provide for engineer's approval a formal test protocol for use during performance tests.

Sludge Handling

PROPOSAL

TO:	**Calvin Vasicek** **Vasicek.c@northerneastern.edu** Vasicek.c@northeastern.edu 952-905-6549
PROJECT / REF:	**Manchester Maryland WWTP dewatering upgrade study**
PROPOSAL TYPE:	Budget Price and Scope
SPEC. SECTIONS:	N/A
DATE:	07 April 2026
PWT #:	VDP-MD-16020
REV:	1
SIZING INFORMATION:	Sized to dewater up 140 dry lbs per hour of 2% feed solids aerobically digested sludge in ~24 hours/week.
MANUFACTURERS REP:	Dwight Swan Envirep, Inc. DSwan@envirep.com 717-503-4639
NOTES:	
REVISION NOTES:	
PREPARED BY:	Chris Hubbard | Joseph Collar
PROPOSAL CONTENT	• Scope of supply summary • Scope Details • Exceptions and Exclusions • Governing Conditions and Warranty Notes • Price • Data Sheets • GA Drawings • PWTech Terms and Conditions and Warranty

SCOPE OF SUPPLY

Line	Qty.	Item	Manufacturer / Model / Description
1	1	Volute* Dewatering Press	PWTech - ES-202
2	1	Polymer Preparation System	VeloDyne - VeloBlend VM-1P-120-X0D
3	1	Influent Sludge flowmeter	Rosemount™ Model 8750W with 2” ANSI Flanges
4	1	Control System for Item 1-3	PWTech
5		Documentation	Submittals, O&M manuals, Startup Report
6		Field services	Installation inspection, Commissioning, Testing and operator training
7		Delivery to site	

*Volute is registered with the U.S. Patent and Trademark Office as a registered trademark of AMCON, Inc., Yokohama, Japan

SCOPE DETAILS

1. Volute Dewatering Press - PWTech Model ES-202

Design

- The unit to be supplied will be an ES-202 with a MAXIMUM capacity of 140 dry lbs per hour of 2% aerobically digested sludge.

Components

- The Dewatering Press consists of:
  - Flash mixing tank including mixer with gear motor.
  - Flocculation tank including mixer with gear motor.
  - Two (2) x 200 Series Dewatering Drum with a drive motor,
  - Filtrate collection pan and support frame.
  - Integrated, pre-wired control panel for the unit and appurtenances mounted on the flocculation tank. (may be provided mounted separately if requested).
- Connections are:
  - Inlet: DN 2” FNPT
  - Filtrate outlet: DN 4" ANSI B16.5 Class 150 Flanged
  - Drain: DN 3” ANSI B16.5 Class 150
  - Washwater Water inlet: ¾” FNPT

Materials and Construction

- The unit is all stainless steel. No carbon steel is used in the manufacture of the press.
- Unit is manufactured and assembled in the USA. All components are sourced from the USA or Japan.
- Electrical components are manufactured and tested prior to shipment to site in the United States.
- Gear Drives are Nissei GTR gear motors utilizing heloid gear reduction. They are one piece construction and are sealed for life.

Supplied spare parts

- No spare parts are included in this scope.

Additional Press information is appended to this scope.

2. Polymer Preparation unit – Velodyne Model VM-1P-120-X0D

Design

- Polymer Flow Range: 0.05 to 1 GPH
- Dilution Water Flow: 12 to 120 GPH

Components

- Polymer Mixing Chamber:
  - VeloBlend VM - Staged Hydro-Mechanical
  - ½ HP, 230/460 VAC, 1750 RPM, Inverter ready Mixer motor
  - Mechanical Mixer Shaft Seal with seal flushing assembly
  - VeloCheck™ Neat Polymer Check Valve with Quick Release Pin
  - Pressure Rating of 100 psi with Pressure Relief Valve
- Neat Polymer Delivery Assembly
  - A 1 GPH stainless steel & Viton progressive cavity metering pump shall be provided
  - ½ HP, 1750 RPM, 230/460 VAC, Inverter ready with gear reducer
  - Thermal type loss of polymer flow sensor
  - Metering pump calibration assembly with isolation valves: (500 ml)

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- Dilution Water Inlet and Solution Outlet Assembly
  - Primary 12-120 GPH rotameter controlled dilution water flow
  - Low differential pressure alarm switch
  - 0-160 psi inlet water pressure gauge (stainless steel, liquid filled)
  - Swing type PVC and Viton check valve
- Electrical Junction Box
  - All electrical components are pre-wired to an FRP junction box
  - A marked terminal strip is provided for landing all wiring for connection to the Volute Press Panel

Materials and Construction

- Mixing Chamber is Stainless Steel body and impeller with clear polycarbonate cover.
- Plumbing is Schedule 80 PVC
- Frame and fasteners are 304 stainless steel. Frame is open design for access to all components and is designed for bolt-down installation.

3. Magnetic flowmeter, 2" Rosemount™ Model 8750W

Design

- 2" Flowmeter is designed for accurate measurement of flows between 10-200 GPM
- Suitable for direct burial and constant flooding (IP 68).
- Includes Compact mounting of transmitter on the flowmeter body
- Flowmeter out-puts analogue signal (4-20 mA) to Volute Press Control panel

Components

- 2 inch ANSI 150# flange connections.
- Includes grounding rings

Materials and Construction

- Coated Carbon Steel construction with a polyurethane, ceramic, neoprene, or Teflon liner as required by the application.
- All metallic wetted parts are stainless steel type 316

4. Electrical and Control

The Volute* unit is supplied with a pre-mounted, pre-wired control panel designed to control all aspects of the thickening/dewatering operation unless otherwise specified and noted.

- Control panel is:
  - Fed by a single 208, 240, or 480VAC, 3-phase, 60 Hz, power supply (client specified)
    - Built with a Panel Short Circuit Current Rating (SCCR) of 5 kAIC
  - NEMA 4X rated manufactured in Stainless Steel type 304
  - Manufactured in a UL accredited facility and is UL listed
- Panel includes HMI and PLC control modules.
  - PLC/HMI is a single Unitronics Unistream 10.4 unit.
- All manual switching operations are undertaken via the HMI
- Unit includes complete control system for unit and ancillary equipment including operation of the polymer preparation system.
- Control system may utilize a system flow meter and PID loop to allow operator to set the system flow.
- Control panel includes system running and system fault outputs to plant PLC/SCADA and the ability to connect via Ethernet to external controls.

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- A NEMA 4X FRP junction box on the polymer preparation skid is pre-wired to the polymer preparation components and includes numbered terminal block with terminal block legend allowing for easy on-site connection to the main Volute* system control panel.

5. Documentation:

Scope includes:

- Submittals (electronic) and
- O&M Manuals (hard copy and electronic).
- Startup Report
- PLC/HMI Program (electronic copy) – does not include programming software

6. Field Services:

Scope includes the following start-up services -

- On-site start-up and training services for:
  - One (1) trip consisting of four (4) consecutive days (8 hours per day, Monday-Friday) by a PWT field service engineer and/or qualified manufacturer's representative
- Services include:
  - Installation inspection
  - Commissioning of Volute* unit and Controls
  - Start-up of Ancillary equipment included in this Scope
  - Functional testing and calibration of equipment
  - Training on all equipment
- Phone consultation regarding installation will also be provided.
- Should additional services be deemed necessary by the PURCHASER, the additional services can be procured from PWT on a per diem basis. The current rate is $1000 per day plus travel.

7. Delivery and Freight

- Submittals issued approximately six (6) weeks from receipt of written Purchase Order
- Delivery is approx. eighteen (18) weeks from receipt of written acceptance of Submittal documents [x]
- Deliver to site for all components **is INCLUDED in the price**.

[x] **PLEASE NOTE:** While seller believes this estimated delivery time to be a valid and realistic estimate, due to the uncertain nature of future business conditions, this does not constitute any form of guarantee regarding the delivery schedule.

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EXCLUSIONS AND EXCEPTIONS:

The Following items are specifically excluded from this scope unless specifically noted otherwise:

- Taxes, permits, and bonding
- Any civil works including, but not limited to, any building works, construction of suitable foundations, and access structures.
- Installation including, but not limited to, mechanical, plumbing, and electrical hook-ups
- Unloading of delivered equipment on site and storage
- PLC/HMI Programming software unless specified elsewhere.

GOVERNING TERMS AND CONDITIONS AND WARRANTY

This scope is subject to Process Wastewater Technologies, LLC. Standard Terms and Conditions and Standard Warranty as attached. The following items are specific to this project:

Payment Terms:

Payment terms for this scope are as per the table below:

Trigger	Amount		Terms			Condition
Submittals	**20**	%	due NET	30	days	On Approval of Submittals
Delivery	**70**	%	due NET	30	days	On shipping, or the offer to ship
O&M	**5**	%	due NET	30	days	On Delivery of final O&M Manuals
Startup	**5**	%	due NET	30	days	On Completion of startup and any other services provided under this scope.

Validity

Validity of this proposal is strictly 30 days. Written authorization from seller is required to extend this.

Warranty

PWTech warrants that the Products shall be free from defects in material and workmanship for the shorter period of: (i) twelve (12) months from the date of start-up; (ii) the warranty period for the third party good or service embodied in the Product; or (iii) eighteen (18) months from the delivery of the specified Product.

PRICE

Total price for the ES-202 and appurtenances as per this scope: **$305,000.00**

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Volute Dewatering Press Data Sheet: ES-202

Please note- All information here is generic and for preliminary reference only. Detailed throughput and other data is very project specific and this sheet has not been altered to relect that. Project specific data would be available from PWTech at the appropriate time.

General Information	**Model Information**	Over All Dimensions:		106"(L) x 41"(W) x 74"(H)
		Optimal Space requirement of installation:		169" x 100" (L x W)
		Minimum Opening dimensions for installation:		40" x 74"
		Weight	Empty:	1,600 lbs
			Max:	3,100 lbs
		MAX Solids throughput:		160 Dry pounds per hour
		MAX Hydraulic throughput:		28 GPM
		Power use:		3.08 HP
		Washwater use:	@40 PSI	16 GPM intermittent, 24 GPH total

Dewatering Drum	**General**	Dimension:		8" diameter x 45" long
		Quantity:		2
		Material:	Fixed & Moving Rings:	Type 304 Stainless Steel
			Screw:	304 Stainless Steel with CoCr coating
	Drive info	Gear Motor Supplier:		Nissei Corporation
		Model:		FSW-45-600-T020 WEX
		Motor Power:		0.2 kW (0.27HP) 4-Pole
		Enclosure:		TEFC / IP65
		Gear Reduction:		600 : 1

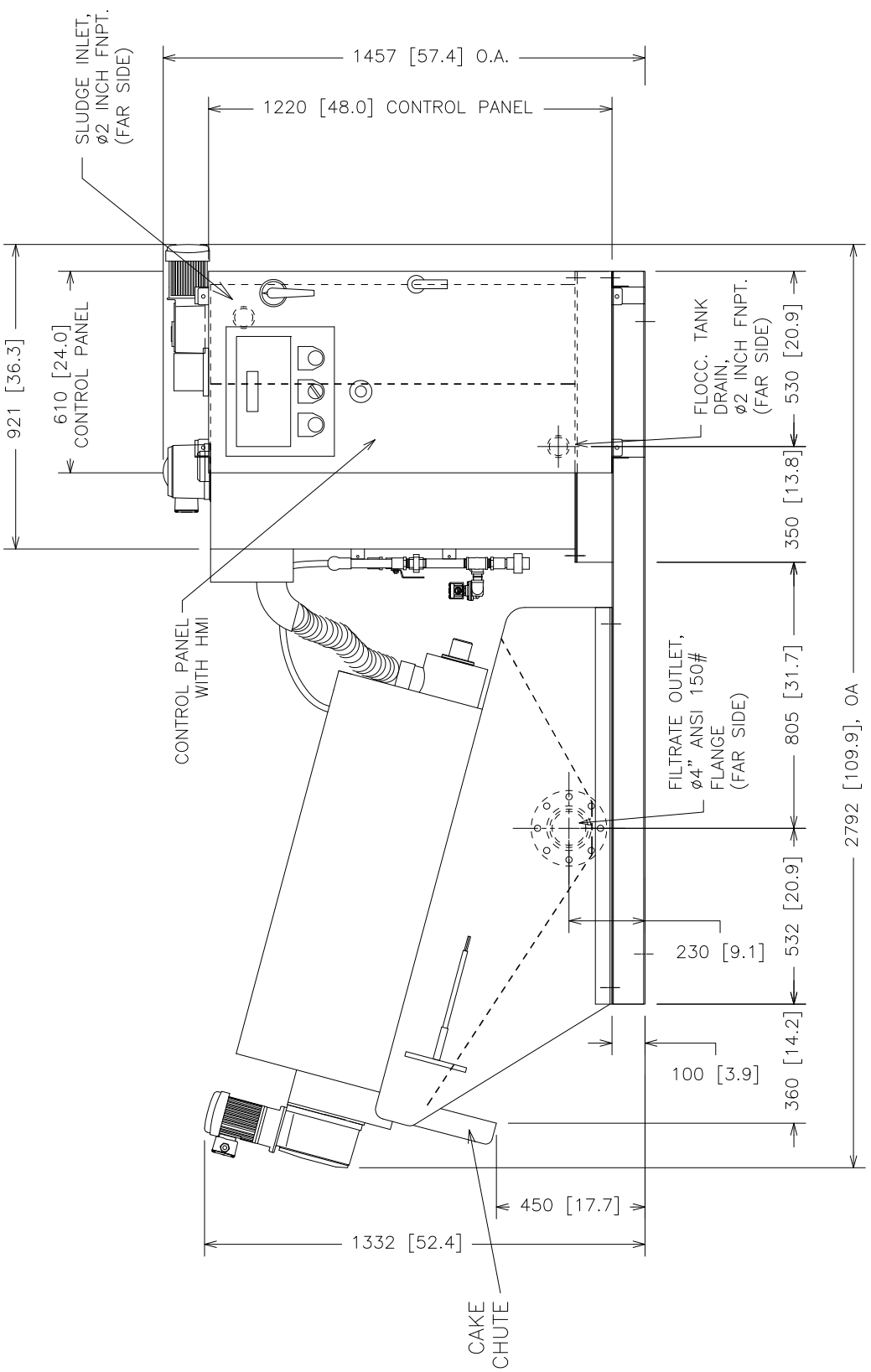
Flash mixing tanks	**General**	Dimensions:		12" x 20" x 39" (L x W x H)
		Volume		39.6 Gallons
		Working Volume:		34.1 Gallons
		Material		Type 304 Stainless Steel
	Drive Info	Gear Motor Supplier:		Nissei Corporation
		Model:		F3S30S10-WB04TAVENX
		Motor Power:		0.4 kW (0.54) 4-Pole
		Enclosure:		TEFC / IP65
		Gear Reduction:		10 : 1

Flocculation tank	**General**	Dimensions:	20" x 20" x 39" (L x W x H)
		Volume	66.1 Gallons
		Working Volume:	56.8 Gallons
		Material	Type 304 Stainless Steel
	Drive Info	Gear Motor Supplier:	Brother
		Model:	F3S35S60-WB08TAVENX
		Motor Power:	0.75 kW (1 HP) 4-Pole
		Enclosure:	TEFC / IP65
		Gear Reduction:	60 : 1

STD. Electrical	**General**	Supply Voltage:	208/240/460/480 VAC
		Service:	3-Phase, 3-Wire (No Neutral)
		Control Voltage:	Dual - 24VDC & 115VAC
		Minimum Required Breaker Size:*	15 Amps * 480 VAC
	Panel	Panel Size:	30"(w) x 48"(h) x 10"(d)
		Panel Material:	Type 304 Stainless Steel
		Panel Rating:	NEMA 4X
		Control Module:	Unitronics Unistream 10.2 PLC/ CompactLogix #5069-L306

Polymer System	Supplier:	Velocity Dynamics, Inc.
	Model:	VM-1P-120-X0D-1C
	Mixing Type:	Variable - Mechanical & Hydraulic
	Feed Pump Type:	Progressive Cavity
	Polymer Feed Capacity:	0.05 - 1 Gallons per hour
	Water Use:	12 - 120 Gallons per hour
	Dimensions:	24" x 40" x 40" (L x W x H)
	Weight:	~200 lbs
	Minimum Supply Pressure:	30 PSI

Connections	Feed Sludge:	2" FNPT Coupling
	Filtrate:	4" ANSI 150# Flange
	Drain:	3" ANSI 150# Flange
	Water:	3/4" FNPT Coupling
	Press Polymer Inlet:	3/4" FNPT Coupling
	Polymer Water Inlet:	1" FNPT
	Polymer Solutions Outlet.	1" FNPT
	Raw Polymer Feed Inlet:	1" FNPT



**ALL METAL COMPONENTS ARE STAINLESS STEEL

SIDE ELEVATION VIEW

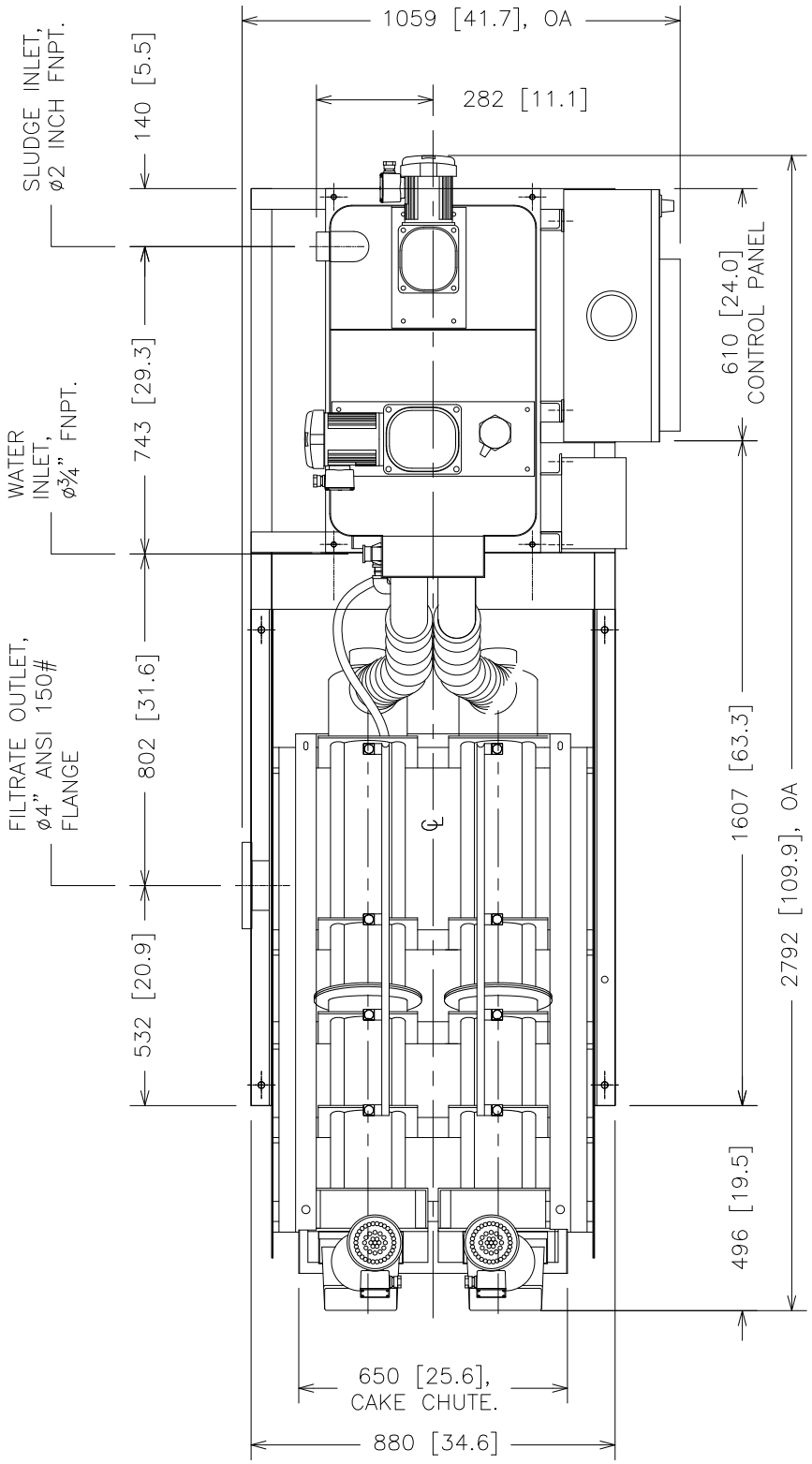
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PWTech
PROCESS WASTEWATER TECHNOLOGIES

VOLUTE DEWATERING PRESS ES202 GA ELEVATION

JOB# PWT VDP ES202 GA	SCALE NTS
DATE JUNE, 2017	
DRAWN PWTech Inc.	SHEET 1 OF 4
APPROV. ALEX DAVEY	

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PLAN VIEW

**ALL METAL COMPONENTS ARE STAINLESS STEEL

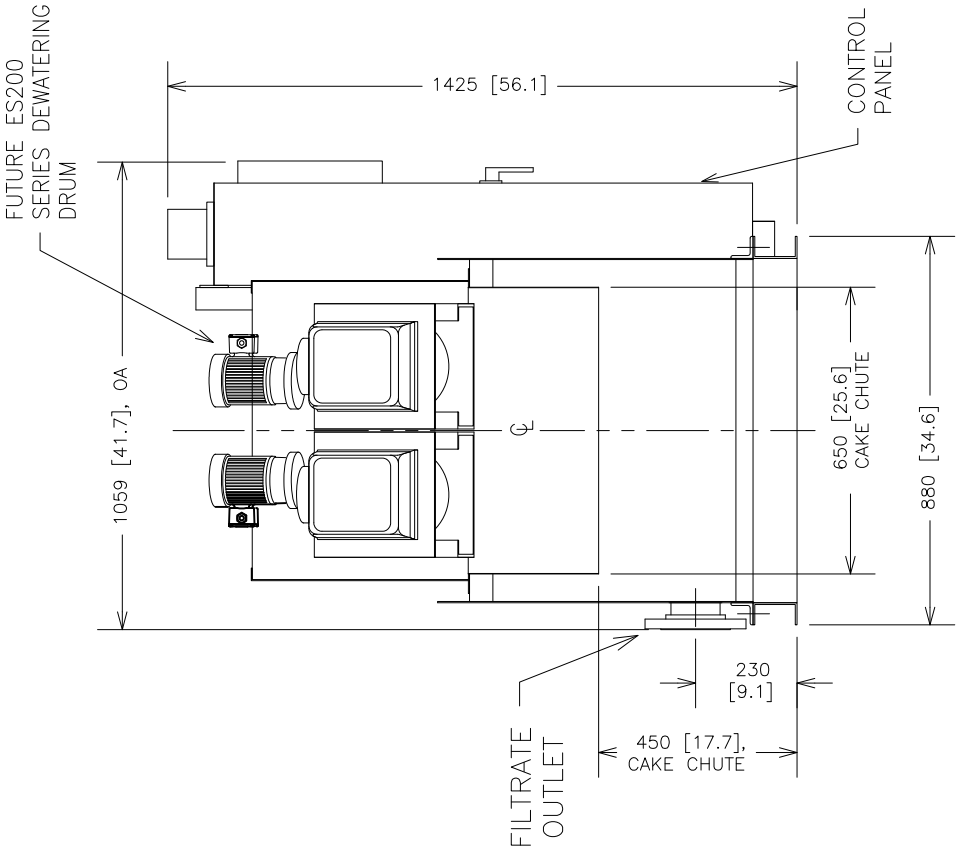
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PWTech
PROCESS WASTEWATER TECHNOLOGIES

VOLUTE DEWATERING PRESS ES202 GA PLAN

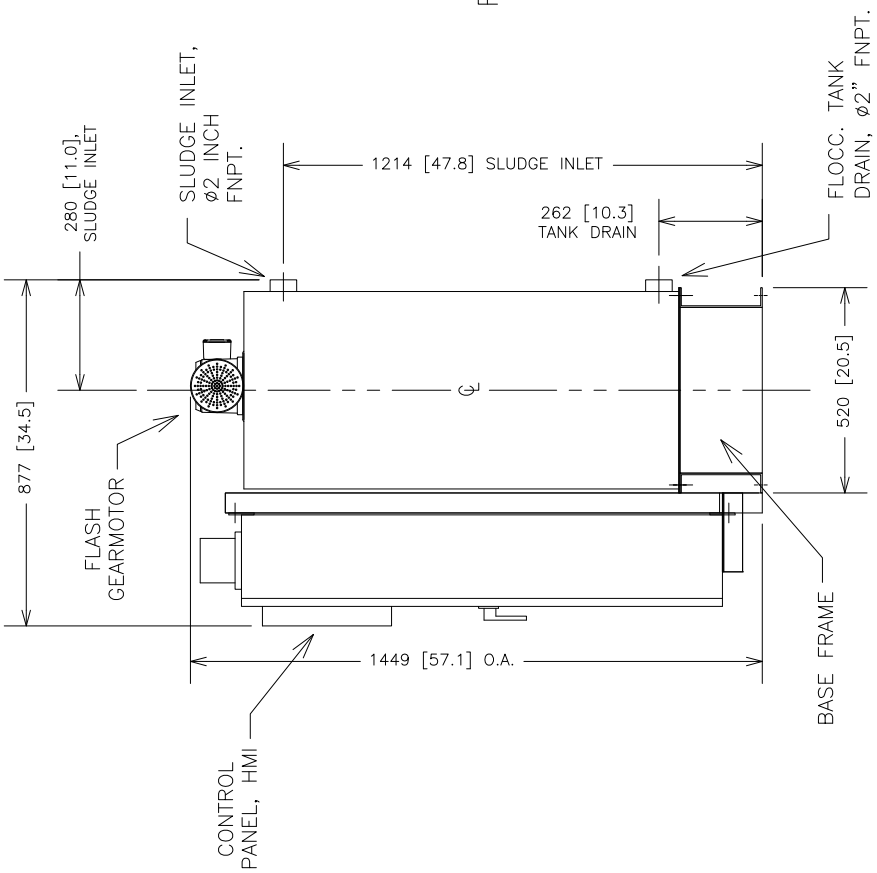
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DATE JUNE, 2017	
DRAWN PWTech Inc.	SHEET 2 OF 4
APPROV. ALEX DAVEY	

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PRESS END ELEVATION

**ALL METAL COMPONENTS ARE STAINLESS STEEL



TANK END ELEVATION

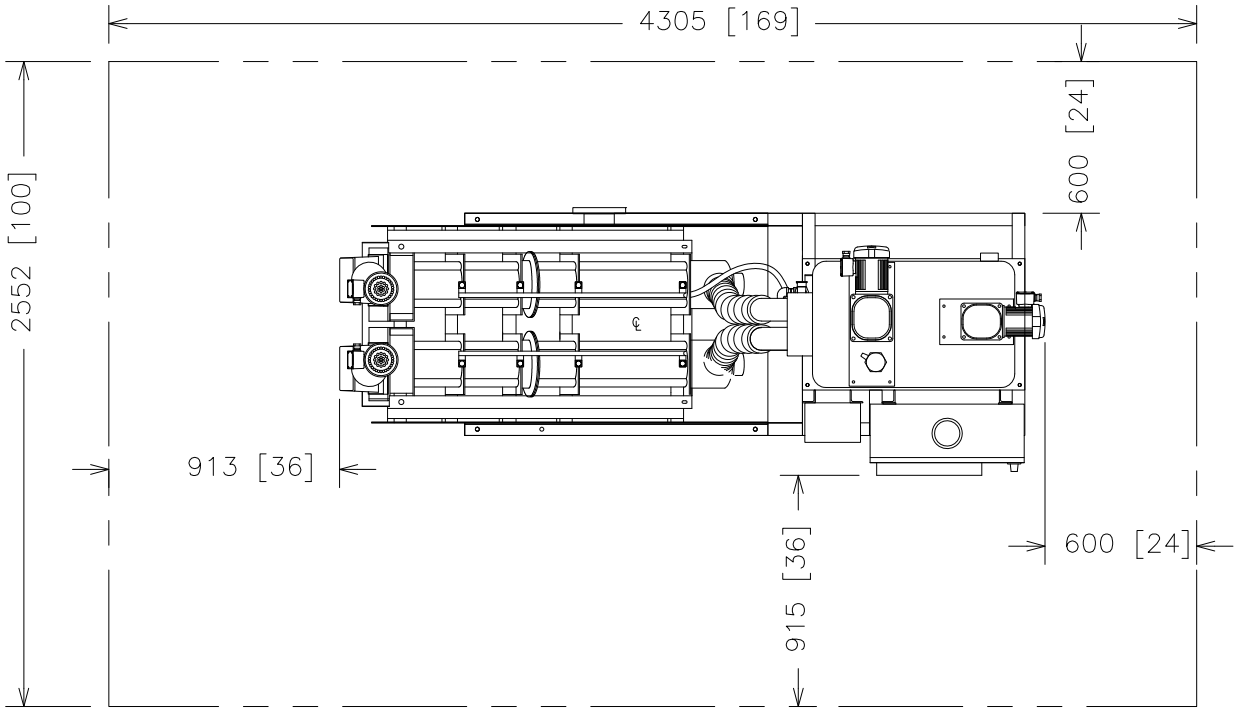
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PWTech
PROCESS WASTEWATER TECHNOLOGIES

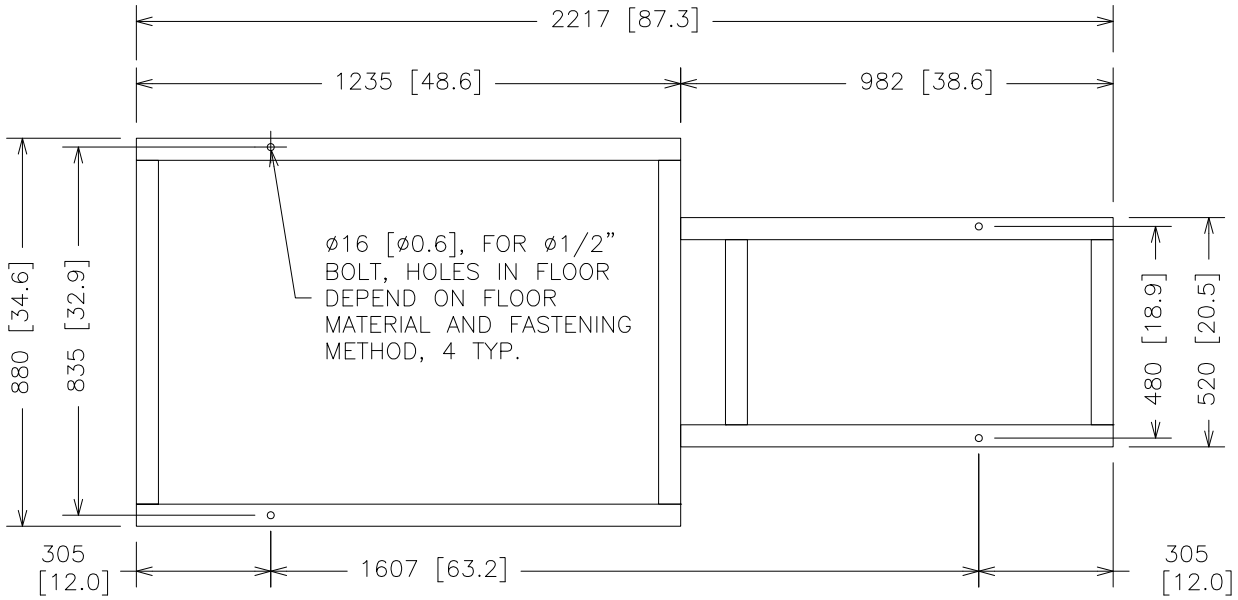
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JOB# PWT VDP ES202 GA	SCALE NTS
DATE JUNE, 2017	
DRAWN PWTech Inc.	SHEET 3 OF 4
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RECOMMENDED SPACE



FOOTPRINT AND ANCHOR POINTS

DIMENSIONS: MM [INCHES]

PWTech
PROCESS WASTEWATER TECHNOLOGIES

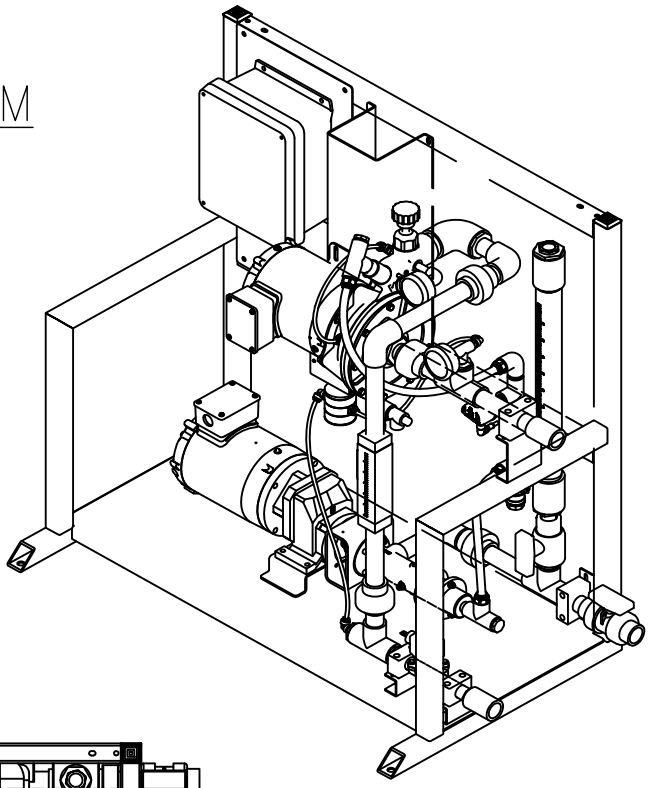
VOLUTE DEWATERING PRESS ES202 GA END & REC. MAINT. SPACE

JOB# PWT VDP ES202 GA	SCALE NTS
DATE JUNE, 2017	
DRAWN PWTech Inc.	SHEET 4 OF 4
APPROV. ALEX DAVEY	

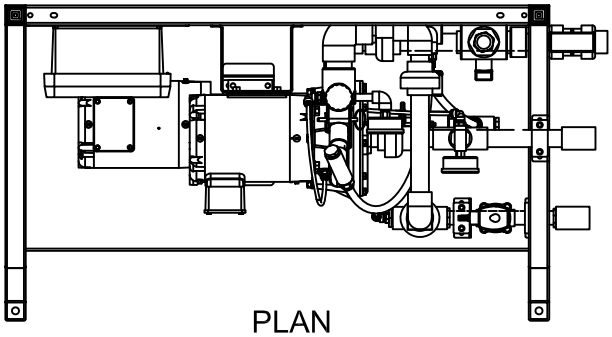
9004 YELLOW BRICK ROAD, SUITE D, ROSEDALE, MD 21237 PHONE: 410 238 7977 WEB: www.PWTech.us

PWTECH STANDARD SUPPLY
POLYMER PREPARATION SYSTEM

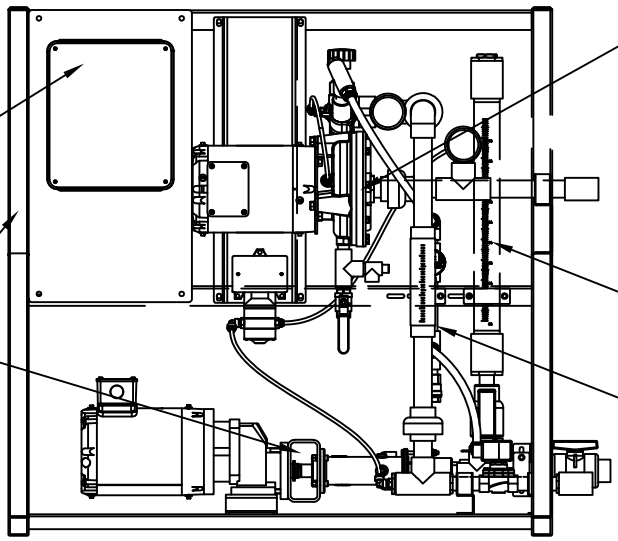
(1P TO 10P MODELS)



ISOMETRIC



PLAN

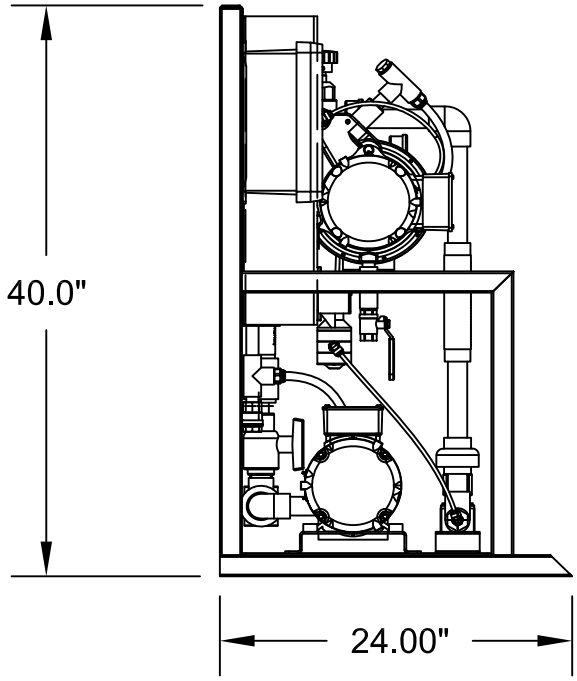


ELEVATION

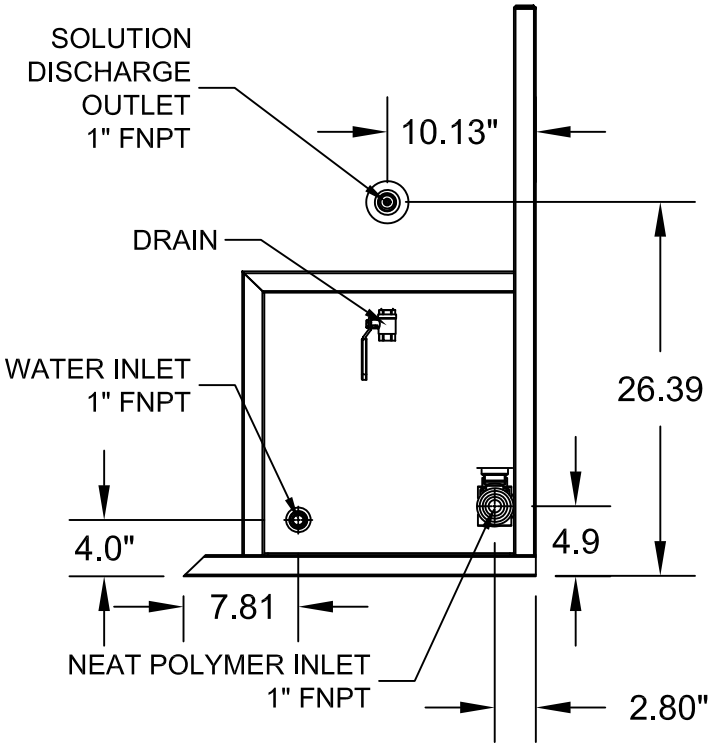
DIMENSIONS: INCHES [mm]

PWTech	VELODYNE POLYMER BLENDING SYSTEN VM-XXP-XXX-X0D-1C LEFT, RIGHT AND ISOMETRIC	JOB# VM-XXP-XXX-X0D-1C	SCALE NTS
		DATE 21 March 2024	
		DRAWN PWTech Inc.	SHEET 1 OF 2
		APPROV. ALEX DAVEY	

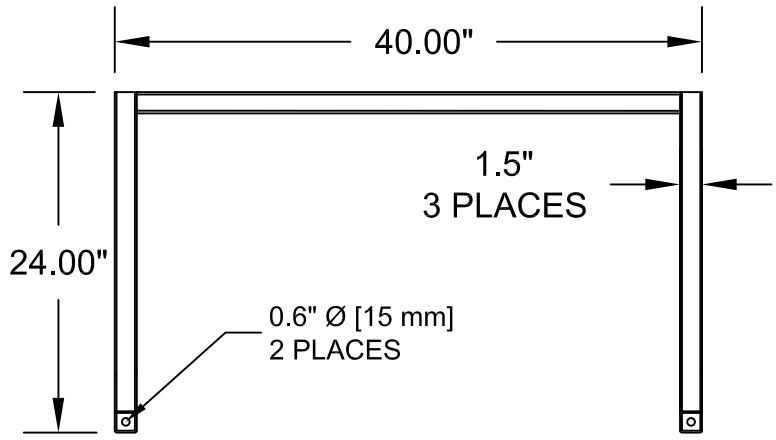
9003 YELLOW BRICK ROAD, SUITE S, ROSEDALE, MD 21237 PHONE: 410 238 7977 WEB: www.PWTech.us



LEFT



RIGHT CONNECTIONS



FOOTPRINT

VELOBLEND MODEL:
VM–XXP–XXX–X0D–1C

DILUTION WATER:
ø1" FNPT INLET

POLYMER:
ø5/8" HOSE BARB INLET

SOLUTION:
ø1" FNPT OUTLET

DRAIN:
DOES NOT NEED TO BE
CONNECTED IN ALL CASES

DIMENSIONS: INCHES [mm]

PWTech	VELODYNE POLYMER BLENDING SYSTEN VM-XXP-X0D-0-D-1C SIDES AND FOOTPRINT	JOB# VM-XXP-XXX-X0D-1-C	SCALE NTS
		DATE 21 March 2024	
		DRAWN PWTech Inc.	SHEET 2 OF 2
		APPROV. ALEX DAVEY	

9003 YELLOW BRICK ROAD, SUITE S, ROSEDALE, MD 21237 PHONE: 410 238 7977 WEB: www.PWTech.us

Process Wastewater Technologies, LLC. Standard Terms and Conditions

These terms and conditions ("Terms") shall exclusively govern the sale of all goods ("Products") and related services ("Services") by Process Wastewater Technologies, LLC. ("PWT") to the party ("Buyer") that issued a Purchase Order in accordance with, and/or signed and accepted the PWT Proposal ("Proposal"), and upon execution, the "Order" along with the Terms and the PWT Standard Limited Warranty attached hereto, the "Agreement").

Item 1. ACCEPTANCE

Buyer may accept this Agreement by executing the Proposal and returning it to PWT or by issuing a written purchase order that is accepted in writing by PWT or by executing an acceptance of offer in lieu of purchase order. No oral acceptance shall be effective. This Agreement is intended by the parties as a final expression of their agreement and is intended as a complete and exclusive statement of the terms of their Agreement. Acceptance or acquiescence in a course of performance rendered under this Agreement shall not be relevant to determine the meaning of this Agreement even though the accepting or acquiescing party has knowledge of the nature of the performance and opportunity for objection. No agent, employee or representative of PWT has any authority to bind PWT to any affirmation, representation or warranty concerning the equipment, components or related services sold under this Agreement, unless an affirmation, representation or warranty made by an agent, employee or representative is specifically included within this Agreement, otherwise it has not formed a part of the basis of this Agreement and shall not in any way be enforceable.

Item 2. CANCELLATION

Once the Buyer has executed the Proposal and submitted it to PWT, Buyer shall have no right to cancel this Agreement or any part thereof, except under the conditions specified in this provision or otherwise agreed to in writing by both parties. Any cancellation by Buyer of this Agreement must be in writing and shall be deemed effective upon receipt by PWT. In the event of cancellation by Buyer prior to the commencement of production of the Products specified under the applicable Order, Buyer shall pay PWT a cancellation charge equal to all of the costs incurred by PWT under the applicable Order up to the time of cancellation, plus fifteen percent (15%) of the full Order amount. In the event that production of the Products under the Order has commenced prior to cancellation, Buyer shall pay a cancellation charge equal to all of the costs incurred by PWT under the applicable Order up to the time of cancellation, plus an amount equal to the greater of: the value of the Products already completed under the applicable Order; or fifteen percent (15%) of the full order amount under the applicable Order.

Item 3. PRICES

Unless otherwise stated in the Proposal, prices are in United States Dollars (US$) and are F.O.B. Point of Origin. Charges for Services not stated in the Proposal (including, but not limited to, on-site technical assistance performed by a factory technical representative) are not included and must be purchased pursuant to a separately executed agreement between the parties.

Item 4. VALIDITY

Unless otherwise specified and subject to PWT's acceptance as described herein, the Proposal is valid for (30) thirty days and is subject to review thereafter. Prices may be extended beyond thirty (30) days only if confirmed in writing by PWT.

Item 5. PAYMENT TERMS

Buyer's payments shall be made in accordance with the terms and conditions of the Proposal. If no payment terms are set forth in the Proposal, then the payment terms are (a) thirty percent (30%) of the purchase price under the applicable Order shall be invoiced net five (5) days upon execution of the Proposal by Buyer; (b) sixty percent (60%) of the purchase price under the applicable Order shall be invoiced net thirty (30) days upon shipping, or upon PWT's offer to ship; (c) five percent (5%) of the purchase price to be invoiced net thirty (30) days upon delivery of Operation and Maintenance manuals and (d) the remaining five percent (5%) will be invoiced net thirty (30) days upon completion and/or performance of all related Services under the applicable Order. Interest will be charged on the unpaid invoiced balance at the rate of one and a half percent (1½%) per month for any amount received after thirty (30) days from the date of invoice. Any collection costs and/or attorney fees incurred by PWT in order to collect payment due will be invoiced to the Buyer, and Buyer agrees to pay said costs. In addition to the foregoing rights, PWT may suspend the shipping of any Products if the Buyer has failed to PWT in a timely manner.

Item 6. FEES AND TAXES

Buyer shall pay directly or reimburse PWT for payment of any and all applicable customs, sales, use, excise or other fees and taxes associated with the production and delivery of Products and PWT's performance under this Agreement. Buyer is responsible for and bears the risk of establishing, if applicable, a valid exemption from any tax, and shall indemnify, defend and hold PWT harmless for any loss, cost, or expense relating to any such exemption.

Item 7. DELAYED SHIPPING

Unless otherwise specified in the Proposal, if Buyer specifies a shipping date more than eight (8) months from the date of Buyer's acceptance of the Proposal, the price stated in the Proposal for the same goods shall be increased by a figure equal to the greater of (a) one percent (1%) per month (or part thereof), or (b) the average percentage increase of the stainless-steel and electronics commodity prices measured among the Consumer Price Index and the Producer Price Index or their successor indices as of the date of such acceptance and the shipping date. If PWT incurs a delay in

production of the Products due to force majeure events or supply chain issues of more than three (3) months or its suppliers have materially increased its costs as reasonably demonstrated to Buyer by PWT, then the Products costs shall be adjusted by the percentage increase of the stainless steel commodity price as measured by Producer Price Index or its successor index as of the date of such acceptance and the manufacturing date of the Products.

Item 8. FINANCIAL RESPONSIBILITY OF BUYER

If at any time before shipment, Buyer's financial ability to pay becomes impaired or unsatisfactory, PWT shall have the right to require Buyer to make payment or provide other assurances in full before shipment. In addition, if at any time before shipment, any proceeding is brought by or against Buyer under the bankruptcy or insolvency laws, PWT shall have the right to cancel an Order and/or terminate this Agreement and Buyer shall pay PWT a cancellation charge equal to all of the costs incurred by PWT up to the time of termination, plus fifteen percent (15%) of the purchase amount under the applicable Order(s).

Item 9. SHIPPING

Unless otherwise specified, all equipment and components will be shipped in one lot by the lowest cost method at the discretion of PWT. Any additional shipping requests by Buyer may be subject to additional shipping and handling charges. All shipments shall be F.O.B. – point of origin - the PWT manufacturing facility. Delivery to the carrier shall constitute delivery to Buyer for purpose of transfer of title, risk of loss or damage in transit. Buyer is responsible for obtaining any desired cargo insurance and shall pursue any loss or damage claims solely with the carrier.

Item 10. DELIVERY SCHEDULE

Unless otherwise specified, delivery dates under this Agreement and each Order are approximate, and failure to meet an exact delivery date shall not constitute a breach of this Agreement.

Item 11. INSPECTION

Upon reasonable advance written notice, Buyer or Buyer's representative may inspect the Products prior to shipment at the PWT point of origin at a time mutually agreeable to both parties. Inspection will be allowed only inasmuch as such inspection does not unreasonably interfere with PWT's production work flow. Complete details of any requested inspection must be submitted to PWT in writing, at least two weeks in advance of the requested inspection date. Any inspection under this provision must be completed prior to shipment of any goods under the applicable Order.

Item 12. OFFER BASIS

This Agreement is exclusively based upon drawings and specifications in the possession of PWT at the time of this Agreement and the applicable Order. PWT expressly reserves the right to modify the price and other terms of this Agreement as reasonably determined by PWT, should additional drawings, documents, amendments, clarifications or other addenda be required to produce or deliver the Products under an applicable Order.

Item 13. LIMITED WARRANTY

PWT's warranty liability under this Agreement is limited to the terms listed in the PWT Standard Limited Warranty that accompanies these Terms and is incorporated herein by reference. No other warranty, express of implied, is made with respect to the Products and/or services provided under this Agreement.

Item 14. MEET AND CONFER

The parties shall amicably work together to negotiate and resolve any controversy or dispute arising out of, or in connection with this Agreement or its interpretation, performance or non-performance or breach thereof. In particular, in the event of a disagreement, the parties shall meet and confer and attempt in good faith to resolve their differences. At the written request of the aggrieved party, a face-to-face meeting between decision-makers of the parties shall be arranged at the offices of the non-aggrieved party. Such a meeting shall occur within thirty (30) days of the delivery of the written request of the aggrieved party, unless otherwise agreed by the parties.

Item 15. FORCE MAJEURE

Neither party will be deemed in default of this Agreement to the extent that performance of its obligations (other than payment of money) or attempts to cure any breach are delayed or prevented by reason of any event beyond the reasonable control of such party, including any act of God (*i.e.*, fire, earthquake, natural disaster), act of government (*i.e.*, war, terrorism, embargo), or any other act or circumstance that is beyond the reasonable control of such party, provided that such party gives the other party prompt written notice thereof. Any delays caused by Buyer which impact costs associated with the Products may result in additional fees.

Item 16. GOVERNING LAW

Subject to Section 14, all disputes and matters arising under, in connection with, or incidental to this Agreement shall be litigated, if at all, in and before the Circuit Court of Baltimore County, Maryland, USA to the exclusion of other courts of other states, the United States or other countries and to the exclusion of other venues. The parties expressly consent to the exclusive jurisdiction of this court and agree that this venue is convenient and not to seek a change of venue or to dismiss this action on the grounds of forum non conveniens, and not to remove any litigation from that court to a federal court. This Agreement shall be construed in accordance with and governed by the substantive laws of the State of Maryland, to the extent state law applies. An action for breach of this Agreement must be commenced within one (1) year after the cause of action has accrued.

Item 17. WAIVER AND MODIFICATION

No waiver by either party of any breach, default or violation of any term, warranty, representation, agreement, covenant, condition or provision of this Agreement shall constitute a waiver of any subsequent breach, default, or violation of the same or other term, warranty, representation, agreement, covenant, condition or provision. No modification, amendment, extension, renewal, rescission, termination or waiver of any of the provisions contained in this Agreement, or any future representation, promise or condition in connection with the subject matter of this Agreement, shall be binding upon either party unless in writing and signed by both parties.

Item 18. SEVERABILITY

Any provision of this Agreement which is invalid, prohibited or unenforceable in any jurisdiction shall, as to such jurisdiction, be ineffective solely to the extent of such invalidity, prohibition or unenforceability without invalidating the remaining provisions hereof, and any such invalidity, prohibition or unenforceability in any such jurisdiction shall not invalidate or render unenforceable such provision in any other jurisdiction.

Item 19. ASSIGNMENT AND DELEGATION

Buyer shall not have the right to assign or delegate this Agreement or its interest in or obligations under this Agreement without the prior written consent of PWT, which shall not be unreasonably withheld. The merger, acquisition, reorganization, or other restructuring of Buyer shall not constitute an assignment under the terms of this Agreement provided the surviving entity has assumed all of the obligations of PWT under this Agreement pursuant to a written confirmation. Subject to the foregoing, the rights and obligations of the parties to this Agreement shall be binding upon, and enforceable by their respective heirs, successors and permitted assigns.

Item 20. CONFIDENTIALITY

The parties recognize that, in the course of their dealings, each may come into possession of information relating to the business of the other which is not generally known in the industry, which reasonably or logically may be considered to be confidential or proprietary and which might reasonably be expected to do harm to the other if divulged ("Confidential Information"). Each party agrees to keep the Confidential Information confidential and not to disclose it, in whole or in part, to any third persons whatsoever, nor even to any of its own employees except those having a "need to know," and otherwise to protect the confidentiality of such Confidential Information in accordance with reasonable industry practices. Confidential Information of a party shall no longer be subject to the foregoing restrictions (a) if it is or becomes available to the public through no fault of the other party, (b) if it is otherwise known to the other party as shown by written records of the other party at the time of disclosure of the Confidential Information, (c) if, subsequent to disclosure hereunder, it is obtained by the other party on a non-confidential basis from a third party who has the right to disclose such information or (d) if it is required to be disclosed pursuant to a court order, so long as the non-disclosing party is given adequate notice and the ability to challenge the required disclosure. Confidential Information will include the terms and conditions of this Agreement. Each receiving party shall immediately notify the disclosing party in writing if the receiving party reasonably determines that there has been an unauthorized access, use or receipt of the disclosing party's Confidential Information.

Item 21. NOTICES.

Any notice given under this Agreement shall be given when delivered in person or by registered or certified mail, postage prepaid, return receipt requested or by other delivery service providing evidence of receipt to the party to whom such notice is to be given at the address set forth above or at such other address as either party shall hereafter give notice of to the other in writing.

Item 22. INDEPENDENT CONTRACTOR.

Buyer has no authority to bind PWT in any contractual manner or to represent to others that the relationship between the other is other than stated herein.

Item 23. INTELLECTUAL PROPERTY

Except as expressly set forth in this Agreement, this Agreement does not grant either party any rights, implied or otherwise, to the other party's intellectual property (including, but not limited to, firmware, technology, data, or software) or any third party's intellectual property. Buyer acknowledges that, as between the parties, PWT retains all right, title, and interest in and to all components of the PWT Products and related intellectual property rights (collectively, the "PWT IP"). PWT hereby grants the Buyer a non-exclusive, irrevocable, worldwide, perpetual, royalty-free right and license to the PWT intellectual property solely as it is embodied in the Products and solely for the purposes of operating and using the Products.

Item 24. INDEMNIFICATION

Buyer hereby agrees to defend, indemnify and hold harmless the PWT, its directors, officers, employees, agents, and any assignee from and against any and all losses, damages, injuries, claims, suits, demands, judgments, decrees, losses, costs, expenses and liabilities, including, but not limited to attorneys' fees and courts costs asserted against, imposed upon or incurred by PWT arising from: any claim that manufacture or use of the Products (or their specifications) infringes upon a third party intellectual or proprietary right, including, but not limited to, patent, copyright, trademark, trade secret or any other intellectual or proprietary right where Buyer provided the specifications therefore.

Process Wastewater Technologies, LLC Standard Limited Warranty

Item 1. LIMITATION OF LIABILITY

EXCEPT AS OTHERWISE SET FORTH HEREIN, THE PRODUCTS ARE PROVIDED "AS IS" AND PWT DOES NOT MAKE ANY OTHER STATUTORY, EXPRESS WARRANTIES OR ANY IMPLIED WARRANTIES WITH RESPECT TO THESE PRODUCTS AND SERVICES PROVIDED HEREIN, INCLUDING ANY IMPLIED WARRANTY OF MERCHANTABILITY, INFRINGEMENT, TITLE, OR OF FITNESS FOR A PARTICULAR PURPOSE OR USE.

PWT does not assume and expressly disclaims any liability for (i) SPECIAL, INDIRECT, INCIDENTAL OR CONSEQUENTIAL DAMAGES which anyone may suffer as a result of the sale, delivery, service, use, or loss of use, of any Products and/or services provided by PWT, or (ii) any charges or expenses of any nature which are incurred without the prior written consent of PWT. Without limiting the foregoing, PWT does not warrant that any Products provided are free from any claim of any third person by way of infringement or the like, and PWT expressly disclaims any liability for any claim of infringement or the like that may result from the sale, delivery, service, use, or loss of use of any Products and/or services provided by PWT.

PWT's total liability under this Agreement or in connection with any claim involving any Products or services is expressly limited to the purchase price of the goods set forth in the applicable Order and/or services in respect of which damages are claimed.

Item 2. DEFECTS WARRANTY

Unless otherwise set forth in the Proposal, PWT warrants that the Products shall be free from defects in material and workmanship for the shorter period of: (i) twelve (12) months from the date of start-up; (ii) the warranty period for the third party good or service embodied in the Product; or (iii) eighteen (18) months from the delivery of the specified Product.

PWT's sole obligation and Buyer's exclusive remedy under this Agreement is expressly limited to the repair or replacement of any Product or parts of the Product or at the option of PWT, a refund of the purchase price, of any Product or parts which are return to PWT freight prepaid; provided that PWT determines in its sole discretion that the Product is defective, failed prematurely or has faulty workmanship or materials.

Item 3. PRODUCTS OF OTHER MANUFACTURERS

Unless otherwise set forth in the Proposal, PWT makes no warranty with regard to any products not manufactured by PWT, including but not limited to, electrical components, firmware, equipment and motors.

Item 4. TYPES OF DAMAGES AND CLAIMS FOR WHICH PWT LLC IS NOT RESPONSIBLE

The following non-exclusive list of items are specifically not covered by the PWT Standard Limited Warranty and, in the event of their occurrence, will render the PWT Defects Warranty null and void:

- defects which are caused by improper installation, improper or abnormal use or operation, or improper storage or handling;
- defects caused by the failure of the Buyer to perform and log normal preventative maintenance;
- defects caused by the use of replacement parts not approved in writing by PWT;
- defects caused by repairs by persons not authorized in writing by PWT;
- defects caused by modifications or alterations made by the Buyer; and/or
- any damage to our any Product occurring while it is in the possession of the Buyer.

Item 5. EQUIPMENT SAFETY PARAMETERS

With respect to operation of the Products, it is the responsibility of the Buyer to define and provide any safety device(s) or associated safety device(s) (other than that which is ordinarily furnished by PWT) which may be necessary and/or required, and to establish safety procedures and operational instructions to safeguard the operator(s) during maintenance, cleaning, or any use of the Products whatsoever, and to subsequently ensure that the Products are operated in conformance with all applicable safety procedures, laws, regulations and instructions.

It is also the responsibility of the Buyer to enforce all safety regulations and operational instructions and to maintain the Product in a safe condition (e.g., guards in place; warning, caution and/or important labels affixed; electrical boxes secure; interlocks operational; etc.). In particular, all warning, caution and/or important labels must be maintained in a readable condition, and if necessary, replaced with new labels.

Additionally, as the nature of the Product does not always make it possible to fully prevent operator access from rotating components, maintenance or cleaning of any nature must not be performed on the Products without first disconnecting all power.

Item 6. OPERATOR SAFETY COMPLIANCE

Buyer warrants and agrees that because it has sole control over the Product, it shall be solely responsible for safety compliance. Operator access and use of Products, and full compliance with all provisions of the Operator Safety section of PWT Instruction Manuals are essential and the user's responsibility; the provisions of that section being expressly incorporated herein.

Sprinkler System

PMR-MF

PRESSURE-MASTER REGULATOR - MEDIUM FLOW

Specifications

The pressure regulator shall be capable of operating at a constant, factory preset, non-adjustable outlet pressure of 6, 10, 12, 15, 20, 25, 30, 35, 40, 50, or 60 PSI (0.41, 0.69, 0.83, 1.03, 1.38, 1.72, 2.07, 2.41, 2.76, 3.45, or 4.14 bar) with a flow range between:

4 - 16 GPM (909 - 3634 L/hr) for 6 - 10 PSI models or
2 - 20 GPM (454 - 4542 L/hr) for 12 - 60 PSI models.

The pressure regulator shall maintain the nominal pressure at a minimum of 5 PSI (0.34 bar) above model inlet pressure and a maximum of 80 PSI (5.52 bar) above nominal model pressure*. Refer to the Model Numbers Chart on page 2 for outlet flow based on the model. Always install downstream from all shut-off valves. Recommended for outdoor use only. Not NSF certified.

All pressure regulator models shall be equipped with one of these inlet-x-outlet configurations:

Inlet	Outlet
¾-inch Female National Pipe Thread (FNPT)	¾-inch Female National Pipe Thread (FNPT)
1-inch Female National Pipe Thread (FNPT)	1-inch Female National Pipe Thread (FNPT)
1-inch Female British Standard Pipe Thread (FBSPT)	1-inch Female British Standard Pipe Thread (FBSPT)

The upper housing, lower housing, and internal molded parts shall be of engineering-grade thermoplastics with internal elastomeric seals and a reinforced elastomeric diaphragm. Regulation shall be accomplished by a fixed stainless steel compression spring, which shall be enclosed in a chamber isolated from the normal water passage.

Outlet pressure and flow shall be clearly marked on each regulator.

The pressure regulator shall carry a two-year manufacturer's warranty on materials, workmanship, and performance.

The pressure regulator shall be manufactured by Senninger Irrigation in Clermont, Florida. Senninger is a Hunter Industries Company.

* Please consult the factory for applications outside of recommended guidelines.

Physical

3/4″ FNPT x 3/4″ FNPT model *(shown on right)*

Overall Length 5.2 inches (13.1 cm)

Overall Width 2.5 inches (6.4 cm)

1″ FNPT x 1″ FNPT model

1″ FBSPT x 1″ FBSPT model

Overall Length 5.8 inches (14.6 cm)

Overall Width 2.5 inches (6.4 cm)



PMR-MF

PRESSURE-MASTER REGULATOR - MEDIUM FLOW

Model Numbers

Model #	Flow Range	Preset Operating Pressure	Maximum Inlet Pressure
PMR06MF3F3FV (3/4″ F x 3/4″ F NPT) or PMR06MF4F4FV (1″ F x 1″ F NPT) or PMR06MF4F3FV (1″ F x 3/4″ F NPT)	4 - 16 GPM (909 - 3634 L/hr)	6 PSI (0.41 bar)	80 psi (5.51 bar)
PMR10MF3F3FV (3/4″ F x 3/4″ F NPT) or PMR10MF4F4FV (1″ F x 1″ F NPT) or PMR10MF4F3FV (1″ F x 3/4″ F NPT)	4 - 16 GPM (909 - 3634 L/hr)	10 PSI (0.69 bar)	90 psi (6.20 bar)
PMR12MF3F3FV (3/4″ F x 3/4″ F NPT) or PMR12MF4F4FV (1″ F x 1″ F NPT) or PMR12MF4F3FV (1″ F x 3/4″ F NPT)	2 - 20 GPM (454 - 4542 L/hr)	12 PSI (0.83 bar)	90 psi (6.20 bar)
PMR15MF3F3FV (3/4″ F x 3/4″ F NPT) or PMR15MF4F4FV (1″ F x 1″ F NPT) or PMR15MF4F3FV (1″ F x 3/4″ F NPT)	2 - 20 GPM (454 - 4542 L/hr)	15 PSI (1.03 bar)	95 psi (6.55 bar)
PMR20MF3F3FV (3/4″ F x 3/4″ F NPT) or PMR20MF4F4FV (1″ F x 1″ F NPT) or PMR20MF4F3FV (1″ F x 3/4″ F NPT)	2 - 20 GPM (454 - 4542 L/hr)	20 PSI (1.38 bar)	100 psi (6.89 bar)
PMR25MF3F3FV (3/4″ F x 3/4″ F NPT) or PMR25MF4F4FV (1″ F x 1″ F NPT) or PMR25MF4F3FV (1″ F x 3/4″ F NPT)	2 - 20 GPM (454 - 4542 L/hr)	25 PSI (1.72 bar)	105 psi (7.24 bar)
PMR30MF3F3FV (3/4″ F x 3/4″ F NPT) or PMR30MF4F4FV (1″ F x 1″ F NPT) or PMR30MF4F3FV (1″ F x 3/4″ F NPT)	2 - 20 GPM (454 - 4542 L/hr)	30 PSI (2.07 bar)	110 psi (7.58 bar)
PMR35MF3F3FV (3/4″ F x 3/4″ F NPT) or PMR35MF4F4FV (1″ F x 1″ F NPT) or PMR35MF4F3FV (1″ F x 3/4″ F NPT)	2 - 20 GPM (454 - 4542 L/hr)	35 PSI (2.41 bar)	115 psi (7.93 bar)
PMR40MF3F3FV (3/4″ F x 3/4″ F NPT) or PMR40MF4F4FV (1″ F x 1″ F NPT) or PMR40MF4F3FV (1″ F x 3/4″ F NPT)	2 - 20 GPM (454 - 4542 L/hr)	40 PSI (2.76 bar)	120 psi (8.27 bar)
PMR50MF3F3FV (3/4″ F x 3/4″ F NPT) or PMR50MF4F4FV (1″ F x 1″ F NPT) or PMR50MF4F3FV (1″ F x 3/4″ F NPT)	2 - 20 GPM (454 - 4542 L/hr)	50 PSI (3.45 bar)	130 psi (8.96 bar)
PMR60MF3F3FV (3/4″ F x 3/4″ F NPT) or PMR60MF4F4FV (1″ F x 1″ F NPT) or PMR60MF4F3FV (1″ F x 3/4″ F NPT)	2 - 20 GPM (454 - 4542 L/hr)	60 PSI (4.14 bar)	140 psi (9.65 bar)

Senninger® Pressure Regulators

Low Pressure - High Performance™

Hunter®

Agricultural Irrigation









hunterirrigation.com/agriculture

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PARTNERING TOGETHER

For over 6 decades, Senninger® has been the proud provider of agricultural irrigation products serving farmers and irrigation professionals around the world. To further strengthen our company, Senninger Irrigation will now proudly carry the family name of our parent company, as Hunter® Agricultural Irrigation.

What This Means to You:

- Continued high-quality Senninger products
- Growing footprint of facilities and personnel to meet your irrigation needs
- Continued outstanding technical support and customer service
- Enhanced production and automation investments worldwide
- Long term commitment to the agricultural irrigation markets we serve

We're grateful to you, our customers, for your partnership and trust over the years. Your support continues to drive our passion for providing industry-leading products, comprehensive educational programs, and exceptional customer service.

WHAT IS A PRESSURE REGULATOR?

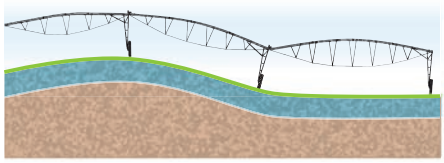
The primary function of a pressure regulator is to maintain an irrigation system's desired performance by controlling excessive and varying inlet pressures to constant outlet pressure.

Proper use of pressure regulators helps maintain the overall efficiency of an irrigation system. Pressure regulators assure good sprinkler performance and can help lower energy costs and save water.

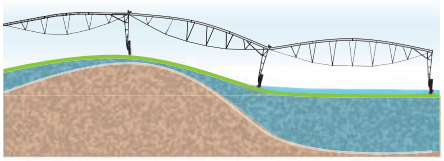
Manufacturers offer several models of pressure regulators to meet various irrigation needs: flow ranges, operating pressure rating, maximum inlet pressure, inlet and outlet connection size, and connection type - NPT, BSPT, and hose connection threads.

WHY DO I NEED A PRESSURE REGULATOR?

Every irrigation system will experience some pressure fluctuation, which also causes unwanted flow deviations. Regulators ensure the sprinklers operate within a specific range of flows and pressures to deliver the intended distribution pattern and application rate. Without regulators, the radius of throw is altered, application rates are not consistent, and uniformity numbers are drastically affected. It may also impact the application of fertilizers, chemicals, and nutrients through the irrigation system.



*Water Application **With** Pressure Regulators*



*Water Application **Without** Pressure Regulators*

Pressure is related to gravity. More pressure is needed to move water uphill. When water moves downhill, more pressure is available.

Every 2.31 ft (0.7 m) of elevation change will result in 1 psi (0.07 bar) pressure change.





WHAT CAUSES PRESSURE FLUCTUATIONS?

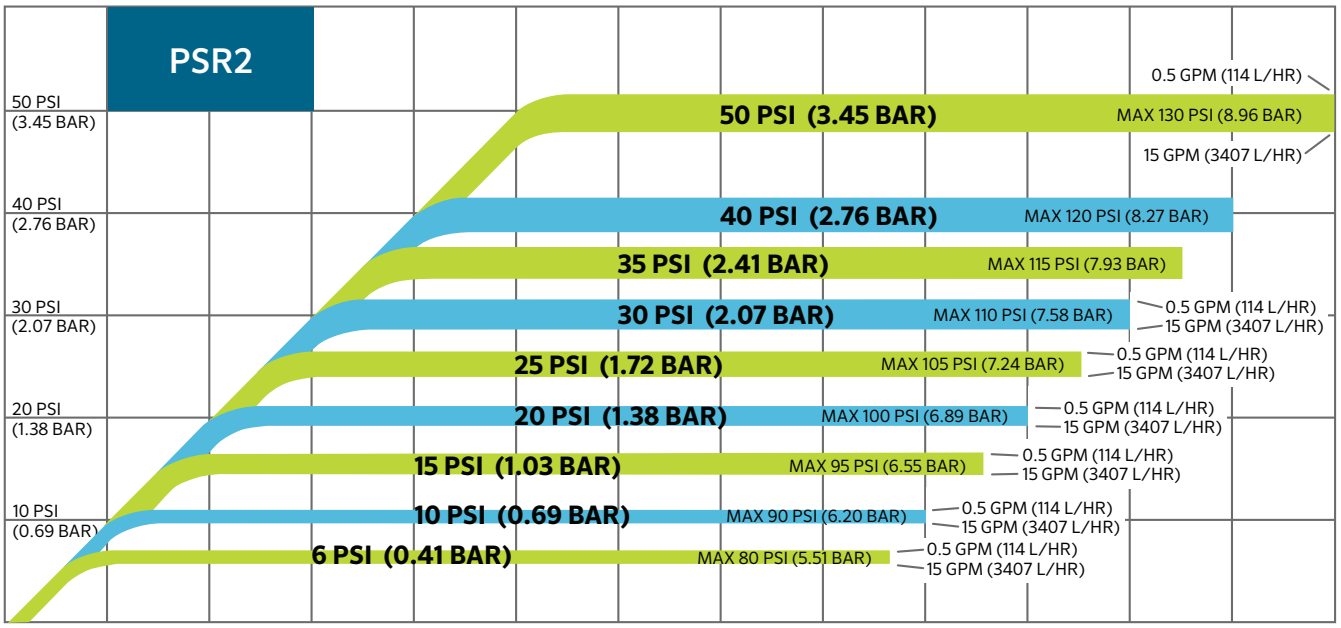
Some causes include elevation changes within the irrigated area; pressure loss through pipes and fittings; fluctuations when zones cycle on or off; system demand change on large projects with multiple wells providing water; and activation of end guns and corner arms on mechanized systems.

HOW DO PRESSURE REGULATORS WORK?

Water travels through the inlets of the regulator across a fixed seat into the critical flow area. Water then enters a hollow cylinder or throttling stem attached to a diaphragm. Increasing inlet pressure causes the valve to close. Decreasing inlet pressure allows the valve to open. The regulated outlet pressure is determined by the spring's compressive strength.

WHAT IS A PERFORMANCE CURVE?

Every pressure regulator is designed to operate at a minimum and maximum inlet pressure and a predetermined flow range. A regulator performance curve illustrates how the pressure regulator will perform within the model's range of inlet pressures and flows. The Y-axis shows outlet pressure, and the X-axis shows inlet pressure.



In this chart, the band for the 30 psi (2.07 bar) model shows the performance at various flows. At the lowest flow (0.5 gpm or 114 L/hr), the regulator will maintain an actual outlet pressure slightly higher than 30 psi (2.07 bar). In contrast, at the highest flow (15 gpm or 3407 L/hr), the actual outlet pressure will be slightly lower than 30 psi (2.07 bar).*

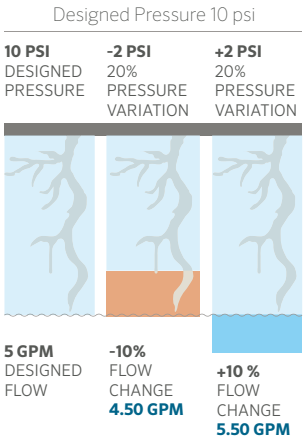
**Source: Rogers, Shaw, Pragada, & Alam, 2010.*

HOW DOES PRESSURE AFFECT FLOW?

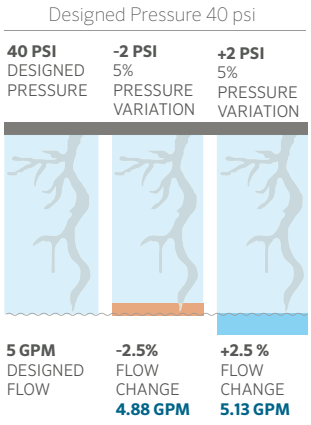
The operating pressure of an irrigation system always affects the flow rate – $Q = K\sqrt{P}$.

Pressure regulation is particularly important in low-pressure systems, where a slight pressure variation can have a significant impact on the application rate.

Keep in mind that all it takes is a ~20% pressure change to create a ~10% flow variation. The lower a sprinkler's design pressure is, the more critical it is to control pressure to maintain its design flow rate.



Above left: A pressure variation of 2 psi (0.14 bar) on a sprinkler designed to operate at 10 psi (0.69 bar) is equivalent to a 20% pressure variation. This alters the flow by 10%. Likewise, a sprinkler designed to operate at 5 gpm (1136 L/hr) will have 0.5 gpm (113 L/hr) variation; delivering 4.5 gpm (1022 L/hr) if the pressure decreases and 5.5 gpm (1249 L/hr) if the pressure increases.



Above right: On a sprinkler designed to operate at 40 psi (2.76 bar), the same 2 psi (0.14 bar) variation will only result in a 5% pressure variation. In this case, the fluctuation in flow will be equivalent to a 2.5% change, which is less than a tenth of a gallon per minute. Thus, the flow will oscillate between 4.88 gpm (1108 L/hr) and 5.13 gpm (1165 L/hr).

KEY: **Under**watering
Overwatering

PRESSURE CHANGE	DESIGN PRESSURE						
	6 psi (0.41 bar)	10 psi (0.69 bar)	15 psi (1.03 bar)	20 psi (1.38 bar)	30 psi (2.07 bar)	40 psi (2.76 bar)	50 psi (3.45 bar)
1 psi (0.069 bar)	16.7	10.0	6.7	5.0	3.3	2.5	2.0
2 psi (0.138 bar)	33.3	20.0	13.3	10.0	6.7	5.0	4.0
3 psi (0.207 bar)	50.0	30.0	20.0	15.0	10.0	7.5	6.0
4 psi (0.276 bar)	66.7	40.0	26.7	20.0	13.3	10.0	8.0
5 psi (0.345 bar)	83.3	50.0	33.3	25.0	16.7	12.5	10.0
6 psi (0.414 bar)	100.0	60.0	40.0	30.0	20.0	15.0	12.0
7 psi (0.483 bar)	N/A	70.0	46.7	35.0	23.3	17.5	14.0
8 psi (0.552 bar)	N/A	80.0	53.3	40.0	26.7	20.0	16.0
	Percentage of Pressure Variation (%)						

Pressure regulators are recommended if there is a 20% pressure and/or a 10% flow variation. The lower a system's design pressure, the more critical it is to accurately control its pressure.

HOW TO INSTALL A PRESSURE REGULATOR

Pressure regulators must always be installed downstream from all shut-off valves in the proper direction.
Each model has a directional arrow on the side that shows the direction of the flow. This arrow should point downstream, toward the sprinklers and emitters.

Hydraulic friction loss is what makes a pressure regulator work. To compensate for friction inside the device, the recommendation is to assure inlet pressure is 5 psi (0.34 bar) higher than the regulator preset psi rating.

Each pressure regulator is designed with a maximum pressure rating, typically 80 psi (5.51 bar) above the designed pressure rating for that model. Operating outside these recommendations will affect the regulator's performance and could cause premature failure.

PRESET OUTLET PRESSURE	MAXIMUM INLET PRESSURE
6 psi (0.41 bar)	80 psi (5.51 bar)
10 psi (0.69 bar)	90 psi (6.20 bar)
12 psi (0.83 bar)	90 psi (6.20 bar)
15 psi (1.03 bar)	95 psi (6.55 bar)
20 psi (1.38 bar)	100 psi (6.89 bar)
25 psi (1.72 bar)	105 psi (7.24 bar)
30 psi (2.07 bar)	110 psi (7.58 bar)
35 psi (2.41 bar)	115 psi (7.93 bar)
40 psi (2.76 bar)	120 psi (8.27 bar)
50 psi (3.45 bar)	130 psi (8.96 bar)

Mechanized systems –

- Pressure regulators are usually installed immediately preceding the sprinkler.
- Some prefer to install pressure regulators directly into the outlet on the pivot span or on the outlet side of the gooseneck. Increased pressure between the regulator and the sprinkler should be a design consideration.

Solid Set field installations –

- Regulators are usually installed at the beginning of the lateral.
  Although, based on the design, one regulator can be used to manage pressure for several laterals.
- Certain installations may require a pressure regulator for each sprinkler.
- In high flow scenarios, a high flow model should be used.
  Although, multiple regulators in manifold can be used to handle the specific flow requirements.
- Timer-control installations employ regulators after the control valve, whether for multiple units or inside a valve box.



HOW LONG DO PRESSURE REGULATORS LAST?

Though regulators can last for years, the degree of regulation will change over time as internal parts begin to wear. The conditions under which pressure regulators operate influence their lifespan. Various factors contribute to pressure regulator wear, including poor water quality, unflushed chemicals in the system, abrasive materials in the water, and extended operating hours. Plan to do a yearly check or after every 2,000 hours, whichever comes first. Any significant variance will mean a loss of efficiency and revenue in the long run. At 10,000 hours, you should review the original design parameters of the system, do random checks on two or more sprinklers per span, and see if you have any variance to the original specifications.

WHAT ARE THE MAIN SIGNS OF WEAR?

Malfunctioning pressure regulators can be difficult to identify visually. However, some emit water through the sides of the regulator when they fail structurally, which often happens because the regulator was installed before a shut-off valve. Sometimes they also produce a high-pitched squealing.

A malfunctioning regulator can result in a sprinkler pressure that will be too high. A sprinkler emitting a finer spray or exhibiting a faster rotation speed relative to adjacent sprinklers may indicate a regulator is operating above its nominal rating. If operating below its nominal rating, sprinklers will produce larger droplets and slower rotation speed, as well as reduced wetted diameter.

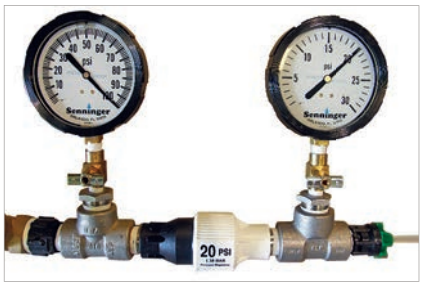


Inlet and outlet of worn pressure regulators.

HOW TO TEST PRESSURE REGULATORS

All users should check their pressure regulators at least once every three years. You can test pressure regulators by installing a high-quality pressure gauge on each side of the regulator.

The gauge on the inlet side assures there is enough pressure for the regulator to operate. Remember that inlet pressure should be at least 5 psi (0.34 bar) above the pressure regulator rating for the regulator to function. The gauge on the outlet side (after the regulator) should match the preset pressure printed on the device, allowing for slight variation due to flow.



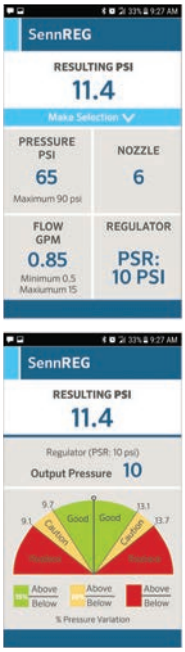
If your irrigation dealer has a regulating testing device, you can also check the readings on a new pressure regulator that matches the model you are testing.

SennREG™ APP

The SennREG app is a handy tool to bring into the field when checking your pressure regulator's performance. It shows the relationship pressure has on flow in either Imperial or Metric units. With just a few clicks, you'll know exactly what to expect out of your pressure regulator – from what your output pressure should be to when you should start thinking about replacements.

- Select your Senninger® pressure regulator model and desired outlet pressure. Be sure you have at least 5 psi (0.34 bar) above the regulated pressure available for the regulator selected.
- Select the UP3® nozzle number currently installed in your sprinkler.
- Enter your expected flow numerically.
- Enter your overall system pressure.

Test your pressure regulator to see the outlet pressure. In the SennREG app, replace the outlet pressure with your actual pressure and review the results on the chart. If the line falls within the green area, the pressure regulator operates as intended. If it falls within the yellow area, use caution and monitor system performance. If it falls within the red area, it is time to replace your pressure regulators.

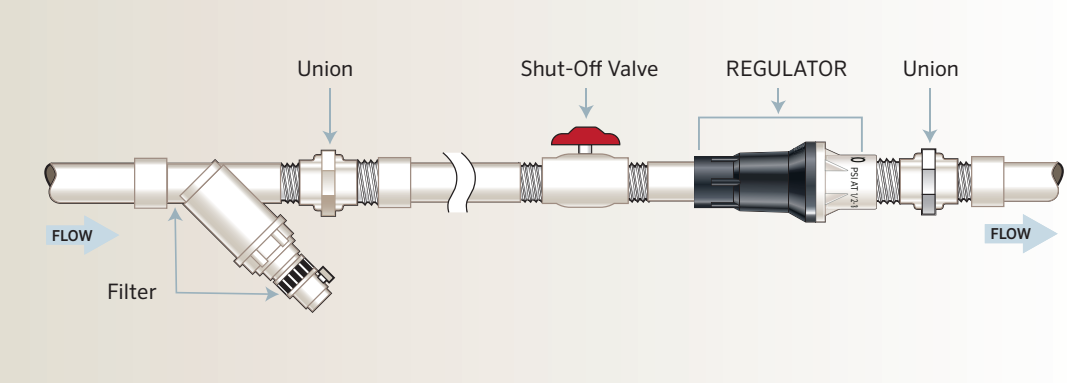


*Download the app for **Apple or Android devices** from the app store.*

PRESSURE REGULATION
DYNAMIC OR STATIC

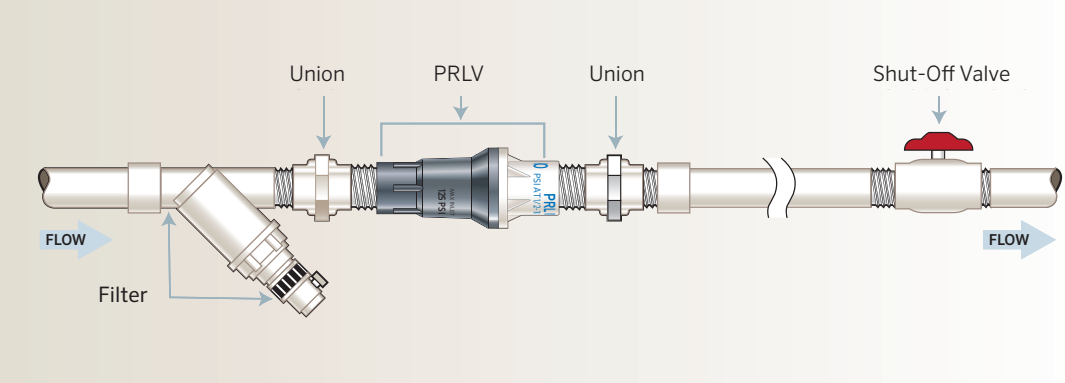
DYNAMIC – PRESSURE REGULATOR

Dynamic pressure regulators must always be installed **downstream** from all shut-off valves and filters in the proper direction. Each model has a directional arrow on the side that shows the direction of the flow. This arrow should point downstream, toward the sprinklers and emitters.



STATIC – PRESSURE REGULATING LIMIT VALVE

Static pressure regulators, like our Pressure Regulating Limit Valve (PRLV and PRU-LV) must always be installed **upstream** from all shut-off valves and filters in the proper direction. Each model has a directional arrow on the side that shows the direction of the flow. This arrow should point downstream, toward the sprinklers and emitters.



WHY SENNINGER® PRESSURE REGULATORS?



Recognizing the importance of maintaining correct system pressure, Senninger® introduced the first in-line pressure regulators to the industry in 1966. This revolutionized the irrigation industry by improving overall system performance and efficiency.

Senninger continued to develop the concept earning several patents on additional design features. The Senninger black and white pressure regulators are known worldwide for their accuracy and reliable performance.



The design and materials used to manufacture pressure regulators greatly impact their accuracy. Senninger pressure regulators are designed and built to rigorous quality standards. They are 100% pressure tested to ensure quality and performance before they are packaged and shipped. Senninger pressure regulators are backed with a two-year warranty on materials, workmanship, and performance.

Several models have been developed throughout the years to meet a variety of installation needs including mechanized systems, nurseries, greenhouses, and open fields.

HOW TO SELECT A PRESSURE REGULATOR

When selecting the proper pressure regulator for an irrigation system, there are several factors to consider. These include the range of fluctuations in inlet pressure, the required outlet pressure, and the allowable variation.

Other factors are:

- The maximum flow rate required and expected variation
- Any size and inlet/outlet connection constraints
- Any specific application needs such as those in wastewater or mining installations

Note that in many instances, irrigation design software such as the Senninger SennPAQ™ or WinSIPP™ programs will automatically let you know what type of pressure regulator you need.





MPR MINI PRESSURE REGULATOR

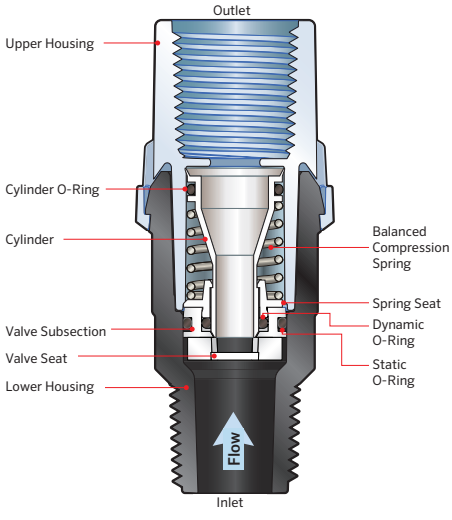


The Senninger® Mini Pressure Regulator (MPR) is an economical solution to help reduce excessive pressure. Because pressure impacts flow, the MPR reduces flow fluctuations so that each sprinkler performs consistently and helps reduce overwatering throughout the irrigation zone, including changing elevations and long lateral runs.

Product Specs	
Flow	0.5 - 3.5 gpm (114 - 804 L/hr)
Pressure	15 - 40 psi (1.0 - 2.8 bar)

FEATURES

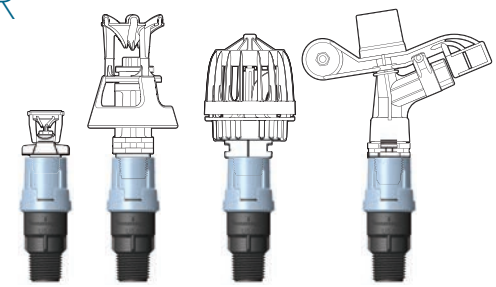
- Designed for use immediately beneath the sprinkler
- Maintains the sprinkler's designed flow to +/-10% of nominal flow
- Allows pressure regulation on sprinklers along laterals or mainlines with up to 115 ft (35 m) elevation change.
- Inlet size: ½" male NPT
- Outlet size: ½" female NPT
- Models available: 15 psi (1.0 bar), 20 psi (1.4 bar), 30 psi (2.1 bar), and 40 psi (2.8 bar)
- Senninger pressure regulators are available with models for a wide range of flows
- Two-year warranty on materials, workmanship, and performance





MPR MINI PRESSURE REGULATOR

Sprinkler	Nozzles	Model MPR
mini-Wobbler™	#4 - #8 nozzles	15 or 20 psi (1.0 or 1.4 bar)
Xcel-Wobbler™	#6 - #9 nozzles	20 psi (1.4 bar)
Smooth Drive™	#6 - #8 nozzles	30 or 40 psi (2.1 or 2.8 bar)
20 Series Impacts	#6 - #9 nozzles	30 or 40 psi (2.1 or 2.8 bar)

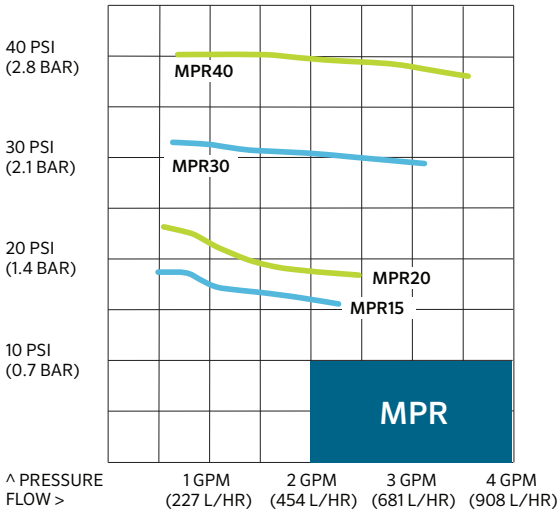


MPR MODELS	Description	Preset Outlet Pressure	Maximum Inlet Pressure	Flow Range
MPR152M2F	15 psi, inlet ½" M NPT, outlet ½" F NPT	15 psi (1.0 bar)	45 psi (3.1 bar)	0.5 - 2.3 gpm (114 - 513 L/hr)
MPR202M2F	20 psi, inlet ½" M NPT, outlet ½" F NPT	20 psi (1.4 bar)	50 psi (3.5 bar)	0.5 - 2.5 gpm (114 - 559 L/hr)
MPR302M2F	30 psi, inlet ½" M NPT, outlet ½" F NPT	30 psi (2.1 bar)	60 psi (4.1 bar)	0.6 - 3.1 gpm (136 - 704 L/hr)
MPR402M2F	40 psi, inlet ½" M NPT, outlet ½" F NPT	40 psi (2.8 bar)	80 psi (5.5 bar)	0.7 - 3.5 gpm (159 - 804 L/hr)

The pressure regulator shall maintain the predetermined pressure provided that the inlet pressure is at least 5 psi (0.3 bar) above the expected outlet pressure, but not exceeding the maximum inlet pressure as shown in this chart.

Pressure regulators should always be installed downstream of all shut-off valves.

Recommended for outdoor use only. Not NSF certified.





PRLG PRESSURE REGULATOR LANDSCAPE GRADE

NEW NEW NEW

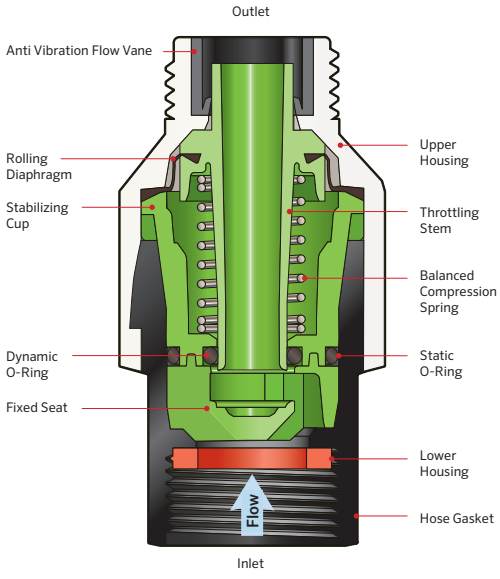
The Senninger® PRLG (Pressure Regulator Landscape Grade) is designed for systems requiring lower flows. With so many connection options, it is ideal for many different types of irrigation installations.



Product Specs	
Flow	0.5 - 7 gpm (114 - 1590 L/hr)
Pressure	10 - 40 psi (0.69 - 2.76 bar)

FEATURES

- Maintains a constant preset outlet pressure while handling varying inlet pressures
- Inlet sizes: ¾" female NPT, ¾" female hose, tape lock barb (⅝"), 500 lock barb (16 mm), 600 lock barb (18 mm)
- Outlet sizes: ¾" male NPT, ¾" male hose, tape lock barb (⅝"), 500 lock barb (16 mm), 600 lock barb (18 mm)
- Models available: 10 psi (0.69 bar), 15 psi (1.03 bar), 20 psi (1.38 bar), 25 psi (1.72 bar), 30 psi (2.07 bar), 35 psi (2.41 bar), and 40 psi (2.76 bar)
- Tamper-proof housing
- Very low hysteresis and friction losses
- Pressure-tested for accuracy
- No external metal parts for excellent corrosion resistance
- Two-year warranty on materials, workmanship, and performance



PRLG PRESSURE REGULATOR LANDSCAPE GRADE

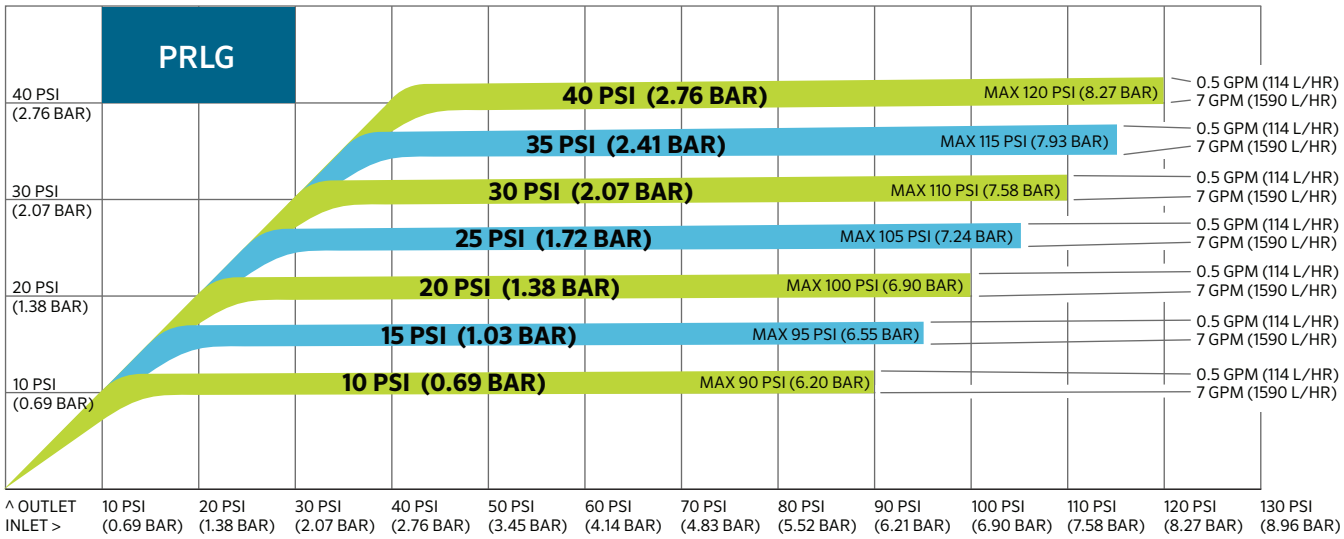
PRLG MODELS	Description	Preset Outlet Pressure	Maximum Inlet Pressure	Flow Range
PRLG103F3M	10 psi, inlet 3/4" F NPT, outlet 3/4" M NPT	10 psi (0.69 bar)	90 psi (6.20 bar)	0.5 - 7 gpm (114 - 1590 L/hr)
PRLG153F3M	15 psi, inlet 3/4" F NPT, outlet 3/4" M NPT	15 psi (1.03 bar)	95 psi (6.55 bar)	0.5 - 7 gpm (114 - 1590 L/hr)
PRLG203F3M	20 psi, inlet 3/4" F NPT, outlet 3/4" M NPT	20 psi (1.38 bar)	100 psi (6.89 bar)	0.5 - 7 gpm (114 - 1590 L/hr)
PRLG253F3M	25 psi, inlet 3/4" F NPT, outlet 3/4" M NPT	25 psi (1.72 bar)	105 psi (7.24 bar)	0.5 - 7 gpm (114 - 1590 L/hr)
PRLG303F3M	30 psi, inlet 3/4" F NPT, outlet 3/4" M NPT	30 psi (2.07 bar)	110 psi (7.58 bar)	0.5 - 7 gpm (114 - 1590 L/hr)
PRLG353F3M	35 psi, inlet 3/4" F NPT, outlet 3/4" M NPT	35 psi (2.41 bar)	115 psi (7.93 bar)	0.5 - 7 gpm (114 - 1590 L/hr)
PRLG403F3M	40 psi, inlet 3/4" F NPT, outlet 3/4" M NPT	40 psi (2.76 bar)	120 psi (8.27 bar)	0.5 - 7 gpm (114 - 1590 L/hr)
PRLG10TLBTLB	10 psi, inlet tape lock barb, outlet tape lock barb (green)	10 psi (0.69 bar)	25 psi (1.72 bar)	0.5 - 7 gpm (114 - 1590 L/hr)
PRLG15TLBTLB	15 psi, inlet tape lock barb, outlet tape lock barb (green)	15 psi (1.03 bar)	25 psi (1.72 bar)	0.5 - 7 gpm (114 - 1590 L/hr)
PRLG105LB5LB	10 psi, inlet 500 lock barb, outlet 500 lock barb (black)	10 psi (0.69 bar)	50 psi (3.45 bar)	0.5 - 7 gpm (114 - 1590 L/hr)
PRLG155LB5LB	15 psi, inlet 500 lock barb, outlet 500 lock barb (black)	15 psi (1.03 bar)	50 psi (3.45 bar)	0.5 - 7 gpm (114 - 1590 L/hr)
PRLG205LB5LB	20 psi, inlet 500 lock barb, outlet 500 lock barb (black)	20 psi (1.38 bar)	50 psi (3.45 bar)	0.5 - 7 gpm (114 - 1590 L/hr)
PRLG106LB6LB	10 psi, inlet 600 lock barb, outlet 600 lock barb (black)	10 psi (0.69 bar)	50 psi (3.45 bar)	0.5 - 7 gpm (114 - 1590 L/hr)
PRLG156LB6LB	15 psi, inlet 600 lock barb, outlet 600 lock barb (black)	15 psi (1.03 bar)	50 psi (3.45 bar)	0.5 - 7 gpm (114 - 1590 L/hr)
PRLG206LB6LB	20 psi, inlet 600 lock barb, outlet 600 lock barb (black)	20 psi (1.38 bar)	50 psi (3.45 bar)	0.5 - 7 gpm (114 - 1590 L/hr)

For the 3/4" female hose x 3/4" female hose connection model, use this part number replacing xx with Preset Outlet Pressure above - **PRLGxx3FH3MH**

The pressure regulator shall maintain the predetermined pressure provided that the inlet pressure is at least 5 psi (0.34 bar) above the expected outlet pressure, but not exceeding the maximum inlet pressure as shown in this chart.

Pressure regulators should always be installed downstream of all shut-off valves.

Recommended for outdoor use only. Not NSF certified.



Every pressure regulator is designed to operate at a minimum and maximum inlet pressure and a predetermined flow range. This regulator performance curve illustrates how the PRLG will perform within the range of inlet pressures and flows.

The Y-axis shows outlet pressure, and the X-axis shows inlet pressure. In this chart, the band for the 30 psi (2.07 bar) model shows the performance at various flows. At the lowest flow (0.5 gpm or 114 L/hr), the regulator will maintain an actual outlet pressure slightly higher than 30 psi (2.07 bar). In contrast, at the highest flow (7 gpm or 1590 L/hr), the actual outlet pressure will be slightly lower than 30 psi (2.07 bar).*

**Source: Rogers, Shaw, Pragada, & Alam, 2010.*



PRL PRESSURE REGULATOR LOW FLOW

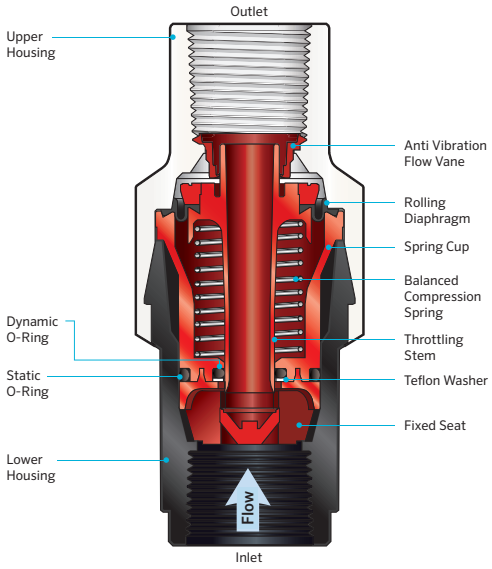


The Senninger® PRL (Pressure Regulator Low Flow) is ideal for installations requiring lower flows. Suggested use in solid-set, drip, other low-volume irrigation systems, as well as center pivot and mechanical-move irrigation systems.

Product Specs	
Flow	0.5 - 8 gpm (114 - 1817 L/hr)
Pressure	6 - 40 psi (0.41 - 2.76 bar)

FEATURES

- Maintains a constant preset outlet pressure while handling varying inlet pressures
- Inlet sizes: ¾" female NPT and ¾" female hose
- Outlet sizes: ¾" female NPT and ¾" female hose
- Models available: 6 psi (0.41 bar), 10 psi (0.69 bar), 12 psi (0.83 bar), 15 psi (1.03 bar), 20 psi (1.38 bar), 25 psi (1.72 bar), 30 psi (2.07 bar), 35 psi (2.41 bar), and 40 psi (2.76 bar)
- Tamper-proof housing
- Very low hysteresis and friction losses
- Pressure-tested for accuracy
- No external metal parts for excellent corrosion resistance
- Two-year warranty on materials, workmanship, and performance



PRL PRESSURE REGULATOR LOW FLOW

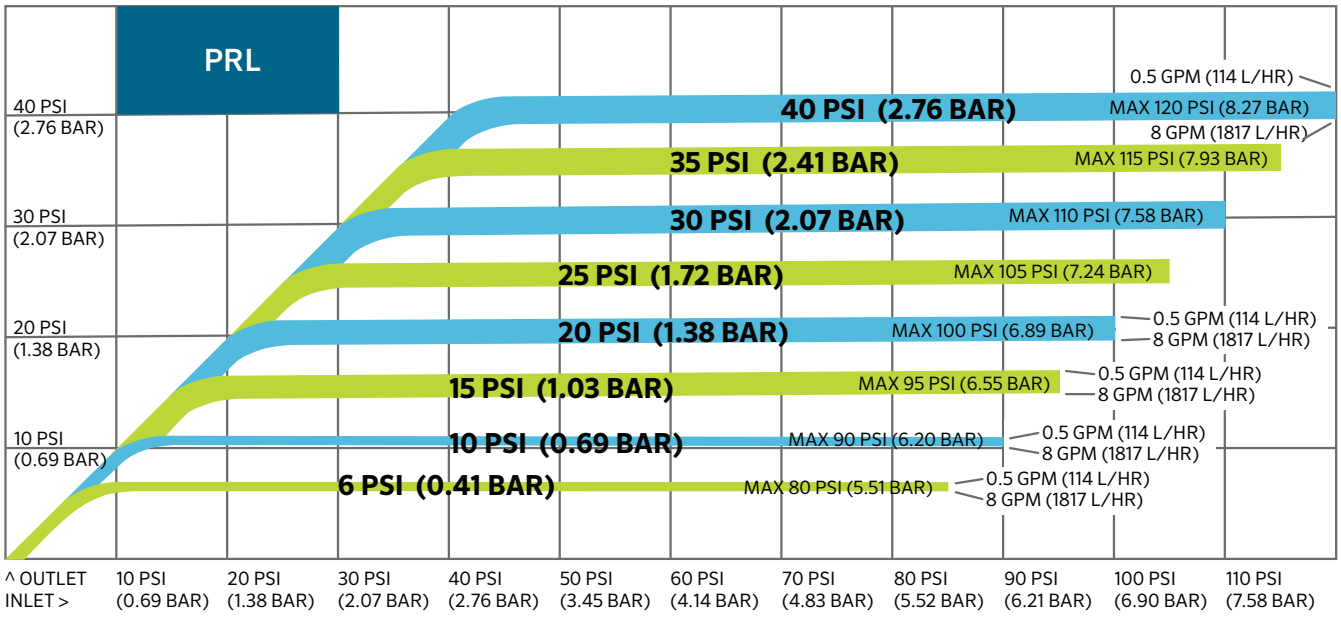
PRL MODELS	Description	Preset Outlet Pressure	Maximum Inlet Pressure	Flow Range
PRL063F3F	6 psi, inlet ¾" F NPT, outlet ¾" F NPT	6 psi (0.41 bar)	80 psi (5.51 bar)	0.5 - 5 gpm (114 - 1136 L/hr)
PRL103F3F	10 psi, inlet ¾" F NPT, outlet ¾" F NPT	10 psi (0.69 bar)	90 psi (6.20 bar)	0.5 - 8 gpm (114 - 1817 L/hr)
PRL123F3F	12 psi, inlet ¾" F NPT, outlet ¾" F NPT	12 psi (0.83 bar)	90 psi (6.20 bar)	0.5 - 8 gpm (114 - 1817 L/hr)
PRL153F3F	15 psi, inlet ¾" F NPT, outlet ¾" F NPT	15 psi (1.03 bar)	95 psi (6.55 bar)	0.5 - 8 gpm (114 - 1817 L/hr)
PRL203F3F	20 psi, inlet ¾" F NPT, outlet ¾" F NPT	20 psi (1.38 bar)	100 psi (6.89 bar)	0.5 - 8 gpm (114 - 1817 L/hr)
PRL253F3F	25 psi, inlet ¾" F NPT, outlet ¾" F NPT	25 psi (1.72 bar)	105 psi (7.24 bar)	0.5 - 8 gpm (114 - 1817 L/hr)
PRL303F3F	30 psi, inlet ¾" F NPT, outlet ¾" F NPT	30 psi (2.07 bar)	110 psi (7.58 bar)	0.5 - 8 gpm (114 - 1817 L/hr)
PRL353F3F	35 psi, inlet ¾" F NPT, outlet ¾" F NPT	35 psi (2.41 bar)	115 psi (7.93 bar)	0.5 - 8 gpm (114 - 1817 L/hr)
PRL403F3F	40 psi, inlet ¾" F NPT, outlet ¾" F NPT	40 psi (2.76 bar)	120 psi (8.27 bar)	0.5 - 8 gpm (114 - 1817 L/hr)

For ¾" F hose x ¾" M hose connection model, use this part number replacing xx with Preset Outlet Pressure above - **PRLxx3FH3MH**

The pressure regulator shall maintain the predetermined pressure provided that the inlet pressure is at least 5 psi (0.34 bar) above the expected outlet pressure, but not exceeding the maximum inlet pressure as shown in this chart.

Pressure regulators should always be installed downstream of all shut-off valves.

Recommended for outdoor use only. Not NSF certified.



Every pressure regulator is designed to operate at a minimum and maximum inlet pressure and a predetermined flow range. This regulator performance curve illustrates how the PRL will perform within the range of inlet pressures and flows.

The Y-axis shows outlet pressure, and the X-axis shows inlet pressure. In this chart, the band for the 30 psi (2.07 bar) model shows the performance at various flows. At the lowest flow (0.5 gpm or 114 L/hr), the regulator will maintain an actual outlet pressure slightly higher than 30 psi (2.07 bar). In contrast, at the highest flow (8 gpm or 1817 L/hr), the actual outlet pressure will be slightly lower than 30 psi (2.07 bar).*

**Source: Rogers, Shaw, Pragada, & Alam, 2010.*



PSR™2 PIVOT SPECIAL REGULATOR

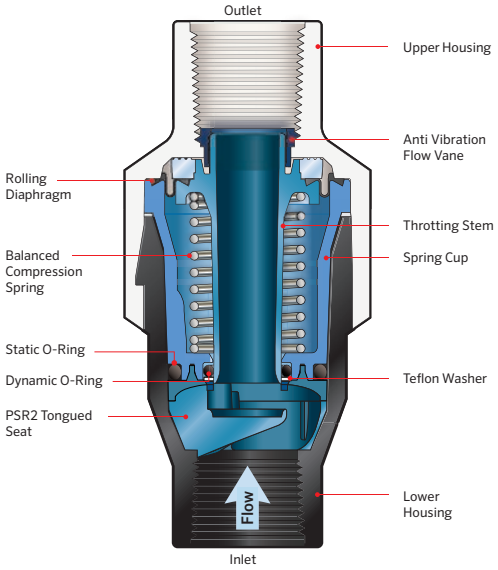


The Senninger® PSR™2 (Pivot Special Regulator) is ideal for mechanical move installations. Its wide flow range allows irrigators to use one model along the entire length of the machine. Its patented design is ideal for systems pumping surface water.

Product Specs	
Flow	0.5 - 15 gpm (114 - 3407 L/hr)
Pressure	6 - 50 psi (0.41 - 3.45 bar)

FEATURES

- Maintains a constant preset outlet pressure while handling varying inlet pressures
- Inlet size: ¾" female NPT
- Outlet size: ¾" female NPT
- Models available: 6 psi (0.41 bar), 10 psi (0.69 bar), 12 psi (0.83 bar), 15 psi (1.03 bar), 20 psi (1.38 bar), 25 psi (1.72 bar), 30 psi (2.07 bar), 35 psi (2.41 bar), 40 psi (2.76 bar), and 50 psi (3.45 bar)
- Tamper-proof housing
- Very low hysteresis and friction losses
- Pressure-tested for accuracy
- No external metal parts for excellent corrosion resistance
- Two-year warranty on materials, workmanship, and performance



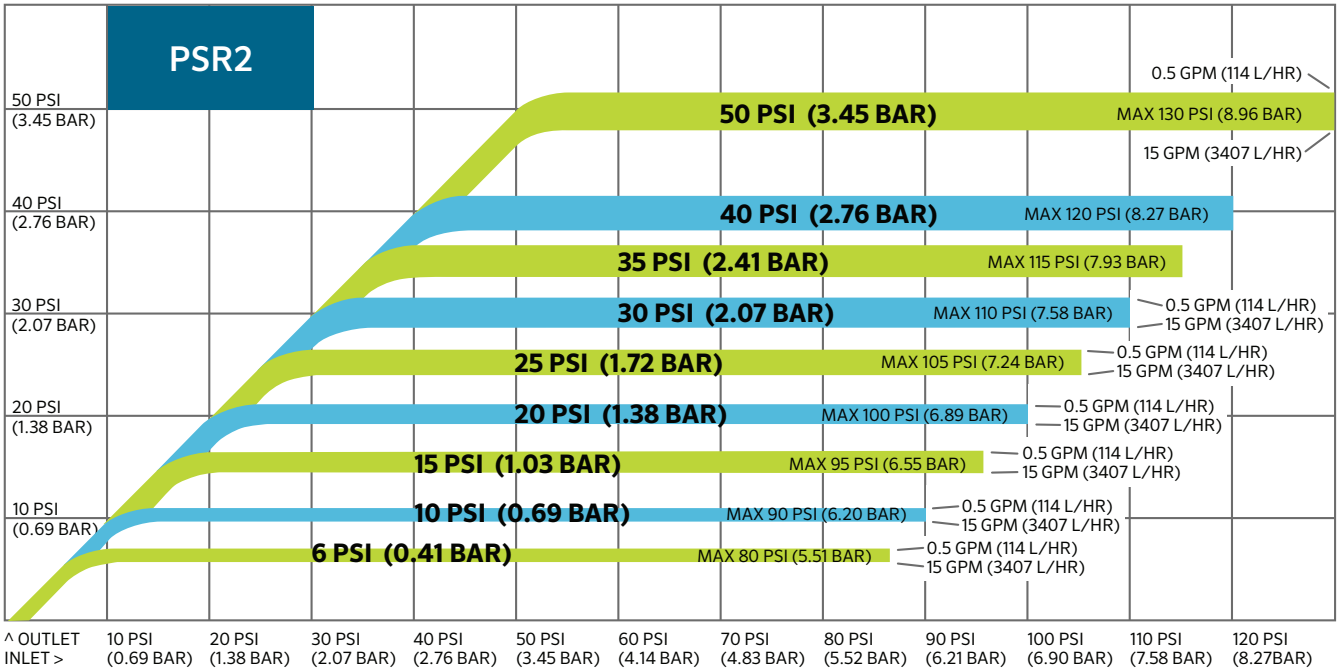
PSR™2 PIVOT SPECIAL REGULATOR

PSR2 MODELS	Description	Preset Outlet Pressure	Maximum Inlet Pressure	Flow Range
PSR2063F3F	6 psi, inlet ¾" F NPT, outlet ¾" F NPT	6 psi (0.41 bar)	80 psi (5.51 bar)	0.5 - 15 gpm (114 - 3407 L/hr)
PSR2103F3F	10 psi, inlet ¾" F NPT, outlet ¾" F NPT	10 psi (0.69 bar)	90 psi (6.20 bar)	0.5 - 15 gpm (114 - 3407 L/hr)
PSR2123F3F	12 psi, inlet ¾" F NPT, outlet ¾" F NPT	12 psi (0.83 bar)	90 psi (6.20 bar)	0.5 - 15 gpm (114 - 3407 L/hr)
PSR2153F3F	15 psi, inlet ¾" F NPT, outlet ¾" F NPT	15 psi (1.03 bar)	95 psi (6.55 bar)	0.5 - 15 gpm (114 - 3407 L/hr)
PSR2203F3F	20 psi, inlet ¾" F NPT, outlet ¾" F NPT	20 psi (1.38 bar)	100 psi (6.89 bar)	0.5 - 15 gpm (114 - 3407 L/hr)
PSR2253F3F	25 psi, inlet ¾" F NPT, outlet ¾" F NPT	25 psi (1.72 bar)	105 psi (7.24 bar)	0.5 - 15 gpm (114 - 3407 L/hr)
PSR2303F3F	30 psi, inlet ¾" F NPT, outlet ¾" F NPT	30 psi (2.07 bar)	110 psi (7.58 bar)	0.5 - 15 gpm (114 - 3407 L/hr)
PSR2353F3F	35 psi, inlet ¾" F NPT, outlet ¾" F NPT	35 psi (2.41 bar)	115 psi (7.93 bar)	0.5 - 15 gpm (114 - 3407 L/hr)
PSR2403F3F	40 psi, inlet ¾" F NPT, outlet ¾" F NPT	40 psi (2.76 bar)	120 psi (8.27 bar)	0.5 - 15 gpm (114 - 3407 L/hr)
PSR2503F3F	50 psi, inlet ¾" F NPT, outlet ¾" F NPT	50 psi (3.45 bar)	130 psi (8.96 bar)	0.5 - 15 gpm (114 - 3407 L/hr)

The pressure regulator shall maintain the predetermined pressure provided that the inlet pressure is at least 5 psi (0.34 bar) above the expected outlet pressure, but not exceeding the maximum inlet pressure as shown in this chart.

Pressure regulators should always be installed downstream of all shut-off valves.

Recommended for outdoor use only. Not NSF certified.



Every pressure regulator is designed to operate at a minimum and maximum inlet pressure and a predetermined flow range. This regulator performance curve illustrates how the PSR2 will perform within the range of inlet pressures and flows.

The Y-axis shows outlet pressure, and the X-axis shows inlet pressure. In this chart, the band for the 30 psi (2.07 bar) model shows the performance at various flows. At the lowest flow (0.5 gpm or 114 L/hr), the regulator will maintain an actual outlet pressure slightly higher than 30 psi (2.07 bar). In contrast, at the highest flow (15 gpm or 3407 L/hr), the actual outlet pressure will be slightly lower than 30 psi (2.07 bar).*

**Source: Rogers, Shaw, Pragada, & Alam, 2010.*



FILTER REGULATOR

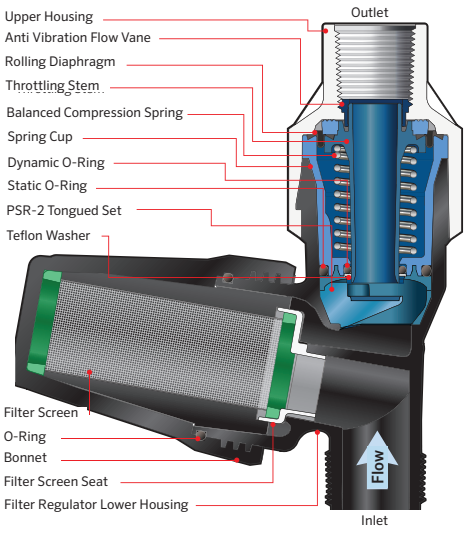


The Senninger® Filter Regulator combines filtration and pressure regulation into one device for installation convenience. Combining PSR™2 performance with reduced nozzle clogging provides a solution for overall efficiency of an irrigation system.

Product Specs	
Flow	0.5 - 15 gpm (114 - 3407 L/hr)
Pressure	6 - 20 psi (0.41 - 1.38 bar)

FEATURES

- Maintains a constant preset outlet pressure while handling varying inlet pressures
- Quality field proven PSR2 internal components
- Easy access to mesh screens with a twist of the bonnet; no tools required; no need to dismantle the drop assembly
- Convenient installation above the sprinkler
- Inlet size: ¾" male NPT
- Outlet size: ¾" female NPT
- Models available: 6 psi (0.41 bar), 10 psi (0.69 bar), 15 psi (1.03 bar), and 20 psi (1.38 bar)
- Pressure-tested for accuracy
- Two-year warranty on materials, workmanship, and performance



Screen Models	Description	Screen Mesh Orifice (microns)
FPSR220SCREEN	Filter PSR2, 20 mesh screen, **black rings**	841
FPSR230SCREEN	Filter PSR2, 30 mesh screen, **green rings**	595
FPSR240SCREEN	Filter PSR2, 40 mesh screen, **grey rings**	400
FPSR2120SCREEN	Filter PSR2, 120 mesh screen, **red rings**	125
FPSR2140SCREEN	Filter PSR2, 140 mesh screen, **blue rings**	105



Shaded models designed for use with drip systems.

Color-coded stickers available for the outer bonnet to assist installers in matching the mesh size to the correct nozzle.

Easy in-field maintenance to exchange installed filter screens for new or cleaned screens. Clean screens for reinstallation during the next scheduled maintenance cycle.

FILTER REGULATOR

FILTER REGULATOR MODELS	Description	Mesh Orifice (microns)	UP3 Nozzle Numbers	Preset Outlet Pressure	Maximum Inlet Pressure
FPSR2063M3F20	6 psi, Filter PSR2, ¾" M NPT x ¾" F NPT, **20 mesh screen**	841	#13 - #26	6 psi (0.41 bar)	80 psi (5.51 bar)
FPSR2063M3F30	6 psi, Filter PSR2, ¾" M NPT x ¾" F NPT, **30 mesh screen**	595	#6 - #12.5		
FPSR2063M3F40	6 psi, Filter PSR2, ¾" M NPT x ¾" F NPT, **40 mesh screen**	400	#2 - #5.5		
FPSR2103M3F20	10 psi, Filter PSR2, ¾" M NPT x ¾" F NPT, **20 mesh screen**	841	#13 - #26	10 psi (0.69 bar)	90 psi (6.20 bar)
FPSR2103M3F30	10 psi, Filter PSR2, ¾" M NPT x ¾" F NPT, **30 mesh screen**	595	#6 - #12.5		
FPSR2103M3F40	10 psi, Filter PSR2, ¾" M NPT x ¾" F NPT, **40 mesh screen**	400	#2 - #5.5		
FPSR2153M3F20	15 psi, Filter PSR2, ¾" M NPT x ¾" F NPT, **20 mesh screen**	841	#13 - #26	15 psi (1.03 bar)	95 psi (6.55 bar)
FPSR2153M3F30	15 psi, Filter PSR2, ¾" M NPT x ¾" F NPT, **30 mesh screen**	595	#6 - #12.5		
FPSR2153M3F40	15 psi, Filter PSR2, ¾" M NPT x ¾" F NPT, **40 mesh screen**	400	#2 - #5.5		
FPSR2203M3F20	20 psi, Filter PSR2, ¾" M NPT x ¾" F NPT, **20 mesh screen**	841	#13 - #26	20 psi (1.38 bar)	100 psi (6.89 bar)
FPSR2203M3F30	20 psi, Filter PSR2, ¾" M NPT x ¾" F NPT, **30 mesh screen**	595	#6 - #12.5		
FPSR2203M3F40	20 psi, Filter PSR2, ¾" M NPT x ¾" F NPT, **40 mesh screen**	400	#2 - #5.5		

FPSR2103M3F120	10 psi, Filter PSR2, ¾" M NPT x ¾" F NPT, **120 mesh screen**	125	0.5 - 15 gpm (114 - 3407 L/hr)	10 psi (0.69 bar)	90 psi (6.20 bar)
FPSR2103M3F140	10 psi, Filter PSR2, ¾" M NPT x ¾" F NPT, **140 mesh screen**	105			
FPSR2153M3F120	15 psi, Filter PSR2, ¾" M NPT x ¾" F NPT, **120 mesh screen**	125	0.5 - 15 gpm (114 - 3407 L/hr)	15 psi (1.03 bar)	95 psi (6.55 bar)
FPSR2153M3F140	15 psi, Filter PSR2, ¾" M NPT x ¾" F NPT, **140 mesh screen**	105			
FPSR2203M3F120	20 psi, Filter PSR2, ¾" M NPT x ¾" F NPT, **120 mesh screen**	125	0.5 - 15 gpm (114 - 3407 L/hr)	20 psi (1.38 bar)	100 psi (6.89 bar)
FPSR2203M3F140	20 psi, Filter PSR2, ¾" M NPT x ¾" F NPT, **140 mesh screen**	105			

Shaded models designed for use with drip systems.

The pressure regulator shall maintain the predetermined operating pressure provided that the inlet pressure is at least 5 psi (0.34 bar) above the expected outlet pressure, with flows up to 11 gpm (2498 L/hr), but not exceeding the maximum inlet pressure as shown above. Higher flows require additional inlet pressure to engage the regulator. Where flows are greater than 11 gpm (2498 L/hr), the inlet pressure should be at least 9 psi (0.62 bar) above the expected outlet pressure but not exceeding the maximum inlet pressure as shown above.

Pressure regulators should always be installed downstream of all shut-off valves.

Recommended for outdoor use only. Not NSF certified.



PMR-MF PRESSURE-MASTER REGULATOR™ MEDIUM FLOW

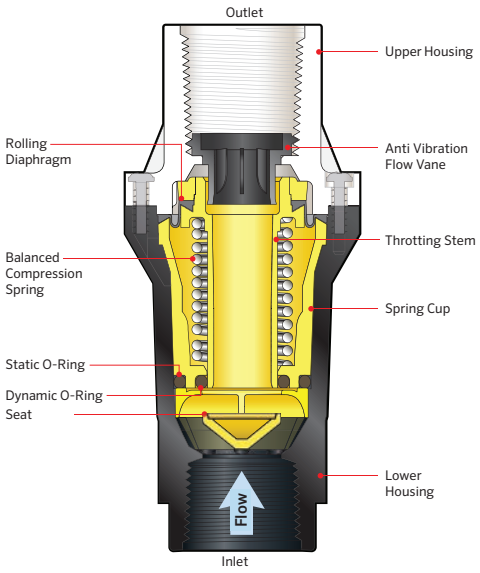


The Senninger® PMR-MF (Pressure-Master Regulator™ Medium Flow) is ideal for installations requiring mid-range flows. It can be installed above or below ground and is used in solid set, drip and low volume systems as well as on center pivots.

Product Specs	
Flow	2 - 20 gpm (454 - 4542 L/hr)
Pressure	6 - 60 psi (0.41 - 4.14 bar)

FEATURES

- Maintains a constant preset outlet pressure while handling varying inlet pressures
- Inlet sizes: ¾" female NPT, 1" female NPT, and 1" female BSPT
- Outlet size: ¾" female NPT, 1" female NPT, and 1" female BSPT
- Models available: 6 psi (0.41 bar), 10 psi (0.69 bar), 12 psi (0.83 bar), 15 psi (1.03 bar), 20 psi (1.38 bar), 25 psi (1.72 bar), 30 psi (2.07 bar), 35 psi (2.41 bar), 40 psi (2.76 bar), 50 psi (3.45 bar), and 60 psi (4.14 bar)
- Very low hysteresis and friction losses
- Pressure-tested for accuracy
- Two-year warranty on materials, workmanship, and performance.



WARNING:

DO NOT DISASSEMBLE the Pressure-Master Regulator Medium Flow. Each PMR-MF contains a compressed spring which could cause personal injury if released. Please have the dealer return PMR-MF regulators to factory for repair.

PMR-MF PRESSURE-MASTER REGULATOR™ MEDIUM FLOW

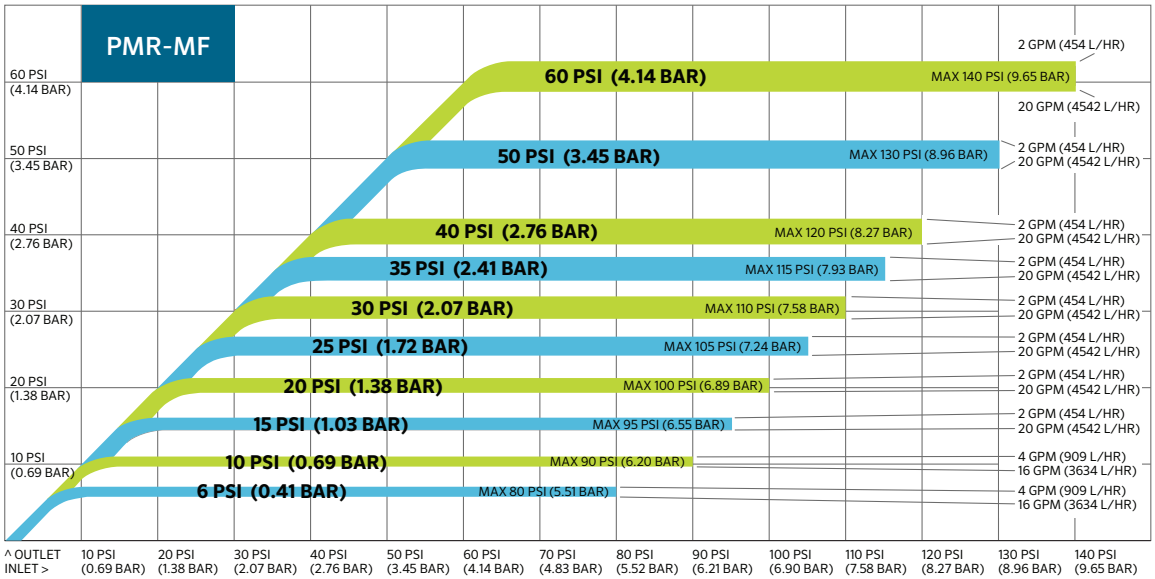
PMR-MF MODELS	Description	Preset Outlet Pressure	Maximum Inlet Pressure	Flow Range
PMR06MF3F3FV	6 psi, inlet ¾" F NPT, outlet ¾" F NPT w/ vane	6 psi (0.41 bar)	80 psi (5.51 bar)	4 - 16 gpm (909 - 3634 L/hr)
PMR10MF3F3FV	10 psi, inlet ¾" F NPT, outlet ¾" F NPT w/ vane	10 psi (0.69 bar)	90 psi (6.20 bar)	4 - 16 gpm (909 - 3634 L/hr)
PMR12MF3F3FV	12 psi, inlet ¾" F NPT, outlet ¾" F NPT w/ vane	12 psi (0.83 bar)	90 psi (6.20 bar)	2 - 20 gpm (454 - 4542 L/hr)
PMR15MF3F3FV	15 psi, inlet ¾" F NPT, outlet ¾" F NPT w/ vane	15 psi (1.03 bar)	95 psi (6.55 bar)	2 - 20 gpm (454 - 4542 L/hr)
PMR20MF3F3FV	20 psi, inlet ¾" F NPT, outlet ¾" F NPT w/ vane	20 psi (1.38 bar)	100 psi (6.89 bar)	2 - 20 gpm (454 - 4542 L/hr)
PMR25MF3F3FV	25 psi, inlet ¾" F NPT, outlet ¾" F NPT w/ vane	25 psi (1.72 bar)	105 psi (7.24 bar)	2 - 20 gpm (454 - 4542 L/hr)
PMR30MF3F3FV	30 psi, inlet ¾" F NPT, outlet ¾" F NPT w/ vane	30 psi (2.07 bar)	110 psi (7.58 bar)	2 - 20 gpm (454 - 4542 L/hr)
PMR35MF3F3FV	35 psi, inlet ¾" F NPT, outlet ¾" F NPT w/ vane	35 psi (2.41 bar)	115 psi (7.93 bar)	2 - 20 gpm (454 - 4542 L/hr)
PMR40MF3F3FV	40 psi, inlet ¾" F NPT, outlet ¾" F NPT w/ vane	40 psi (2.76 bar)	120 psi (8.27 bar)	2 - 20 gpm (454 - 4543 L/hr)
PMR50MF3F3FV	50 psi, inlet ¾" F NPT, outlet ¾" F NPT w/ vane	50 psi (3.45 bar)	130 psi (8.96 bar)	2 - 20 gpm (454 - 4542 L/hr)
PMR60MF3F3FV	60 psi, inlet ¾" F NPT, outlet ¾" F NPT w/ vane	60 psi (4.14 bar)	140 psi (9.65 bar)	2 - 20 gpm (454 - 4542 L/hr)

For 1" F NPT x 1" F NPT connection model, use this part number replacing xx with Preset Outlet Pressure above - **PMRxxMF4F4FV**
For 1" F BSPT x 1" F BSPT connection model, use this part number replacing xx with Preset Outlet Pressure above - **PMRxxMF4FB4FBV**

The pressure regulator shall maintain the predetermined pressure provided that the inlet pressure is at least 5 psi (0.34 bar) above the expected outlet pressure, but not exceeding the maximum inlet pressure as shown in this chart.

Pressure regulators should always be installed downstream of all shut-off valves.

Recommended for outdoor use only. Not NSF certified.



Every pressure regulator is designed to operate at a minimum and maximum inlet pressure and a predetermined flow range. This regulator performance curve illustrates how the PMR-MF will perform within the range of inlet pressures and flows.

The Y-axis shows outlet pressure, and the X-axis shows inlet pressure. In this chart, the band for the 30 psi (2.07 bar) model shows the performance at various flows. At the lowest flow (4 gpm or 909 L/hr), the regulator will maintain an actual outlet pressure slightly higher than 30 psi (2.07 bar). In contrast, at the highest flow (16 gpm or 3634 L/hr), the actual outlet pressure will be slightly lower than 30 psi (2.07 bar).*

**Source: Rogers, Shaw, Pragada, & Alam, 2010.*



PR-HF PRESSURE REGULATOR HIGH FLOW

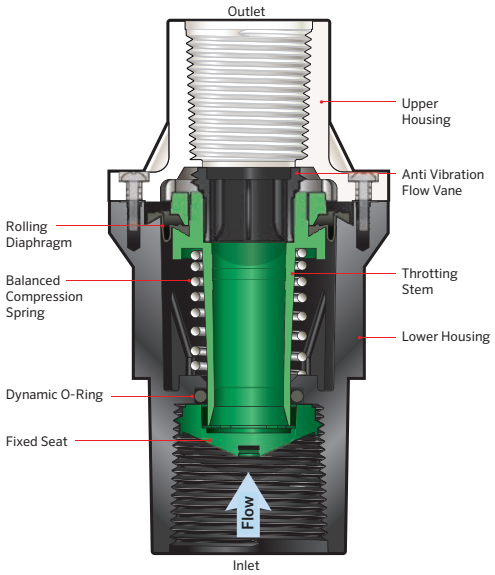


The Senninger® PR-HF (Pressure Regulator High Flow) is ideal for installations requiring higher flows. It can be installed above or below ground and is used in solid set, drip and low volume systems.

Product Specs	
Flow	10 - 32 gpm (2271 - 7268 L/hr)
Pressure	10 - 50 psi (0.69 - 3.45 bar)

FEATURES

- Maintains a constant preset outlet pressure while handling varying inlet pressures
- Inlet sizes: 1 ¼" female NPT and 1 ¼" female BSPT
- Outlet sizes: 1" female NPT, 1" female BSPT, 1 ¼" female NPT and 1 ¼" female BSPT
- Models available: 10 psi (0.69 bar), 15 psi (1.03 bar), 20 psi (1.38 bar), 25 psi (1.72 bar), 30 psi (2.07 bar), 40 psi (2.76 bar), and 50 psi (3.45 bar)
- Very low hysteresis and friction losses
- Pressure-tested for accuracy
- Two-year warranty on materials, workmanship, and performance



WARNING:

DO NOT DISASSEMBLE the Pressure Regulator High Flow. Each PR-HF contains a compressed spring which could cause personal injury if released. Please have the dealer return PR-HF regulators to factory for repair.

PR-HF PRESSURE REGULATOR HIGH FLOW

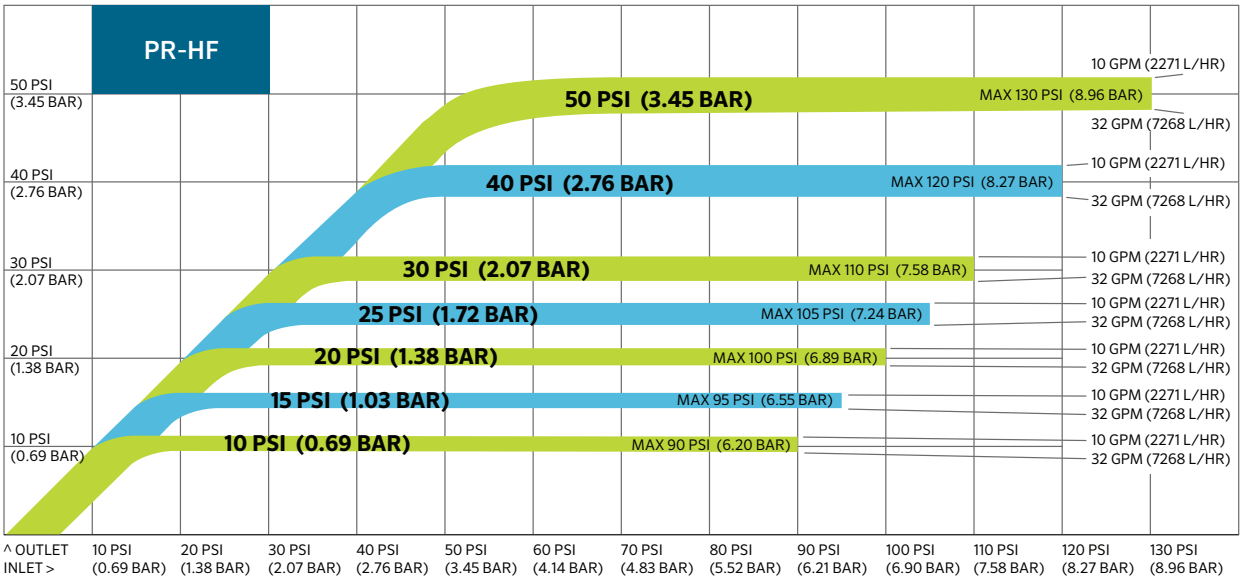
PR-HF MODELS	Description	Preset Outlet Pressure	Maximum Inlet Pressure	Flow Range
PR10HF5F4FV	10 psi, inlet 1 ¼" F NPT, outlet 1" F NPT	10 psi (0.69 bar)	90 psi (6.20 bar)	10 - 32 gpm (2271 - 7268 L/hr)
PR15HF5F4FV	15 psi, inlet 1 ¼" F NPT, outlet 1" F NPT	15 psi (1.03 bar)	95 psi (6.55 bar)	10 - 32 gpm (2271 - 7268 L/hr)
PR20HF5F4FV	20 psi, inlet 1 ¼" F NPT, outlet 1" F NPT	20 psi (1.38 bar)	100 psi (6.89 bar)	10 - 32 gpm (2271 - 7268 L/hr)
PR25HF5F4FV	25 psi, inlet 1 ¼" F NPT, outlet 1" F NPT	25 psi (1.72 bar)	105 psi (7.24 bar)	10 - 32 gpm (2271 - 7268 L/hr)
PR30HF5F4FV	30 psi, inlet 1 ¼" F NPT, outlet 1" F NPT	30 psi (2.07 bar)	110 psi (7.58 bar)	10 - 32 gpm (2271 - 7268 L/hr)
PR40HF5F4FV	40 psi, inlet 1 ¼" F NPT, outlet 1" F NPT	40 psi (2.76 bar)	120 psi (8.27 bar)	10 - 32 gpm (2271 - 7268 L/hr)
PR50HF5F4FV	50 psi, inlet 1 ¼" F NPT, outlet 1" F NPT	50 psi (3.45 bar)	130 psi (8.96 bar)	10 - 32 gpm (2271 - 7268 L/hr)

For 1 ¼" F NPT x 1 ¼" F NPT connection model, use this part number replacing xx with Preset Outlet Pressure above - **PRxxHF5F5FV**
For 1 ¼" F BSPT x 1" F BSPT connection model, use this part number replacing xx with Preset Outlet Pressure above - **PRxxHF5FB4FBV**
For 1 ¼" F BSPT x 1 ¼" F BSPT connection model, use this part number replacing xx with Preset Outlet Pressure above - **PRxxHF5FB5FBV**

The pressure regulator shall maintain the predetermined pressure provided that the inlet pressure is at least 5 psi (0.34 bar) above the expected outlet pressure, but not exceeding the maximum inlet pressure as shown in this chart.

Pressure regulators should always be installed downstream of all shut-off valves.

Recommended for outdoor use only. Not NSF certified.



Every pressure regulator is designed to operate at a minimum and maximum inlet pressure and a predetermined flow range. This regulator performance curve illustrates how the PR-HF will perform within the range of inlet pressures and flows.

The Y-axis shows outlet pressure, and the X-axis shows inlet pressure. In this chart, the band for the 30 psi (2.07 bar) model shows the performance at various flows. At the lowest flow (10 gpm or 2271 L/hr), the regulator will maintain an actual outlet pressure slightly higher than 30 psi (2.07 bar). In contrast, at the highest flow (32 gpm or 7268 L/hr), the actual outlet pressure will be slightly lower than 30 psi (2.07 bar).*

**Source: Rogers, Shaw, Pragada, & Alam, 2010.*



PRU PRESSURE REGULATOR ULTRA

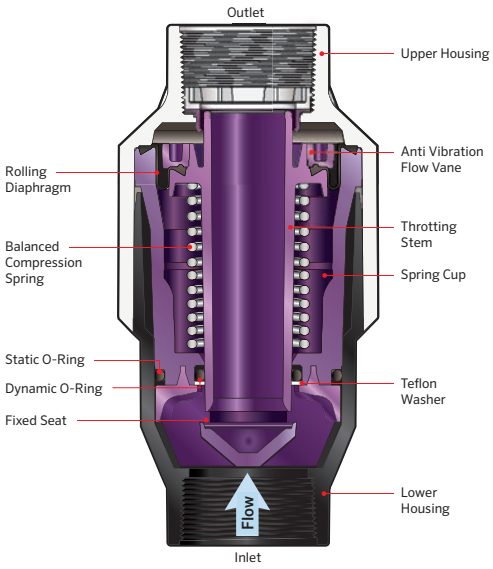


The Senninger® PRU (Pressure Regulator Ultra) was designed to handle higher flows. Its 2-inch inlet and outlet size make it an ideal option for accurate zone and individual sprinkler pressure control. Its compact size fits in a valve box.

Product Specs	
Flow	20 - 100 gpm (4542 - 22713 L/hr)
Pressure	10 - 60 psi (0.69 - 4.14 bar)

FEATURES

- Maintains a constant preset outlet pressure while handling varying inlet pressures
- Inlet sizes: 2" female NPT and 2" female BSPT
- Outlet size: 2" female NPT and 2" female BSPT
- Models available: 10 psi (0.69 bar), 15 psi (1.03 bar), 20 psi (1.38 bar), 25 psi (1.72 bar), 30 psi (2.07 bar), 40 psi (2.76 bar), 50 psi (3.45 bar), and 60 psi (4.14 bar)
- Very low hysteresis and friction losses
- Pressure-tested for accuracy
- Two-year warranty on materials, workmanship, and performance



PRU PRESSURE REGULATOR ULTRA

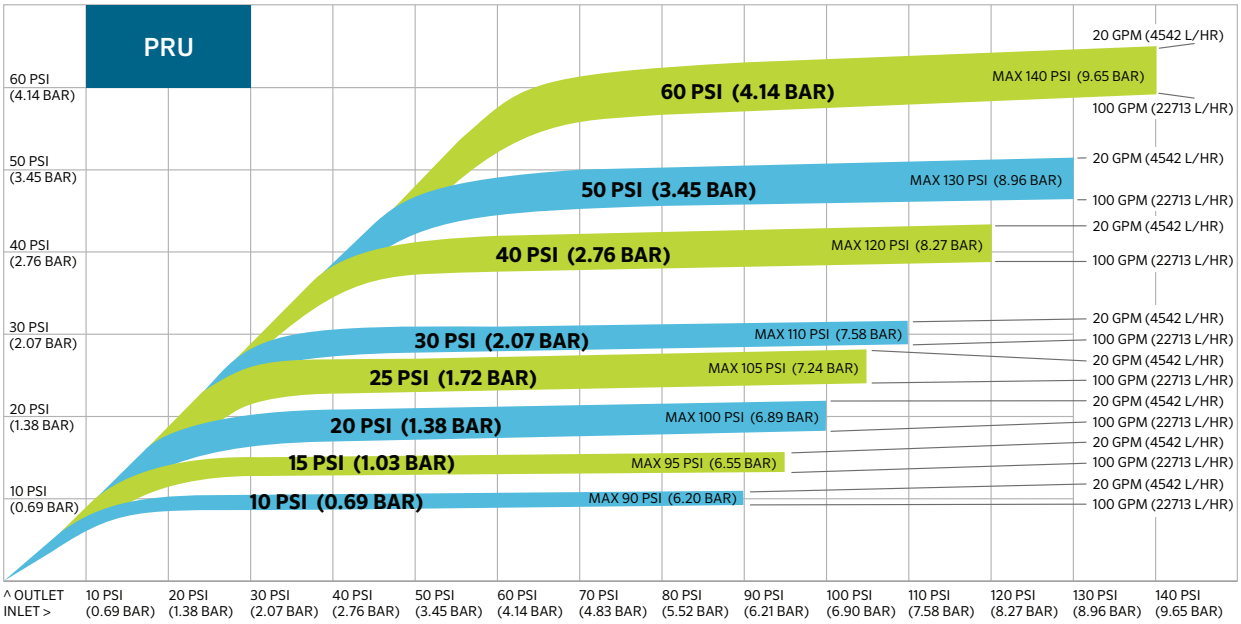
PRU MODELS	Description	Preset Outlet Pressure	Maximum Inlet Pressure	Flow Range
PRU108F8F	10 psi, inlet 2" F NPT, outlet 2" F NPT	10 psi (0.69 bar)	90 psi (6.20 bar)	20 - 100 gpm (4542 - 22713 L/hr)
PRU158F8F	15 psi, inlet 2" F NPT, outlet 2" F NPT	15 psi (1.03 bar)	95 psi (6.55 bar)	20 - 100 gpm (4542 - 22713 L/hr)
PRU208F8F	20 psi, inlet 2" F NPT, outlet 2" F NPT	20 psi (1.38 bar)	100 psi (6.89 bar)	20 - 100 gpm (4542 - 22713 L/hr)
PRU258F8F	25 psi, inlet 2" F NPT, outlet 2" F NPT	25 psi (1.72 bar)	105 psi (7.24 bar)	20 - 100 gpm (4542 - 22713 L/hr)
PRU308F8F	30 psi, inlet 2" F NPT, outlet 2" F NPT	30 psi (2.07 bar)	110 psi (7.58 bar)	20 - 100 gpm (4542 - 22713 L/hr)
PRU408F8F	40 psi, inlet 2" F NPT, outlet 2" F NPT	40 psi (2.76 bar)	120 psi (8.27 bar)	20 - 100 gpm (4542 - 22713 L/hr)
PRU508F8F	50 psi, inlet 2" F NPT, outlet 2" F NPT	50 psi (3.45 bar)	130 psi (8.96 bar)	20 - 100 gpm (4542 - 22713 L/hr)
PRU608F8F	60 psi, inlet 2" F NPT, outlet 2" F NPT	60 psi (4.14 bar)	140 psi (9.65 bar)	20 - 100 gpm (4542 - 22713 L/hr)

For 2" F BSPT x 2" F BSPT connection model, use this part number replacing xx with Preset Outlet Pressure above - **PRUxx8FB8FBV**

The pressure regulator shall maintain the predetermined pressure provided that the inlet pressure is at least 5 psi (0.34 bar) above the expected outlet pressure, but not exceeding the maximum inlet pressure as shown in this chart.

Pressure regulators should always be installed downstream of all shut-off valves.

Recommended for outdoor use only. Not NSF certified.



Every pressure regulator is designed to operate at a minimum and maximum inlet pressure and a predetermined flow range. This regulator performance curve illustrates how the PRU will perform within the range of inlet pressures and flows.

The Y-axis shows outlet pressure, and the X-axis shows inlet pressure. In this chart, the band for the 30 psi (2.07 bar) model shows the performance at various flows. At the lowest flow (20 gpm or 4542 L/hr), the regulator will maintain an actual outlet pressure slightly higher than 30 psi (2.07 bar). In contrast, at the highest flow (100 gpm or 22713 L/hr), the actual outlet pressure will be slightly lower than 30 psi (2.07 bar).*

**Source: Rogers, Shaw, Pragada, & Alam, 2010.*



PRLV PRESSURE REGULATING LIMIT VALVE

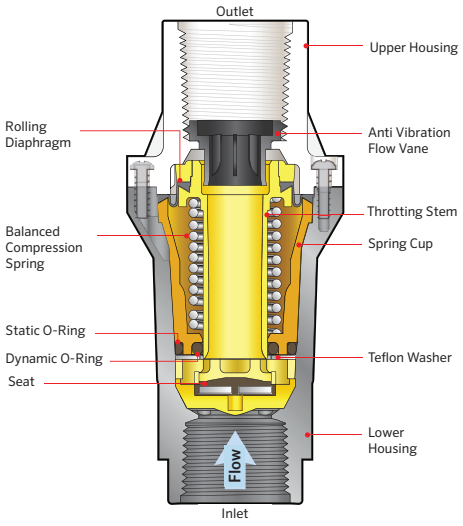


The Senninger® PRLV (Pressure Regulating Limit Valve) is designed to be used in place of a standard water pressure regulator to limit static (no flow) water pressure when a shut-off valve is used downstream from the regulation point.

Product Specs	
Flow	up to 18 gpm (up to 4088 L/hr)
Pressure	10 - 60 psi (0.69 - 4.14 bar)

FEATURES

- Limits downstream pressure to no more than 15 psi (1.03 bar) above regulated pressure rating during static (no flow) conditions
- Inlet sizes: ¾" female NPT and 1" female NPT
- Outlet size: ¾" female NPT and 1" female NPT
- Models available: 10 psi (0.69 bar), 15 psi (1.03 bar), 20 psi (1.38 bar), 30 psi (2.07 bar), 40 psi (2.76 bar), 50 psi (3.45 bar), and 60 psi (4.14 bar)
- Very low hysteresis and friction losses
- Pressure-tested for accuracy
- One-year warranty on materials, workmanship, and performance



DESIGN NOTES

Because the Pressure Regulating Limit Valve is designed to operate with clean water, the use of a filter upstream of all PRLV's is recommended. Filters should be 100 mesh or finer and be capable of flowing up to 15 gpm (3407 L/hr) with no more than 5 psi (0.34 bar) internal friction loss.

If all shutoff valves are upstream from the point of regulation, then the use of a Senninger Pressure Regulator is recommended instead of a PRLV.

WARNING:

DO NOT DISASSEMBLE the Pressure Regulating Limit Valve. Each PRLV contains a compressed spring which could cause personal injury if released. Please have the dealer return PRLV valves to factory for repair.

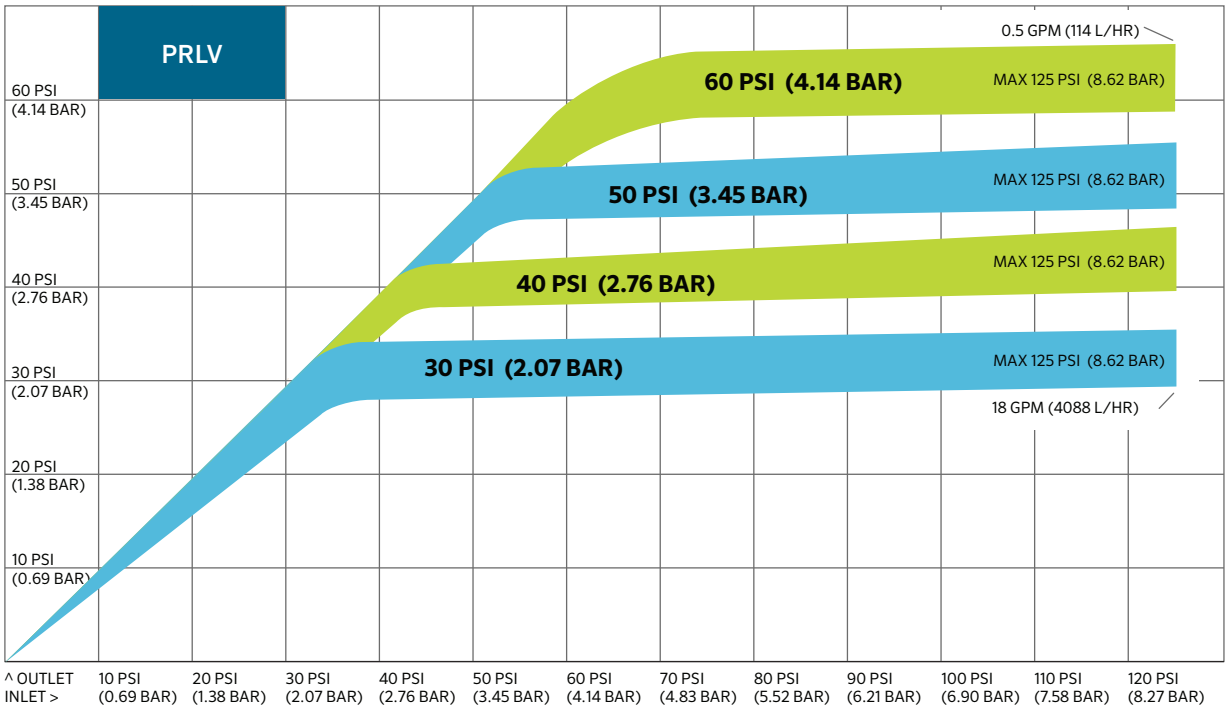
PRLV PRESSURE REGULATING LIMIT VALVE

PRLV MODELS	Description	Preset Outlet Pressure	Maximum Inlet Pressure	Flow Range
PRLV10MF3F3FV	10 psi, inlet ¾" F NPT, outlet ¾" F NPT	10 psi (0.69 bar)	125 psi (8.62 bar)	up to 18 gpm (up to 4088 L/hr)
PRLV15MF3F3FV	15 psi, inlet ¾" F NPT, outlet ¾" F NPT	15 psi (1.03 bar)	125 psi (8.62 bar)	up to 18 gpm (up to 4088 L/hr)
PRLV20MF3F3FV	20 psi, inlet ¾" F NPT, outlet ¾" F NPT	20 psi (1.38 bar)	125 psi (8.62 bar)	up to 18 gpm (up to 4088 L/hr)
PRLV30MF3F3FV	30 psi, inlet ¾" F NPT, outlet ¾" F NPT	30 psi (2.07 bar)	125 psi (8.62 bar)	up to 18 gpm (up to 4088 L/hr)
PRLV40MF3F3FV	40 psi, inlet ¾" F NPT, outlet ¾" F NPT	40 psi (2.76 bar)	125 psi (8.62 bar)	up to 18 gpm (up to 4088 L/hr)
PRLV50MF3F3FV	50 psi, inlet ¾" F NPT, outlet ¾" F NPT	50 psi (3.45 bar)	125 psi (8.62 bar)	up to 18 gpm (up to 4088 L/hr)
PRLV60MF3F3FV	60 psi, inlet ¾" F NPT, outlet ¾" F NPT	60 psi (4.14 bar)	125 psi (8.62 bar)	up to 18 gpm (up to 4088 L/hr)

For 1" F NPT x 1" F NPT connection model, use this part number replacing xx with Preset Outlet Pressure above - **PRLVxxMF4F4FV**

The PRLV limits downstream pressure to no more than 15 psi (1.03 bar) above regulated pressure during static (no flow) conditions.

Recommended for outdoor use only. Not NSF certified.



Every pressure regulating limit vavle is designed to operate at a minimum and maximum inlet pressure and a predetermined flow range. This regulation performance curve illustrates how the PRLV will perform within the range of inlet pressures and flows.

The Y-axis shows outlet pressure, and the X-axis shows inlet pressure. In this chart, the band for the 30 psi (2.07 bar) model shows the performance at various flows. At the lowest flow (0.5 gpm or 114 L/hr), the regulator will maintain an actual outlet pressure slightly higher than 30 psi (2.07 bar). In contrast, at the highest flow (18 gpm or 4088 L/hr), the actual outlet pressure will be slightly lower than 30 psi (2.07 bar).*

**Source: Rogers, Shaw, Pragada, & Alam, 2010.*



PRU-LV PRESSURE REGULATING ULTRA LIMIT VALVE

NEW

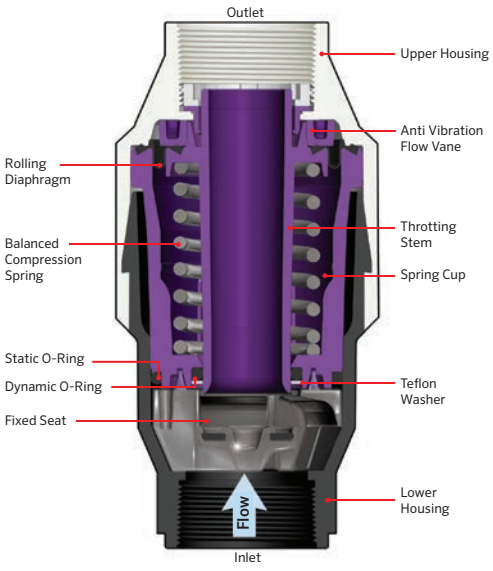


The Senninger® PRU-LV is the only in-line regulator that quickly and effectively controls pressures above recommended levels in both dynamic (with flow) and static (no flow) conditions.

Product Specs	
Flow	up to 100 gpm (up to 22713 L/hr)
Pressure	10 - 60 psi (0.69 - 4.14 bar)

FEATURES

- Limits downstream pressure to no more than 15 psi (1.03 bar) above regulated pressure rating during static (no flow) conditions
- Inlet sizes: 2" female NPT and 2" female BSPT
- Outlet size: 2" female NPT and 2" female BSPT
- Models available: 10 psi (0.69 bar), 15 psi (1.03 bar), 20 psi (1.38 bar), 25 psi (1.72 bar), 30 psi (2.07 bar), 40 psi (2.76 bar), 50 psi (3.45 bar), and 60 psi (4.14 bar)
- Very low hysteresis and friction losses
- Pressure-tested for accuracy
- One-year warranty on materials, workmanship, and performance



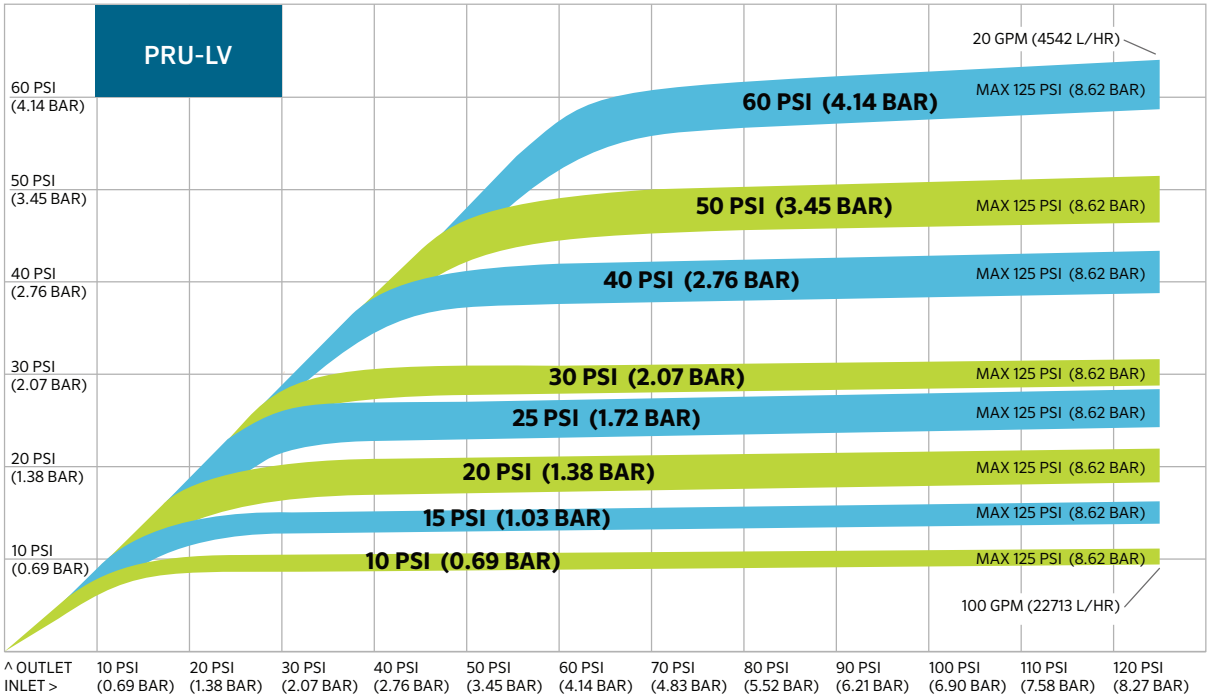
PRU-LV PRESSURE REGULATING ULTRA LIMIT VALVE

PRU MODELS	Description	Preset Outlet Pressure	Maximum Inlet Pressure	Flow Range
PRULV108F8F	10 psi, inlet 2" F NPT, outlet 2" F NPT	10 psi (0.69 bar)	125 psi (8.62 bar)	up to 100 gpm (up to 22713 L/hr)
PRULV158F8F	15 psi, inlet 2" F NPT, outlet 2" F NPT	15 psi (1.03 bar)	125 psi (8.62 bar)	up to 100 gpm (up to 22713 L/hr)
PRULV208F8F	20 psi, inlet 2" F NPT, outlet 2" F NPT	20 psi (1.38 bar)	125 psi (8.62 bar)	up to 100 gpm (up to 22713 L/hr)
PRULV258F8F	25 psi, inlet 2" F NPT, outlet 2" F NPT	25 psi (1.72 bar)	125 psi (8.62 bar)	up to 100 gpm (up to 22713 L/hr)
PRULV308F8F	30 psi, inlet 2" F NPT, outlet 2" F NPT	30 psi (2.07 bar)	125 psi (8.62 bar)	up to 100 gpm (up to 22713 L/hr)
PRULV408F8F	40 psi, inlet 2" F NPT, outlet 2" F NPT	40 psi (2.76 bar)	125 psi (8.62 bar)	up to 100 gpm (up to 22713 L/hr)
PRULV508F8F	50 psi, inlet 2" F NPT, outlet 2" F NPT	50 psi (3.45 bar)	125 psi (8.62 bar)	up to 100 gpm (up to 22713 L/hr)
PRULV608F8F	60 psi, inlet 2" F NPT, outlet 2" F NPT	60 psi (4.14 bar)	125 psi (8.62 bar)	up to 100 gpm (up to 22713 L/hr)

For 2" F BSPT x 2" F BSPT connection model, use this part number replacing xx with Preset Outlet Pressure above - **PRULVxx8FB8FBV**

The PRU-LV limits downstream pressure to no more than 15 psi (1.03 bar) above regulated pressure during static (no flow) conditions.

Recommended for outdoor use only. Not NSF certified.



Every pressure regulator is designed to operate at a minimum and maximum inlet pressure and a predetermined flow range. This regulator performance curve illustrates how the PRU-LV will perform within the range of inlet pressures and flows.

The Y-axis shows outlet pressure, and the X-axis shows inlet pressure. In this chart, the band for the 30 psi (2.07 bar) model shows the performance at various flows. At the lowest flow (20 gpm or 4542 L/hr), the regulator will maintain an actual outlet pressure slightly higher than 30 psi (2.07 bar). In contrast, at the highest flow (100 gpm or 22713 L/hr), the actual outlet pressure will be slightly lower than 30 psi (2.07 bar).*

**Source: Rogers, Shaw, Pragada, & Alam, 2010.*

Hunter® | Agricultural Irrigation

At Hunter® Agricultural Irrigation, our commitment is to continue developing world-class Senninger® irrigation products and providing local support and technical expertise. This results in the most efficient and reliable agricultural irrigation solutions available today.



Steve Abernethy, President of Hunter Agricultural Irrigation

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Appendix J – Water Reuse Plan

Christmas Tree Park

Two baseball diamonds being irrigated with a total of 0.065 MGD (55 gpm).

Three sprinklers per diamond discharging 9.2 gpm per sprinkler.

Remaining open space being irrigated with a total 0.065 MGD there (55 gpm).

Four sprinklers discharging 13.75 gpm per sprinkler.

Monitoring wells 1 through 5 are installed for downstream groundwater monitoring.

Monitoring wells 6 and 7 are installed for upstream groundwater monitoring. These are at a higher elevation than sprinkler system.

MVHS

A total of 0.13 MGD (110 gpm) discharged to irrigate two baseball diamonds, a football field, a track field, and additional green space.

10 sprinklers discharging 11 gpm per sprinkler.

Monitoring wells 8, 9, 11 and 12 are installed for downstream groundwater monitoring.

Monitoring wells 10 and 13 are installed for upstream groundwater monitoring. These are at a higher elevation than sprinkler system.

In total, the sprinkler system will require 20 PMR-MF sprinklers priced at $20.85.



A&E Consulting

Water Reuse System

N

0 215 430 Feet

Manchester WWTP
Enhanced Nutrient Removal
Manchester, MD

Legend

- Sprinklers
- Monitoring Wells (MW)
- Manchester WWTP Parcel Boundary
- MVHS Parcel Boundary



A&E Consulting

Water Reuse System

N

0 375 750 Feet

Manchester WWTP
Enhanced Nutrient Removal
Manchester, MD

Legend

- Sprinklers
- Monitoring Wells (MW)
- Christmas Tree Park Parcel Boundary
- Manchester WWTP Parcel Boundary

Appendix K – Cost Estimate

Table K-1: Itemized Cost Estimate

Item	Quantity	Unit	Unit Cost ($)	Cost ($)
Preliminary Treatment				
Model 0.5B PISTAWORKS Grit Removal Skid Mounted System	1	Lump Sum	685,000	685,000
Nutrient Removal				
Blowers	3	Lump Sum	200,000	600,000
Pumps	6	Lump Sum	45,000	270,000
Disinfection				
Sprinklers	20	$/Sprinkler	20.85	417
Filtration				
Aqua MiniDisk® Cloth Media Filter	2	Lump Sum	197930	395,860
Sludge Handling				
PWTech Volute Dewatering Press	1	Lump Sum	305,000	305,000
Blowers	2	Lump sum	200,000	400,000
Construction				
Concrete	15,000	$/yd^3	160	2,400,000
8" DIA Piping	1,552	ft	45	68,490
Total Capital Cost			$	5,124,767