GREAT BASIN ENGINEERING INC

TERAKEE VILLAGE/MEADOWS SECONDARY WATER MODEL
APPROX 900 SOUTH 4300 WEST
WEBER COUNTY, UTAH 84404
SECONDARY WATER MODEL
Project No. 16N719
1-20-2021

General Site Information:

The proposed Terakee Village and Terakee Meadows Subdivisions site are located a few hundred feet to the northwest and southeast of the intersection of 900 South and 4300 West in Unincorporated Weber County and a couple miles to the west of Marriot-Slaterville, Utah. Construction will consist of a new 79 Lot Residential Subdivision (Terakee Village), a 12 Lot Residential Subdivision (Terakee Meadows), agricultural land and common areas, public roadways, sidewalks, curb and gutter, underground utilities (including a secondary water system, herein after referred to as the "System"), a secondary water reservoir, and similar related improvements when completed. Secondary water will be piped through the System via water pumps, 6- and 8-inch diameter main line, 2-inch residential laterals, and 1.0-inch individual lot connections, where individual meters may be required.

Secondary water will be supplied by a new well and be stored in a re-shaped on-site pond. Water Rights are or will be available for this use. This water will be supplemented by any storm water which falls on the site. The water will be stored in the afore-mentioned reservoir until used. Pumps will be provided which will deliver water through new secondary water piping to each residential lot of these subdivisions, as well as common/agricultural lots for use with landscaping on these lots.

Some Design Requirements were located in Rule R309 of the Utah Office of Administrative Rules. These were supplemented by some of the design requirements of a nearby incorporated City. These supplemental requirements were found in Section 20 of the Marriot-Slaterville City Corporation Public Works Standards (revised Sept 2012), as no numerical secondary water system design requirements were found for Unincorporated Weber County regulations at https://weber.municipalcodeonline.com/. The attached figures show the System Layout, the lot layout for the subdivisions, as well as a Labeling Convention Map (LCM) for ease of coordination of subdivision layout with Water Model callouts/labels.

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Design Requirements:

This development lies within Zone 4 of the Irrigated Crop Consumptive Use Zones and Normal Annual Effective Precipitation, Utah map in R39-510-7(3). The State requires developers within this Zone to design for an irrigation water rights of 1.87 acre feet per irrigated acre per year (ac-ft/irr-ac-yr) with a unit peak day demand of 3.96 gpm/irr-ac which is delivered from the well to the proposed irrigation pond. For Zone 4, the State also requires storage (in the irrigation pond for this development) amounting to 2848 gal/irr-ac and a peak instantaneous demand (PID) of 7.92 gpm/irr-ac for irrigation use.

A safety factor of 2 is used for the PID, resulting in a design rate of 15.84 gpm/irr-ac. This 15.84 gpm/irr-ac is divided through the development in a pro-rated fashion to each lot or area based upon required landscaping area within the Water Model. It is understood that not every lot, common area, or agricultural area will be watering at the same time, and that at any given time, a single lot or area may be utilizing more or less than 15.84 gpm/irr-ac, as this PID is an average throughout the development.

The requirements provided by the State are supplemented, as mentioned above, by some requirements from nearby Marriott-Slaterville Public Works Standards. These standards require that pressures be designed between 60psi and 100 psi for individual connections. In addition, water mains are to be no smaller than 6" diameter, and use class 200 PVC for 6", 8", and 10" piping. Diameters of 6" and 8" were selected for all main lines in this model.

Copies of the State and Marriott-Slaterville Standards are attached to this report.

Watering days/times will be split or assigned to decrease the irrigated acreage being watered at any given time during the watering season.

Model Software and Input:

The software used for this analysis is EPANET 2.2, which is a free service that is available on the epa.gov website. Naming conventions for junctions (nodes) and pipes (links) are as follows:

- Connection nodes for individual lots, common area, and agricultural areas (requiring demand) are labeled by a "C" followed by a whole number, beginning at the most upstream connection (serving the Agricultural area and Lot 63 labeled as "C1"). The numbering continues proceeding incrementally (to C50) in the directions indicated by the attached LCM. For example, the node serving as connection for Lots 73/74 is labeled as "C17".
- The relatively short laterals that lead to the connection nodes are labeled with an "L" followed by the corresponding connection number. For example, the short lateral serving Lots 73/74 is labeled as "L17".

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- The nodes on the upstream ends of each lateral are labeled with "J." followed by the corresponding connection number(s) (separated by "." if necessary) attached to the connected laterals. For example, the node on the upstream end of L17 is also the node on the upstream end of L18 (which serves Lots 77/78) and is labeled as "J.17.18".
- The remaining nodes are along the main lines, are not at the ends of connection laterals, and do not have associated demands. These are labeled "101" through 110" likewise in the directions indicated by the attached LCM. For example, the junction in the intersection nearest Lot 59 is labeled as "105".
- The remaining irrigation lines are all mainlines and are designated as Pa, Pb,…, Pz, P1a, P1b,…, P1z organized in the directions indicated by the attached LCM. For example, the pipe connecting nodes 105 and J.26.27 is labeled as "P1d".

To model the System, head vs. flow curves were needed to incorporate the water pumps. The Design Peak Instantaneous Demand calculates to about 859 gpm. It is reasonable to consider using 400 gpm constant flow, a 400 gpm VFD, and a 200 gpm VFD to provide a conservative total 1000 gpm for the System. A reputable manufacturer, Grundfos, was contacted to provide guidance on selecting a possible pump combination to meet these criteria. The manufacturer's website was consulted to locate suitable choices. For the pumps, selected were a 400 gpm Constant flow (25707 LCS), a 400 gpm VFD (25707-2P-30HP LCSE), and a 200 gpm VFD (20709-2P-20HP LCSE). Corresponding headloss/head (ft) vs. flow (gpm) curves and O&M manuals are attached to this report.

The water pumps were modeled as "pumps" in EPANET. They are labeled as "Pump-1", "Pump-2", and "Pump-3" on the attached exhibits. For analyses, either all three or only two of the pumps are assumed functioning, as explained on the next section. This is for considering the event where one of the pumps may be shut down at any one time for servicing, etc.

Modeled Scenarios:

Four Scenarios are analyzed using the EPANET model, conservatively assuming PID for the site under each scenario. The VFD pumps will provide less head, as needed, when there is a reduction in flow during times of low water use. First, all four pumps are considered functioning properly. Next it is assumed that one of the remaining pumps is not functioning, considered for each one of the three pumps. The four scenarios are:

1. All pumps functioning.
2. Pump-1 (400 gpm Constant) is not functioning.
3. Pump-2 (400 gpm VFD) is not functioning.
4. Pump-3 (200 gpm VFD) is not functioning.

Data showing specifics for the pipe and node properties can be found in the attached exhibits (Appendix A) and calculations/results (Appendix D) as well.

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The results are sorted by base demand for nodes, and length for pipes to make it easier to analyze/critique the data.

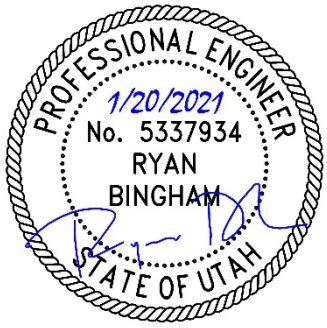
Results:

Peak Instantaneous Demand was used in this Water Model applying a safety factor of (2). Under the first Scenario, all pumps were assumed to be functioning. This scenario produces all pressures between 60 and 100 psi for all 50 Connection Points, as required. Under scenarios where one of the three pumps are considered off for maintenance etc., the pressures at connection points were still at least 45 psi or greater. While these scenarios do not meet the 60 to 100 psi criteria, it is assumed that pumps that are down for maintenance will be serviced promptly so that these occasional decreased pressures will be temporary and short-lived for the water users. Velocities in each pipe were less than 10 fps under all scenarios. Moreover, most of the velocities are under 5 fps for each scenario, which is reasonable for secondary water systems.

Great Basin Engineering, Inc.

Prepared by

Ryan Bingham, P.E.



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APPENDICES

Appendix A – Maps

Appendix B – Design Parameters and Details

Appendix C – Head / Headloss Curves

Appendix D – Model Calculations/Results

Appendix E – Pump O&M Manuals

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APPENDIX A

Maps

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Scale: 1" = 100'

100 0 50 100 150 200

Graphic Scale

Pond Details:
Lowest Point Along Top of Berm: 4238.69
Assumed Top of Water: 4137.19
Freeboard: 1.5 ft.
Pond Volume: 44,800 Cu.ft.
Deepest Point in pond: 4234.00

Assisted Senior Living

Terakee Village

900 South Street

4300 West Street

Terakee Meadows

Secondary Water Model Exhibit

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APPENDIX B

Design Parameters and Details

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MARRIOTT-SLATERVILLE CITY CORPORATION

PUBLIC WORKS STANDARDS

DECEMBER 2002

(Revised September 2012)

Prepared by:

JONES & ASSOCIATES
CONSULTING ENGINEERS

demand. The storage amount given herein correlates with Pine View Water System requirements. This is done so that if a transfer ever takes place, the system will comply.

1. **Fencing**: Reservoirs should be fenced around the perimeter with room between the fence and the perimeter for maintenance vehicles (min 20'). Fencing shall be 6 feet tall chain link in accordance with these Public Works Standards and conform to City Zoning requirements.
2. **Lining**: Reservoirs shall be clay lined to inhibit percolation or infiltration. The corners should rounded to avoid stress concentrations in the event of future concrete lining.
3. **Side Slope**: Due to the fact that most of these basins will be in residential areas, the maximum side slope of the basis shall be two (2) feet horizontal to one (1) feet vertical.
4. **Depth**: Irrigation basins shall not exceed 12 feet deep and, in the presence of ground water, consideration for draining the basin must be given.
5. **Grates, Pipes and Screens**: All grates and screens shall be hot dip galvanized to avoid corrosion. Pipes shall be in accordance with the pipe specification given herein.
6. **Freeboard**: The top of the embankment in all areas shall be one (1) foot above the highest water elevation.
7. **Ground Covers:** The surface area around the basin shall be covered with weed barrier fabric and gravel. Gravel shall 2" minus and be 4" thick over the top of the weed barrier.
8. **Embankment (Fill) Construction:** If a raised embankment is constructed for the reservoir (constructed with granular materials), it shall be provided with a minimum of 6" of clay cover on the inside of the berm to prevent water passage through the soil as well as the clay lining.
9. **Excavation (Cut) Construction:** If the basin is constructed primarily by excavation, then it may be necessary to provide an impermeable liner and land drain system when constructed in the proximity of basements or other below grade structures as determined by a geotechnical evaluation.

G. PRESSURIZATION

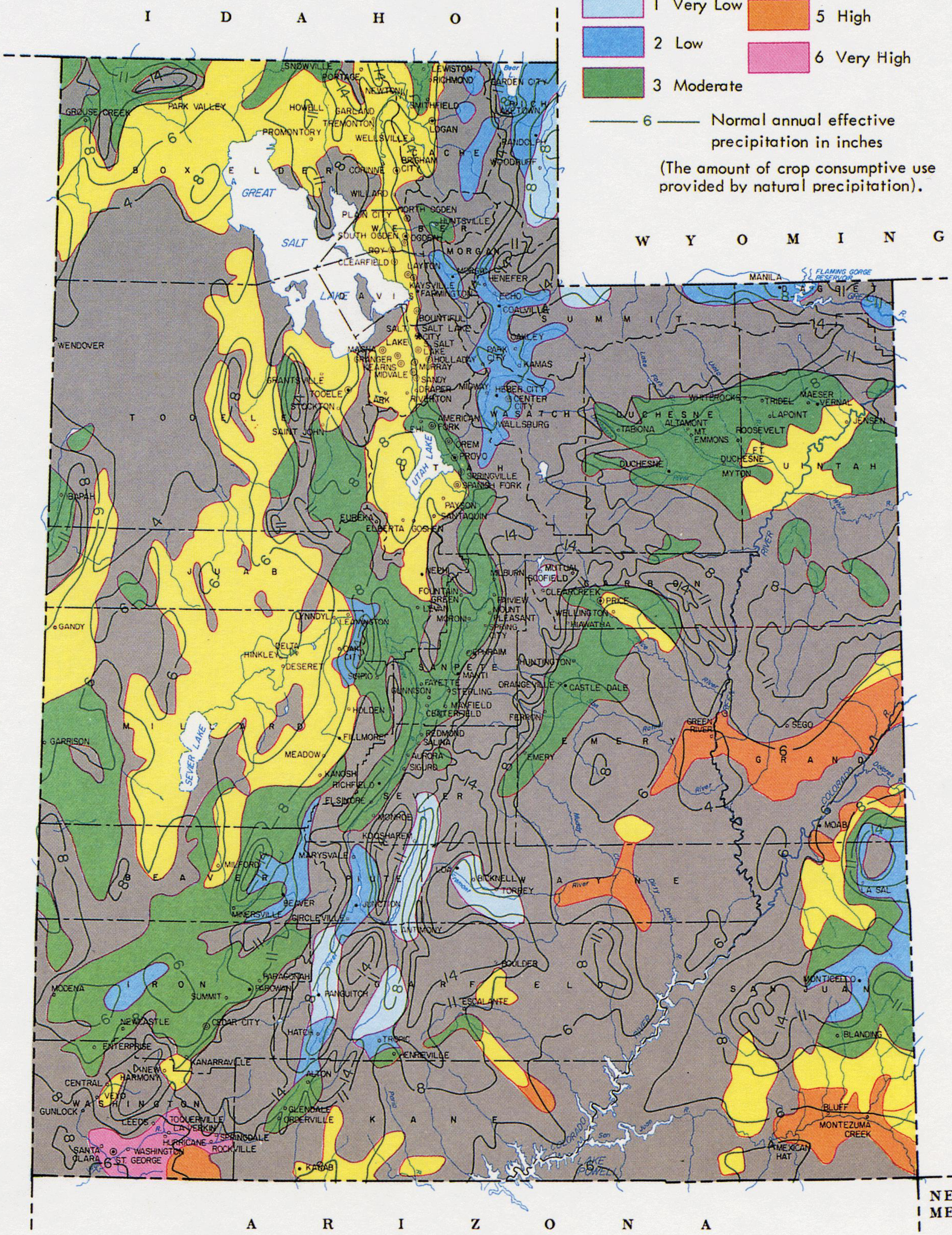
Gravity systems are always desirable, however pumps may need to be used. Pumps, which shall directly pressurize the system, shall be Variable Frequency Drive (VFD) pumps with redundancy designed for meeting the peak instantaneous flows.

The hydraulics of the system should be set for a peak instantaneous flow equal to the following formula:

$$\mathbf{Q = U*180*N^{0.55}}$$

Where: Q is the instantaneous flow rate in g.p.m.
U is the usage factor (no less than 60% or 0.6)
N is the total number of Irrigable acres

In no case shall the Peak Instantaneous Flow Rate per irrigable acre be less than 8gpm. Pressures should be designed between 60 psi (139' TDH) and 100 psi (230' TDH). Pump



IRRIGATED CROP CONSUMPTIVE USE ZONES AND NORMAL ANNUAL EFFECTIVE PRECIPITATION

UTAH

NOVEMBER 1978

10 0 10 20 30 40 50 60 MILES

SCALE 1:3,000,000

M7-0L-23893

Source:
Base map prepared by SCS, WTSC Carto Staff from USGS 1:1,000,000 National Atlas.
Thematic detail compiled by state staff.

U.S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE USDA-SCS-FORT WORTH, TEXAS 1983

Note 4. Or Peak Day Demand = 20 x [Water Area (ft^2)/30] + Deck Area (ft^2)

(3) Irrigation Use.

If a water system provides water for irrigation, Table 510-3 shall be used to determine the peak day demand and average yearly demand for irrigation water use. The following procedure shall be used:

(a) Determine the location of the water system on the map entitled *Irrigated Crop Consumptive Use Zones and Normal Annual Effective Precipitation, Utah* as prepared by the Soil Conservation Service (available from the Division). Find the numbered zone, one through six, in which the water system is located (if located in an area described "non-arable" find nearest numbered zone).

Guidance: The irrigation zone map is provided below. This map is available on the Division of Drinking Water's website.

(b) Determine the net number of acres which may be irrigated.

Guidance: To determine the net number of acres to be irrigated, start with the gross acreage, then subtract any area of roadway, driveway, sidewalk, or patio pavement along with housing foundation footprints that can be reasonably expected for lots within a new subdivision or which is representative of existing lots. Before any other land area which may be considered "non-irrigated" (e.g., steep slopes, wooded acres, etc.) is subtracted from the gross area, the Director should be consulted and agree that the land in question will not be irrigated. For instance, in the case of a heavily wooded mountain home subdivision, it may be claimed that large lawns will not be put in by the lot owners. The division should review and concur with this judgment.

(c) Refer to Table 510-3, which assumes direct application of water to vegetation, to determine peak day demand and average yearly demand for irrigation use.

(d) Consider water losses due to factors such as evaporation, irrigation delivery method, overwatering, pipe leaks, etc. Apply a safety factor to the irrigation demand in the design accordingly.

Table 510-3 Source Demand for Irrigation		
Map Zone	Peak Day Demand (gpm/irrigated acre)	Average Yearly Demand (AF/ irrigated acre) (Note 1)

1	2.26	1.17
2	2.80	1.23
3	3.39	1.66
4	3.96	1.87
5	4.52	2.69
6	4.90	3.26

NOTE FOR TABLE 510-3:

Note 1. The average yearly demand for irrigation water use (in acre-feet per irrigated acre) is based on 213 days of irrigation, e.g., April 1 to October 31.

Guidance: If the irrigation season differs from the assumed 213 days, the average yearly demand numbers may need to adjusted.

(4) Variations in Source Yield.

(a) Water systems shall consider that flow from sources may vary seasonally and yearly. Where flow varies, the number of service connections supported by a source shall be based on the minimum seasonal flow rate compared to the corresponding seasonal demand.

(b) Where source capacity is limited by the capacity of treatment facilities, the maximum number of service connections shall be determined using the treatment plant design capacity instead of the source capacity.

Guidance: Some water sources, such as deep wells, yield consistent quantities of water while others, such as springs, yield inconsistent quantities that vary seasonally and annually. Sources that yield inconsistent quantities of water should be studied and understood prior to the commitment of those sources for future uses, such as providing will-serve letters or approving proposed developments.

Labor Camp; per unit	25
Recreational Vehicle Park; per pad	50
Roadway Rest Stop; per vehicle	3.5
Recreational Home Development (i.e., developments with limited water use); per connection (See Note 2 in Table 510-1)	400

(c) Where a drinking water system provides water for irrigation use, Table 510-5 shall be used to determine the minimum equalization storage volumes for irrigation. The procedure for determining the map zone and irrigated acreage for using Table 510-5 is outlined in R309-510-7(3).

Table 510-5 Storage Volume for Irrigation Use	
Map Zone	Volume Required (gallons/irrigated acre)
1	1,782
2	1,873
3	2,528
4	2,848
5	4,081
6	4,964

(3) Fire Flow Storage.

(a) Fire flow storage shall be provided if fire flow is required by the local fire code official or if fire hydrants intended for fire flow are installed.

(b) Water systems shall consult with the local fire code official regarding needed fire flows in the area under consideration. The fire flow information shall be provided to the Division during the plan review process.

(c) When direction from the local fire code official is not available, the water system shall use Appendix B of the International Fire Code, 2015 edition, for guidance. Unless otherwise approved by the local fire code official, the fire flow and fire flow duration shall not be less than 1,000 gallons per minute for 60 minutes.

Guidance: Utah has adopted a state-wide fire code. However, local fire code officials are authorized to determine fire flow requirements in their jurisdictions.

(4) Emergency Storage.

Emergency storage shall be considered during the design process. The amount of emergency storage shall be based upon an assessment of risk and the desired degree of system

60 to 239	$Q= 80+ 20N^{0.5}$
240 or greater	Q= 1.6N

NOTES FOR TABLE 510-6:

Q is total peak instantaneous demand (gpm). N is the maximum number of connections. However, if the only water use is via service buildings, the peak instantaneous demand shall be calculated for the number of plumbing fixture units as presented in the state-adopted plumbing code.

(d) For small non-community water systems, the peak instantaneous demand for indoor water use shall be calculated on a per-building basis for the number of plumbing fixture units as presented in the state-adopted plumbing code.

(3) Peak Instantaneous Demand for Irrigation Use.

Peak instantaneous demand for irrigation use is given in Table 510-7. The procedure for determining the map zone and irrigated acreage for using Table 510-7 is outlined in R309-510-7(3).

Table 510-7 Peak Instantaneous Demand for Irrigation Use	
Map Zone	Peak Instantaneous Demand (gpm/irrigated acre)
1	4.52
2	5.60
3	6.78
4	7.92
5	9.04
6	9.80

(4) Fire Flow.

(a) Distribution systems shall be designed to deliver needed fire flow if fire flow is required by the local fire code official or if fire hydrants intended for fire flow are provided. The distribution system shall be sized to provide minimum pressures as required by R309-105-9 to all points in the distribution system when needed fire flows are imposed during peak day demand in the distribution system.

(b) The water system shall consult with the local fire code official regarding needed fire flow in the area under consideration. The fire flow information shall be provided to the Division during the plan review process.

Terakee Village/Meadow

Schedule Export | Duplicate (/projects/600602da6fc978607100047e/clone) | Request Assistance/Quote

Scroll to Add Equipment

Pump

Tag	Service	Flow	Head	Speed	Pump Type	Model	Efficiency	NPSH required	Nameplate Rating	Volts	Phase	Notes	
001 (/projects/600602da6fc978607100047e/items/600602da6fc978607100048c) (/projects/600602da6fc978607100047e/restore_item_in_selector?item_id=3630242&selector_id=591714a53590a80001000004)		400.0 USgpm	190.0 ft	3530 rpm	LCS – Split Coupled End Suction	25707 LCS	84.07 %	25.41 ft	30.00 hp / 22.37 kW	230/460 V	3 Phase		(/projects/600602da
002 (/projects/600602da6fc978607100047e/items/6006030ca1269a77310013f6) (/projects/600602da6fc978607100047e/restore_item_in_selector?item_id=3630245&selector_id=591714a53590a80001000004)		400.0 USgpm	190.0 ft	3530 rpm	LCSE – Split Coupled, with integrated VFD End Suction	25707-2P-30HP LCSE	84.30 %	25.25 ft	30.00 hp / 22.37 kW (Fixed)	460 V	3 Phase		(/projects/600602da
003 (/projects/600602da6fc978607100047e/items/60060365ef241d7fc90082f8) (/projects/600602da6fc978607100047e/restore_item_in_selector?item_id=3630249&selector_id=591714a53590a80001000004)		200.0 USgpm	190.0 ft	3530 rpm	LCSE – Split Coupled, with integrated VFD End Suction	20709-2P-20HP LCSE	74.96 %	15.38 ft	20.00 hp / 14.91 kW (Fixed)	460 V	3 Phase		(/projects/600602da

Add an item(/projects/600602da6fc978607100047e/create_new_item_in_selector?equipment_template_id=600602da6fc978607100047f) Edit Pump

Grundfos North America

902 Koomey Road
Brookshire, TX 77423

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APPENDIX C

Head / Headloss Curves

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Terakee Village/Meadow

Status:
Designing
Customer:
Brad Blanch
Location:
Ogden, Utah
Description:

Design Peak Instantaneous Demand = 859 gpm. It is reasonable to analyze a System with 3 pumps in parallel: 400 gpm constant, 400 gpm VFD, 200 gpm VFD. This yields a conservative total 1000 gpm.

Pump

Tag	Service	Flow	Head	Speed	Pump Type		Efficiency	NPSH required	Nameplate Rating	Volts	Phase	Notes
001		400.0 USgpm	190.0 ft	3530 rpm	LCS – Split Coupled End Suction	25707 LCS	84.07 %	25.41 ft	30.00 hp / 22.37 kW	230/460 V	3 Phase	
002		400.0 USgpm	190.0 ft	3530 rpm	LCSE – Split Coupled, with integrated VFD End Suction	25707-2P-30HP LCSE	84.30 %	25.25 ft	30.00 hp / 22.37 kW (Fixed)	460 V	3 Phase	
003		200.0 USgpm	190.0 ft	3530 rpm	LCSE – Split Coupled, with integrated VFD End Suction	20709-2P-20HP LCSE	74.96 %	15.38 ft	20.00 hp / 14.91 kW (Fixed)	460 V	3 Phase	

GRUNDFOS EXPRESS

Custom Units | 60 Hz | English | Edit

INPUTS (/IEQ_HYDSEL/HYDSEL_JSP/APP/CONDITIONSOFSERVICE) » RESULTS (/IEQ_HYDSEL/HYDSEL_JSP/APP/SEARCHRESULTS) » **25707 LCS**

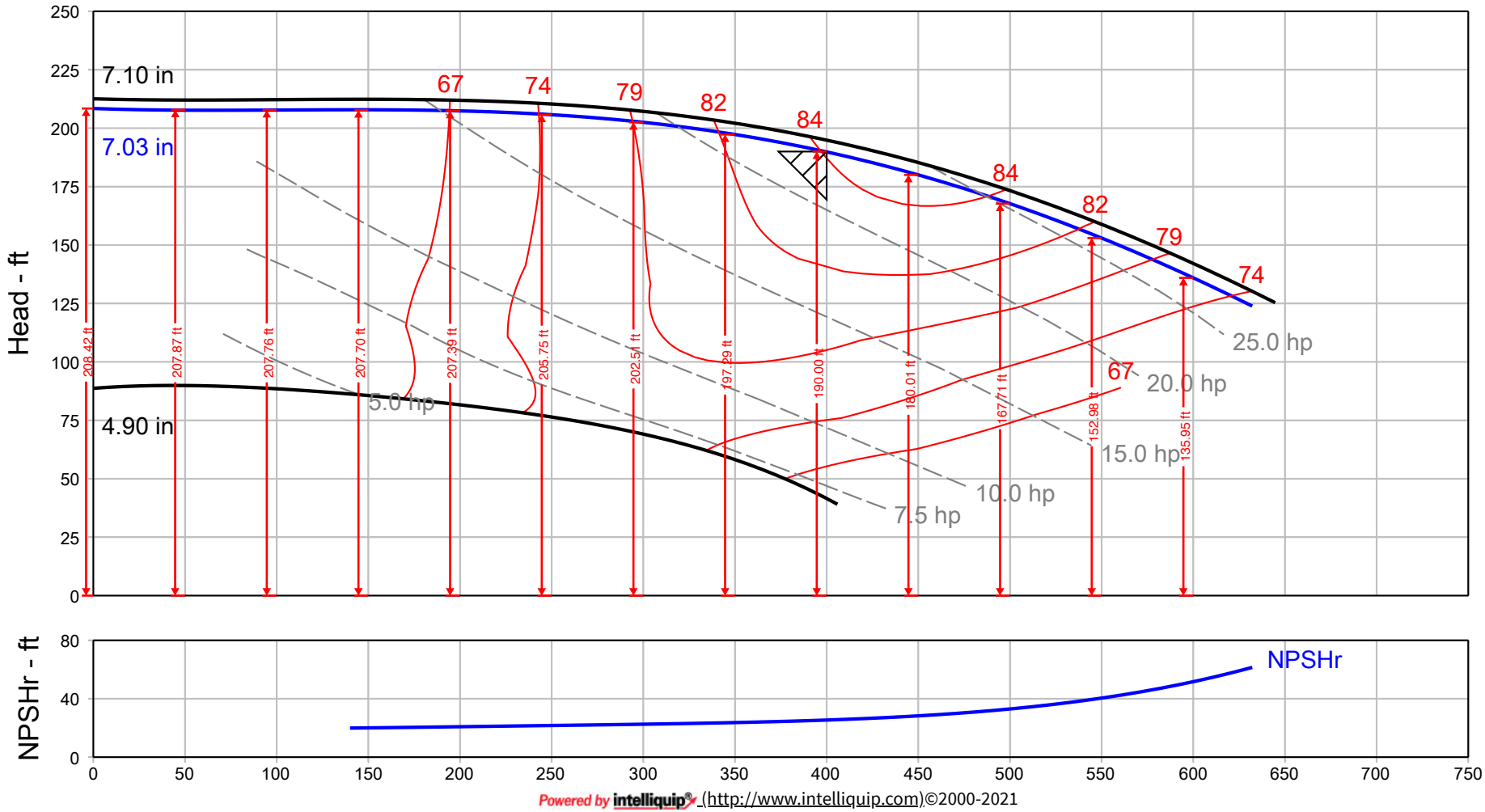
New pump

25707 LCS 3530 rpm / 400.0 USgpm / 190.0 ft / 84.07 % / 22.80 hp

Schedule

⚠ Suction pressure was not added on Inputs page

Curve | Overview | Performance | Options

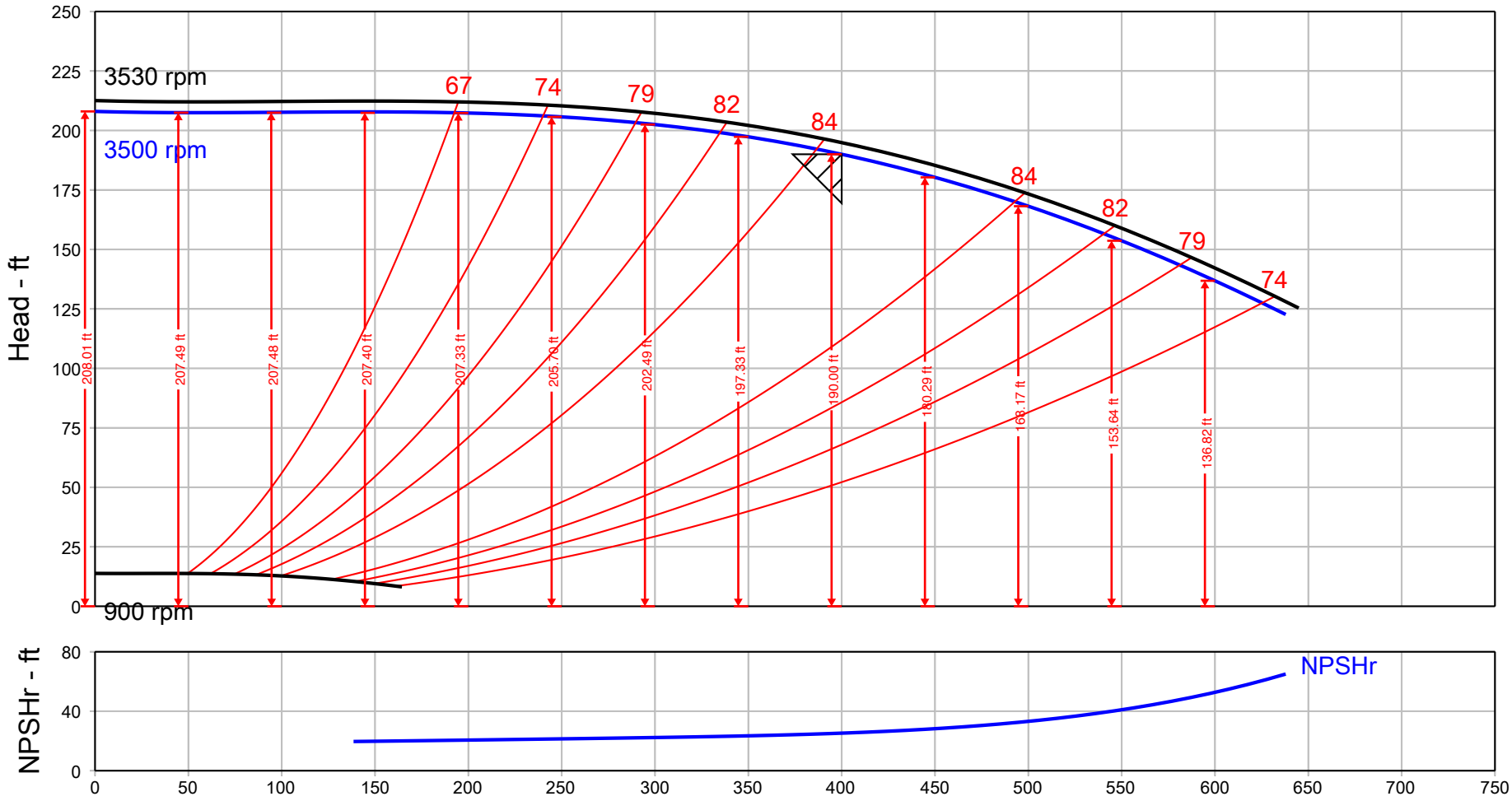


25707-2P-30HP LCSE 3500 rpm / 400.0 USgpm / 190.0 ft / 84.30 % / 22.76 hp

Schedule

⚠ Suction pressure was not added on Inputs page

Curve | Overview | Performance | Options



GRUNDFOS EXPRESS

Custom Units | 60 Hz | English | Edit

INPUTS (/IEQ_HYDSEL/HYDSEL_JSP/APP/CONDITIONSOFSERVICE) » RESULTS (/IEQ_HYDSEL/HYDSEL_JSP/APP/SEARCHRESULTS) » **20709-2P-20HP LCSE**

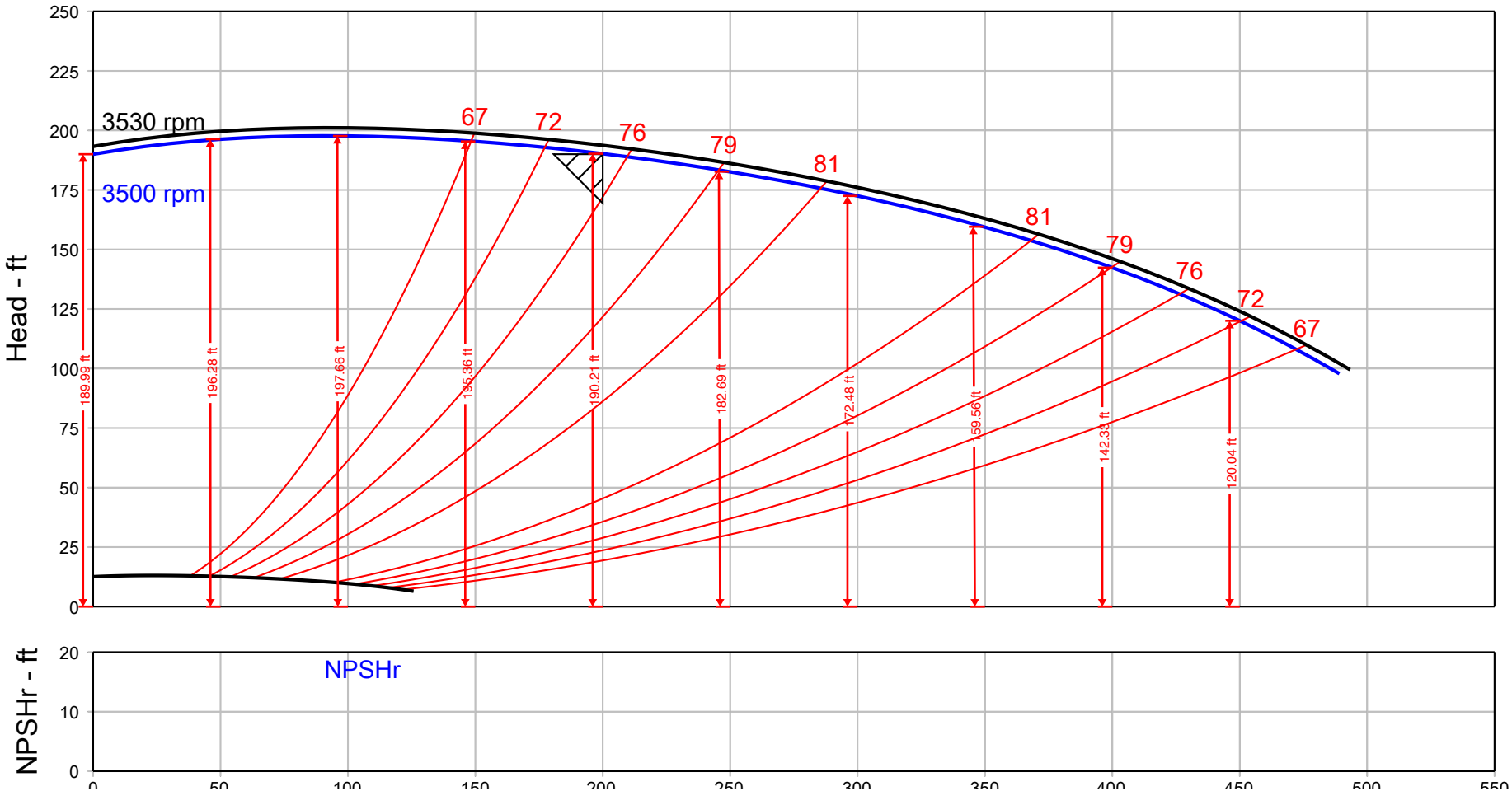
New pump

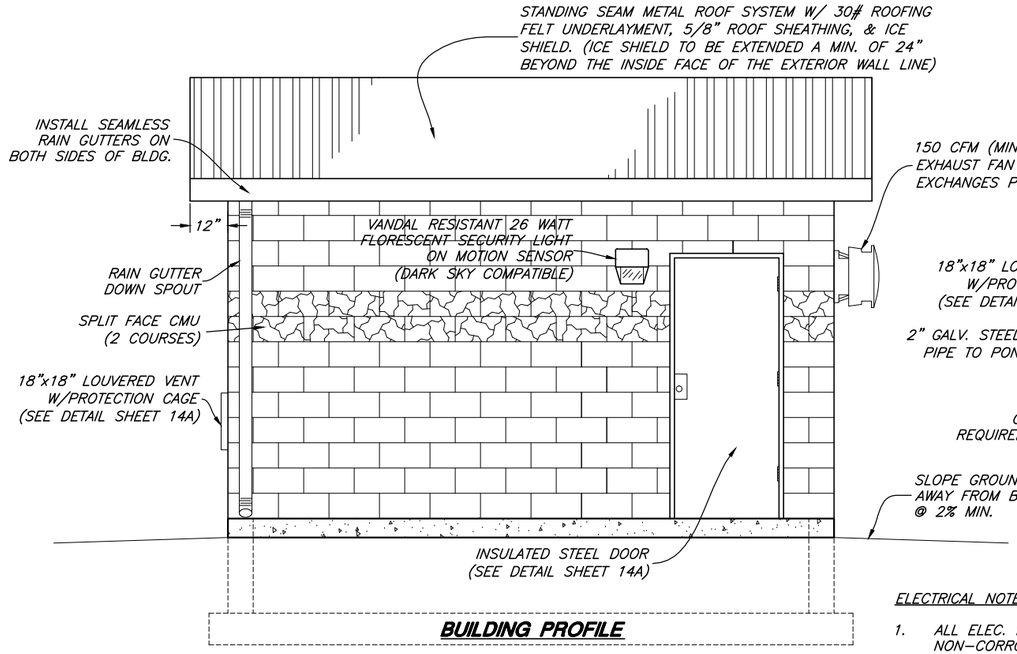
20709-2P-20HP LCSE 3500 rpm / 200.0 USgpm / 190.0 ft / 74.96 % / 12.81 hp

Schedule

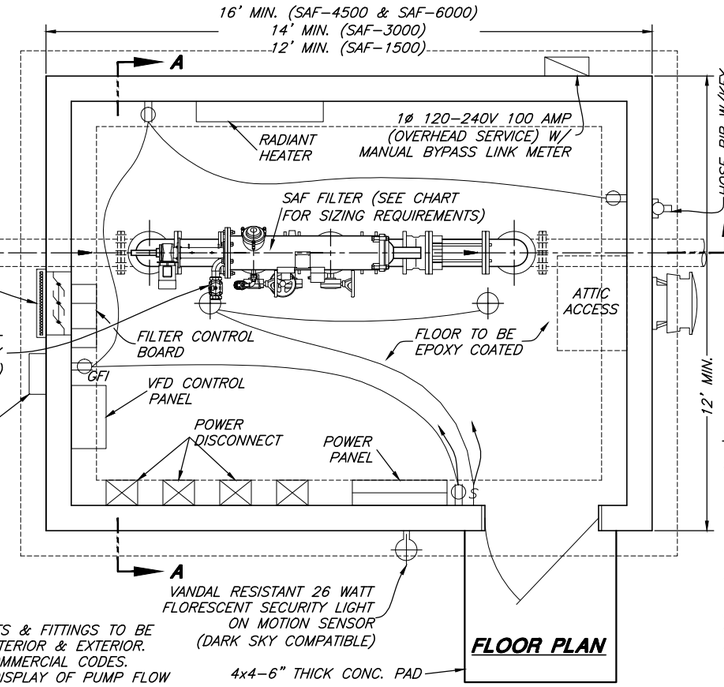
⚠ Suction pressure was not added on Inputs page

Curve | Overview | Performance | Options





BUILDING PROFILE



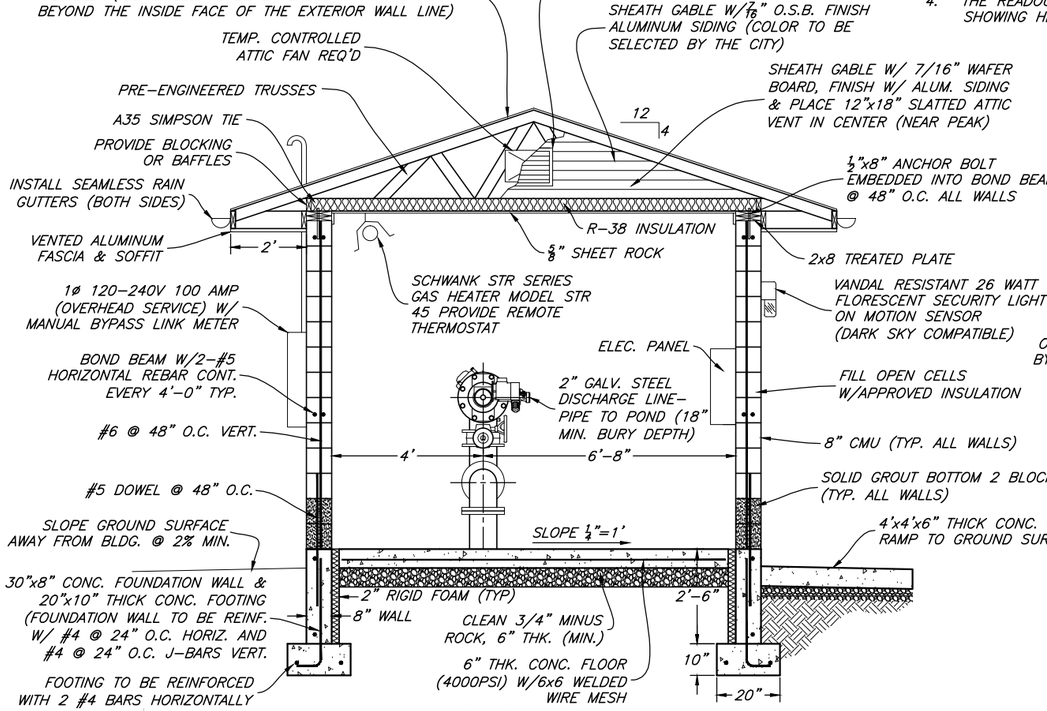
FLOOR PLAN

AMIAD MODEL "SAF" FILTER				
MODEL	MIN. LINE SIZE	MAX. FLOW	DIM "A"	DIM "B" MIN.
2" SAF-1500	3"	100 GPM	13.8"	2.66'
3" SAF-1500	4"	200 GPM	13.8"	2.66'
4" SAF-1500	6"	350 GPM	13.8"	2.66'
4" SAF-3000	6"	400 GPM	24.4"	3.94'
6" SAF-3000	8"	660 GPM	24.4"	3.94'
6" SAF-4500	10"	880 GPM	24.4"	4.92'
8" SAF-4500	10"	1100 GPM	24.4"	4.92'
8" SAF-6000	12"	1400 GPM	24.4"	4.26'
10" SAF-6000	12"	1760 GPM	24.4"	4.26'

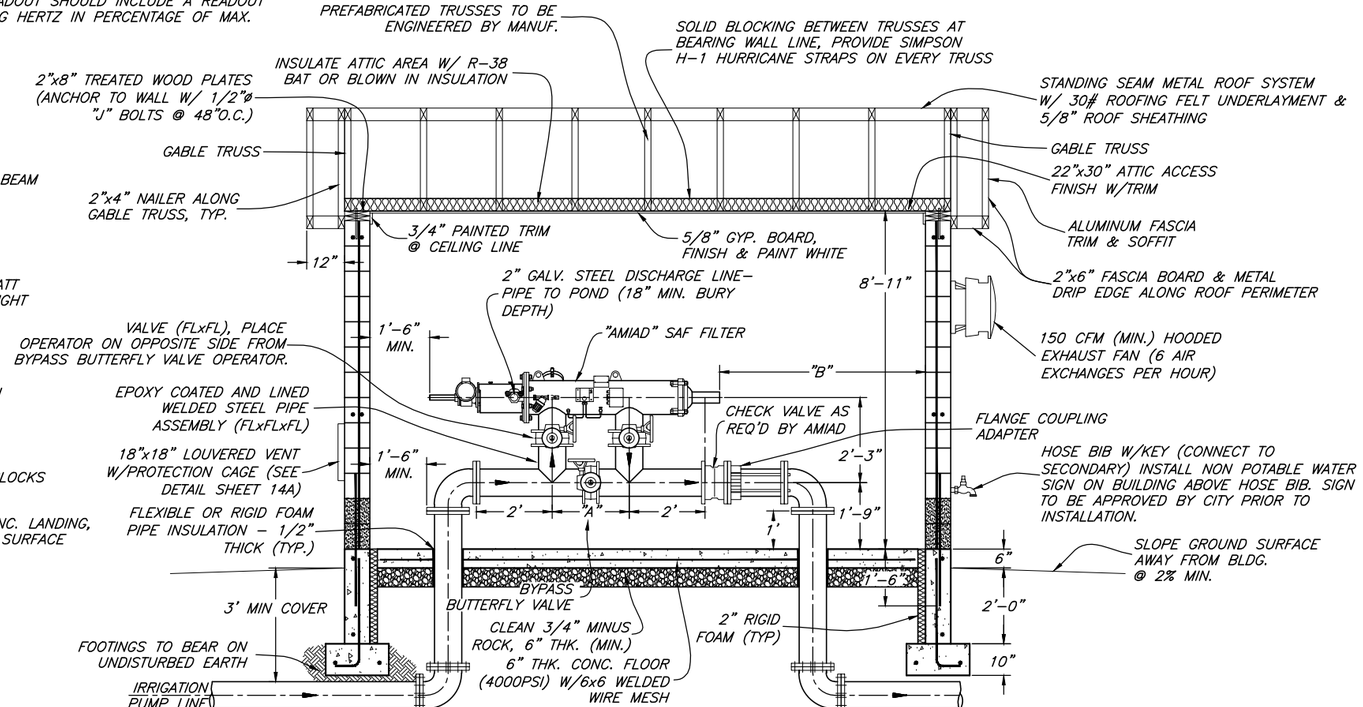
AMIAD FILTER NOTES:
1. SCREEN TO BE 200 MICRON
2. CONTROL TO BE STAINLESS STEEL
3. FILTER LID TO BE EPOXY COATED STEEL
4. CLEANING MECHANISM TO BE STAINLESS STEEL
5. EXHAUST VALVE TO BE EPOXY COATED CAST IRON.

ELECTRICAL NOTES:
1. ALL ELEC. FIXTURES, CONDUITS & FITTINGS TO BE NON-CORROSIVE MATERIAL-INTERIOR & EXTERIOR.
2. ALL ELEC. TO BE TO NEC COMMERCIAL CODES.
3. CONTROLS TO HAVE DIGITAL DISPLAY OF PUMP FLOW RATE.
4. THE READOUT SHOULD INCLUDE A READOUT SHOWING HERTZ IN PERCENTAGE OF MAX.

GENERAL NOTES
1. ALL PIPE SHALL BE DUCTILE IRON CLASS 50 UNLESS OTHERWISE NOTED.
2. ALL STRUCTURAL CONSTRUCTION SHALL COMPLY W/CURRENT UBC & LOCAL BUILDING CODES & SHALL BE CONSISTENT WITH COMMAND CONSTRUCTION PRACTICES OF THE TRADES.
3. EARTH TONE CMU BLOCK COLOR TO BE SELECTED BY THE CITY.
4. METAL ROOF, FASCIA TRIM & SOFFIT, & METAL DRIP EDGE COLOR TO BE SELECTED BY THE CITY.
5. IRRIGATION LINE IS TO HAVE 3' MINIMUM COVER.
6. ALL FLANGES TO BE ANSI CLASS 150/125
7. ALL PIPING, VALVES, FITTINGS, METERS, AND OTHER MISC. PARTS OF THE PIPING SYSTEM SHALL BE PAINTED W/1 COAT OF PRIMER AND 2 COATS OF ACRYLIC ENAMEL PAINT (PURPLE COLOR TO BE APPROVED BY THE CITY.



BUILDING SECTION A-A



BUILDING SECTION B-B

REGISTERED PROFESSIONAL ENGINEER
No. 276381
CHRIS L BREINHOLT
STATE OF UTAH

PROJECT ENGINEER

9/04/12
DATE

REV.	DATE	APPR.	
1	12/04	GLS	INCLUDED IN PUBLIC WORKS STANDARDS
2	8/09	CLB	ADDED EXHAUST FAN AND LOUVERED VENT

SCALE: N.T.S.

DESIGNED BEB
DRAWN BEB
CHECKED CLB

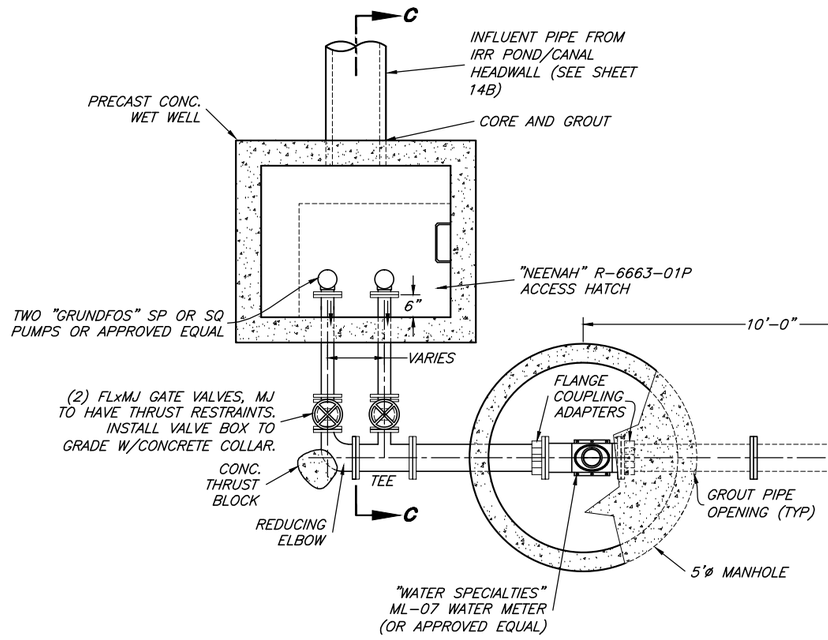
JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
Ogden, Utah 84403 (801) 476-9767

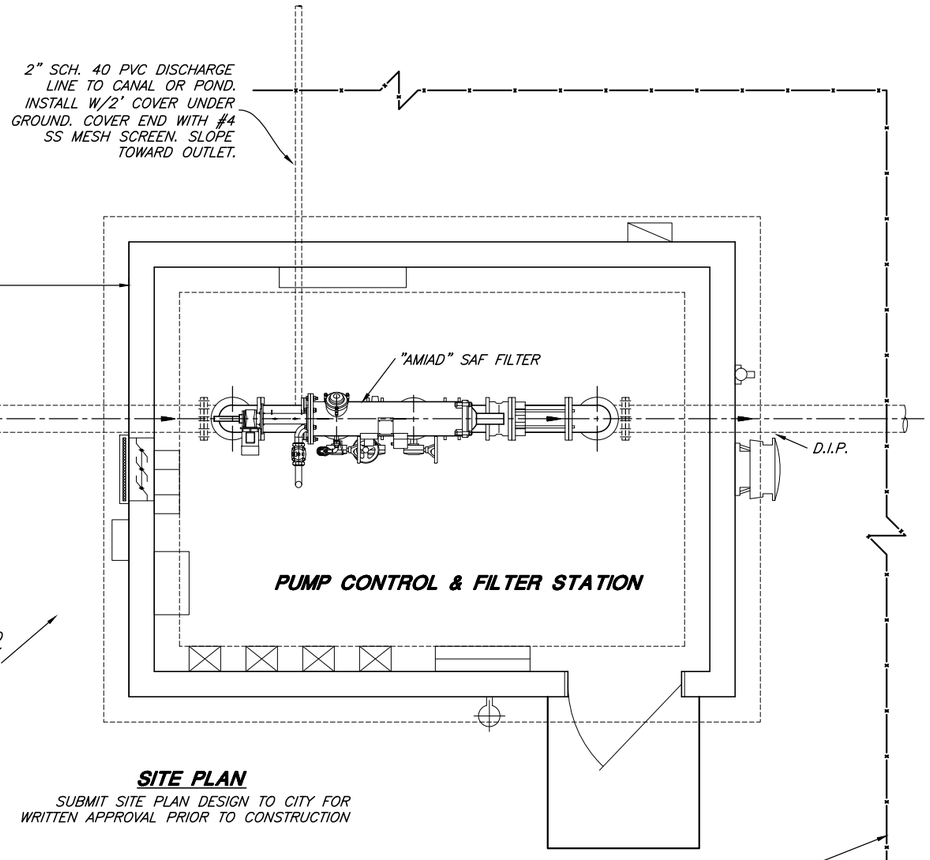
MARRIOTT-SLATERVILLE CITY CORPORATION
PUBLIC WORKS STANDARDS

SECONDARY WATER PUMP CONTROL & FILTER STATION

SHEET: 14 OF 20 SHEETS
0

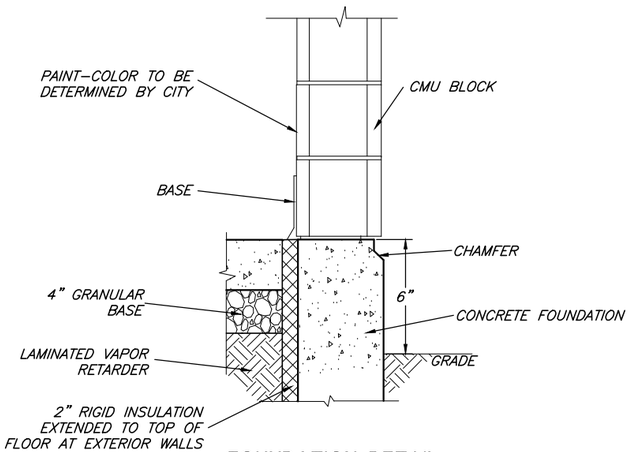
NOTES:
1. ALL MANHOLE OR VAULT PIPE JUNCTIONS ARE TO HAVE RUBBER BOOT OR OTHER APPROVED WATERTIGHT SEAL.
2. COORDINATE INSTALLATION OF POWER TRANSFORMER & POWER LINE W/UP&L SIZE & CONST. TRANSFORMER PAD PER UP&L SPECS. TRANSFORMER TO BE SIZED FOR PUMPS & FILTER REQUIREMENTS.
3. ALL D.I.P. IN CONTACT W/EARTH IS TO BE POLYETHYLENE ENCASED.



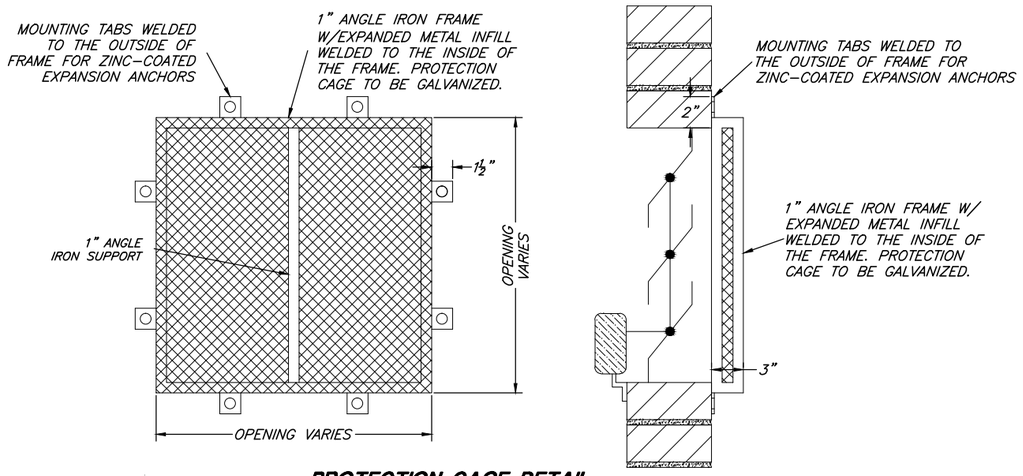


SITE PLAN

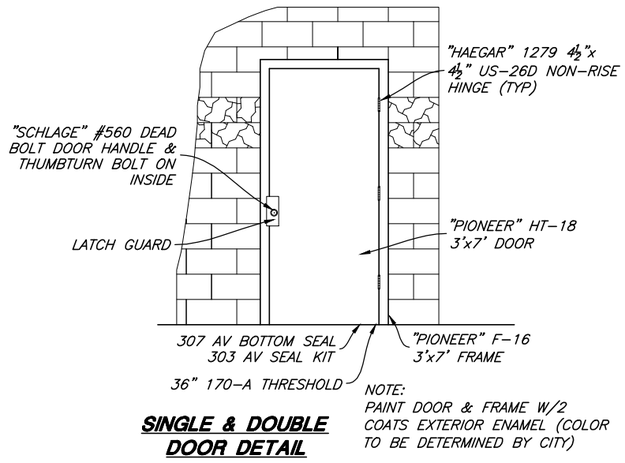
SUBMIT SITE PLAN DESIGN TO CITY FOR WRITTEN APPROVAL PRIOR TO CONSTRUCTION



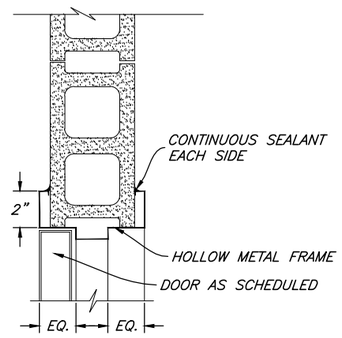
FOUNDATION DETAIL



PROTECTION CAGE DETAIL



SINGLE & DOUBLE DOOR DETAIL



FRAME DETAIL

REGISTERED PROFESSIONAL ENGINEER — No. 276381 — CHRIS L. BRENKHOLT — STATE OF UTAH

PROJECT ENGINEER

9/04/12
DATE

REV.	DATE	APPR.	
1	12/04	GLS	INCLUDED IN PUBLIC WORKS STANDARDS
2	8/09	CLB	ADDED EXHAUST FAN AND LOUVERED VENT

SCALE: N.T.S.

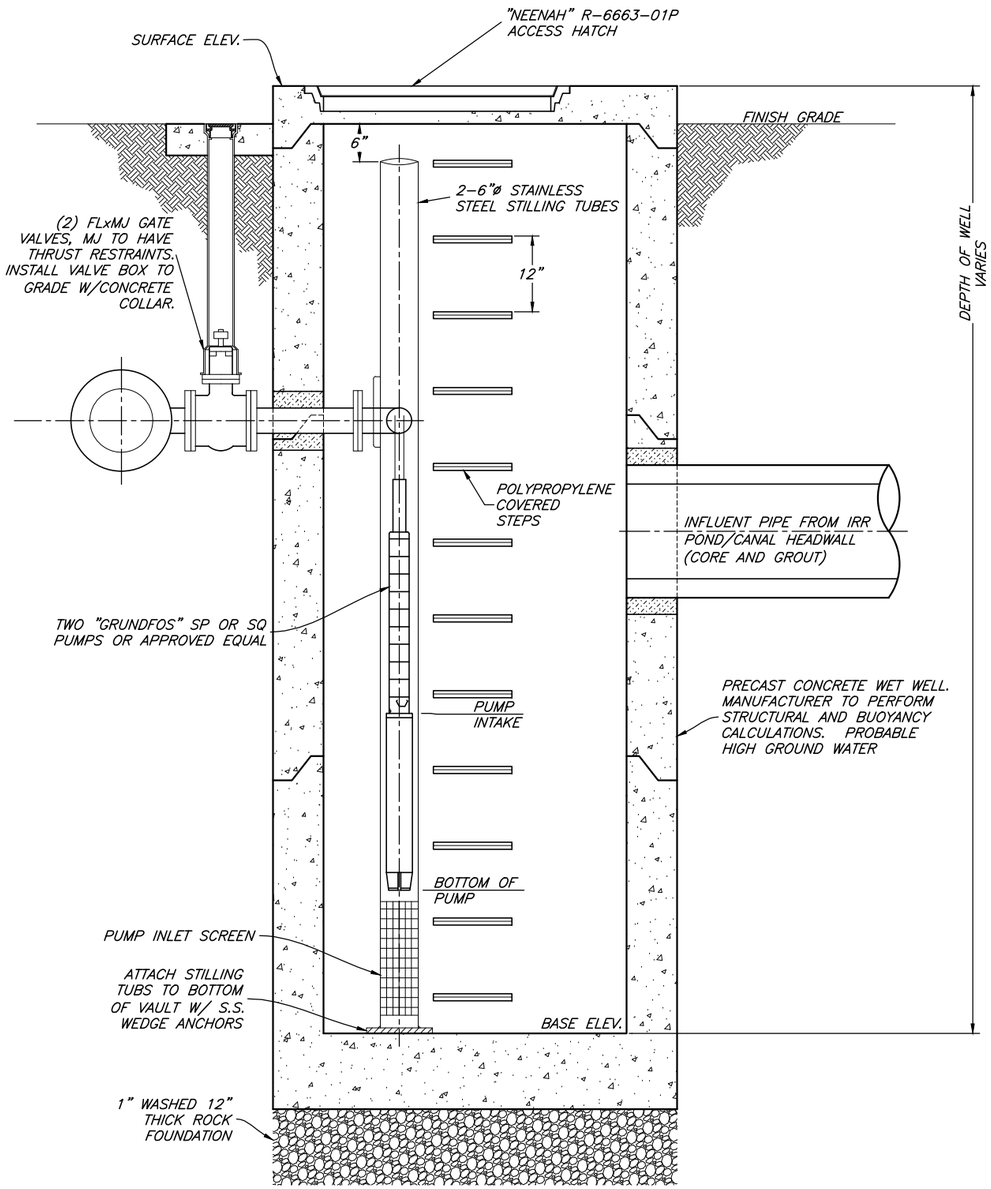
DESIGNED BEB
DRAWN BEB
CHECKED CLB

JA JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
Ogden, Utah 84403 (801) 476-9767

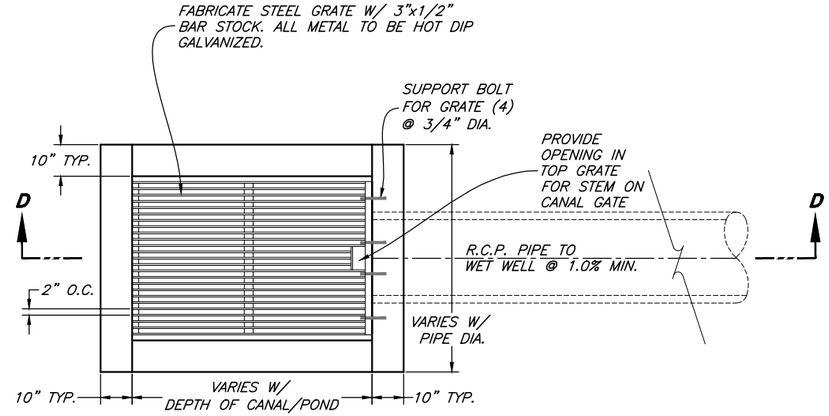
MARRIOTT-SLATERVILLE CITY CORPORATION
PUBLIC WORKS STANDARDS

SECONDARY WATER PUMP CONTROL & FILTER STATION

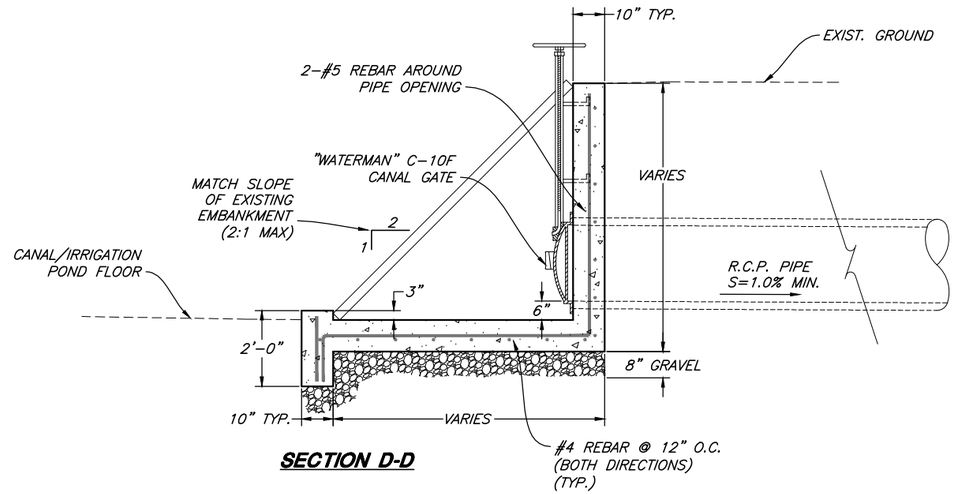
SHEET: 14A
OF 20 SHEETS
0



WET WELL SECTION C-C



PLAN VIEW



SECTION D-D

INLET HEADWALL

IRRIGATION POND OR CANAL

REGISTERED PROFESSIONAL ENGINEER
No. 276381
CHRIS L. BRENNHOLT
STATE OF UTAH

PROJECT ENGINEER

9/04/12
DATE

REV.	DATE	APPR.	
1	12/04	GLS	INCLUDED IN PUBLIC WORKS STANDARDS
2	8/09	CLB	ADDED EXHAUST FAN AND LOUVERED VENT

SCALE: N.T.S.

DESIGNED BEB
DRAWN BEB
CHECKED CLB

JA JONES & ASSOCIATES
CONSULTING ENGINEERS
1716 East 5600 South
Ogden, Utah 84403 (801) 476-9767

MARRIOTT-SLATERVILLE CITY CORPORATION
PUBLIC WORKS STANDARDS

SECONDARY WATER PUMP CONTROL & FILTER STATION

SHEET: 14B
OF 20 SHEETS
0

GREAT BASIN ENGINEERING INC

APPENDIX D

Model Calculations/Results

TEL (801) 394-4515 • FAX (801) 392-7544 • 5746 South 1475 East • Ogden, Utah 84403 • www.greatbasinengineering.com

Design Unit Peak Instantaneous Demand = 15.84 gpm/irr-ac

Village Ph1

Parcel	Size (sf)	Irrigable area (sf)
Lot 1	17846	13846
Lot 2	13474	9474
Lot 3	13532	9532
Lot 4	13589	9589
Lot 5	13647	9647
Lot 6	13705	9705
Lot 7	13830	9830
Lot 8	13830	9830
Lot 9	13830	9830
Lot 10	10576	6576
Lot 11	10576	6576
Lot 12	10576	6576
Lot 13	10576	6576
Lot 14	10576	6576
Lot 15	10576	6576
Lot 16	10576	6576
Lot 17	10548	6548
Lot 18	10548	6548
Lot 19	10576	6576
Lot 20	10576	6576
Lot 21	10576	6576
Lot 22	10576	6576
Lot 23	10576	6576
Lot 24	10576	6576
Lot 25	10548	6548
Lot 26	10548	6548
Lot 27	10576	6576
Lot 28	10576	6576
Lot 29	10576	6576
Lot 30	10576	6576
Lot 31	10576	6576
Lot 32	10576	6576
Lot 33	12527	8527
Lot 34	12432	8432
Lot 35	10577	6577
Lot 36	10556	6556
Parcel A	8908	8463
Parcel B	6725	6389
Parcel C	37461	35588
Parcel D	111748	106161
Assist Living	23941	7182
ROWs	150070	48022
Totals	**755364**	**484316**

Village Ph2

Parcel	Size (sf)	Irrigable area (sf)
Lot 37	10577	6577
Lot 38	10579	6579
Lot 39	13010	9010
Lot 40	13628	9628
Lot 41	10576	6576
Lot 42	10576	6576
Lot 43	10576	6576
Lot 44	10576	6576
Lot 45	10576	6576
Lot 46	10576	6576
Lot 47	11196	7196
Lot 48	11196	7196
Lot 49	10576	6576
Lot 50	10576	6576
Lot 51	10576	6576
Lot 52	10576	6576
Lot 53	10576	6576
Lot 54	10576	6576
Lot 55	11196	7196
Lot 56	21600	17600
Lot 57	15041	11041
Lot 58	14773	10773
Lot 59	14773	10773
Lot 60	14773	10773
Parcel E	6334	6017
Parcel F	8412	7991
Parcel G	1707	1622
Parcel H	1707	1622
Esmt. Comm.	5567	0
ROWs	120734	38635
Agricultural	347003	347003
Parking Lot	34426	0
Totals	**815144**	**596144**

Village Ph3

Parcel	Size (sf)	Irrigable area (sf)
Lot 61	14773	10773
Lot 62	14773	10773
Lot 63	14725	10725
Lot 64	13894	9894
Lot 65	13894	9894
Lot 66	13894	9894
Lot 67	13892	9892
Lot 68	10576	6576
Lot 69	10576	6576
Lot 70	10576	6576
Lot 71	11196	7196
Lot 72	11196	7196
Lot 73	10576	6576
Lot 74	10576	6576
Lot 75	10576	6576
Lot 76	10576	6576
Lot 77	10576	6576
Lot 78	10576	6576
Lot 79	11201	7201
Esmt. Comm.	3340	0
ROWs	63492	20317
Agricultural	660216	660216
Totals	**955670**	**833155**

Meadows Ph1

Parcel	Size (sf)	Irrigable area (sf)
Lot 1M*	21626	16626
Lot 2M*	21758	16758
Lot 3M*	43635	37635
Lot 4M*	43892	37892
Lot 5M*	44157	38157
Lot 6M*	82655	76655
Lot 7M*	64607	58607
Lot 8M*	45559	39559
Lot 9M*	45559	39559
Lot 10M*	45559	39559
Lot 11M*	22455	17455
Lot 12M*	23104	18104
ROWs	73448	13441
Totals	**578014**	**450007**

*"M" added to Meadows Lot Numbers for convenience as an indication that the particular lot is part of Meadows and not Village

Phase	Irrigable Area: Residential Lots*	Agricultural	Common Area**	Assisted Senior Living***	Rights-of-Way****	Units	Totals	Units
Village 1	272511	0	156600	7182	48022	Square Feet	2363622	Square Feet
Village 2	193254	347003	17252	0	38635			
Village 3	152622	660216	0	0	20317			
Meadows 1	436566	0	0	0	13441			
Village 1	6.256	0.000	3.595	0.165	1.102	Acres	54.26	Acres
Village 2	4.437	7.966	0.396	0.000	0.887			
Village 3	3.504	15.156	0.000	0.000	0.466			
Meadows 1	10.022	0.000	0.000	0.000	0.309			

*Assumes 4000 sf non-irrig per lot for Village, 5000 sf for lots 1,2,11,12 and 6000 sf for lots 3 - 10 in Meadows.

**Assumes 5% non-irrig areas for gravel paths, small structures, etc.

***Assumes 70% non-irrig areas for building, sidewalks, etc.

****Use 68.0% non-irrig areas for Village ROWs since 34' out of 50' ROW has asph or conc paving. Use 81.7% non-irrig areas for Meadows since 49' out of of 60' ROW has asph or conc paving.

Project : Terakee Village (Secondary includes Terrakee Meadow) Date: 1/20/2021

(This report assumes that the necessary water rights either are or will be provided to meet the needs of this system)
In this report, **"Source"** refers to ground water being taken by the well and **"Storage"** refers to the secondary water pond.

Secondary Water Source and Storage/Use Sizing for Terakee Village and Meadows

Total Irrigable Acreage =	**54.26**	irr-ac
*Zone =	**4**	

* Zone Determined from Irrigated Crop Consumptive Use Zones and Normal Annual Effective Precipitation, Utah (See Utah Rule R309-510-7(3)

Source Requirements:

Volume: (See Table 510-3 in Utah Rule R309-510-7(3))

Unit Water Right Requirement =	1.87	ac-ft/irr-ac per year
Total Water Right Requirement =	**101.47**	ac-ft/yr
Number of Watering Days =	213	days (Assumes April - October)
Volume available for use =	3.33	ac-ft/wk

Flow Rate: (See Table 510-3 in Utah Rule R309-510-7(3))

Unit Peak Day Demand =	3.96	gpm/irr-acre
Total Peak Day Demand =	**215**	gpm (peak required from well to pond)

Storage/Use Requirements:

Volume: (See Table 510-5 in Utah Rule R309-510-8(2c))

Unit Storage Requirement =	2848	gal/irr-acre
=	0.00874	ac-ft/irr-ac
Total Storage Requirement =	**0.47**	ac-ft

Flow Rate: (See Table 510-7 in Utah Rule R309-510-9(3))

Provided Unit Peak Inst. Demand =	7.92	gpm/irr-acre
Safety Factor =	2	
Design Unit Peak Inst. Demand =	15.84	gpm/irr-acre
Design Peak Inst. Demand =	**859**	gpm (peak delivered from pond to irrigation main)

Design Unit Peak Instantaneous Demand = 15.84 gpm/irr-ac
Total Peak Instantaneous Demand = 859.50 gpm

Residential Lots

Lot	Size (sf)	Initial Irrigable area (sf)	Adjusted** Irrigable area (sf)	Des. Peak Instant. (gpm)
Lot 1	17846	13846	15904	5.78
Lot 2	13474	9474	11028	4.01
Lot 3	13532	9532	11092	4.03
Lot 4	13589	9589	11156	4.06
Lot 5	13647	9647	11220	4.08
Lot 6	13705	9705	11285	4.10
Lot 7	13830	9830	11425	4.15
Lot 8	13830	9830	11425	4.15
Lot 9	13830	9830	11425	4.15
Lot 10	10576	6576	7795	2.83
Lot 11	10576	6576	7795	2.83
Lot 12	10576	6576	7795	2.83
Lot 13	10576	6576	7795	2.83
Lot 14	10576	6576	7795	2.83
Lot 15	10576	6576	7795	2.83
Lot 16	10576	6576	7795	2.83
Lot 17	10548	6548	7764	2.82
Lot 18	10548	6548	7764	2.82
Lot 19	10576	6576	7795	2.83
Lot 20	10576	6576	7795	2.83
Lot 21	10576	6576	7795	2.83
Lot 22	10576	6576	7795	2.83
Lot 23	10576	6576	7795	2.83
Lot 24	10576	6576	7795	2.83
Lot 25	10548	6548	7764	2.82
Lot 26	10548	6548	7764	2.82
Lot 27	10576	6576	7795	2.83
Lot 28	10576	6576	7795	2.83
Lot 29	10576	6576	7795	2.83
Lot 30	10576	6576	7795	2.83
Lot 31	10576	6576	7795	2.83
Lot 32	10576	6576	7795	2.83
Lot 33	12527	8527	9971	3.63
Lot 34	12432	8432	9865	3.59
Lot 35	10577	6577	7796	2.84
Lot 36	10556	6556	7773	2.83
Lot 37	10577	6577	7990	2.91
Lot 38	10579	6579	7992	2.91
Lot 39	13010	9010	10748	3.91
Lot 40	13628	9628	11448	4.16
Lot 41	10576	6576	7989	2.90
Lot 42	10576	6576	7989	2.90
Lot 43	10576	6576	7989	2.90
Lot 44	10576	6576	7989	2.90
Lot 45	10576	6576	7989	2.90
Lot 46	10576	6576	7989	2.90
Lot 47	11196	7196	8691	3.16
Lot 48	11196	7196	8691	3.16
Lot 49	10576	6576	7989	2.90
Lot 50	10576	6576	7989	2.90
Lot 51	10576	6576	7989	2.90
Lot 52	10576	6576	7989	2.90
Lot 53	10576	6576	7989	2.90
Lot 54	10576	6576	7989	2.90
Lot 55	11196	7196	8691	3.16
Lot 56	21600	17600	20485	7.45
Lot 57	15041	11041	13050	4.75
Lot 58	14773	10773	12746	4.63
Lot 59	14773	10773	12746	4.63
Lot 60	14773	10773	12746	4.63
Lot 61	14773	10773	12086	4.39
Lot 62	14773	10773	12086	4.39
Lot 63	14725	10725	12034	4.38
Lot 64	13894	9894	11129	4.05
Lot 65	13894	9894	11129	4.05
Lot 66	13894	9894	11129	4.05
Lot 67	13892	9892	11127	4.05
Lot 68	10576	6576	7516	2.73
Lot 69	10576	6576	7516	2.73
Lot 70	10576	6576	7516	2.73
Lot 71	11196	7196	8191	2.98
Lot 72	11196	7196	8191	2.98
Lot 73	10576	6576	7516	2.73
Lot 74	10576	6576	7516	2.73
Lot 75	10576	6576	7516	2.73
Lot 76	10576	6576	7516	2.73
Lot 77	10576	6576	7516	2.73
Lot 78	10576	6576	7516	2.73
Lot 79	11201	7201	8196	2.98
Lot 1M*	21626	16626	17202	6.26
Lot 2M*	21758	16758	17338	6.30
Lot 3M*	43635	37635	38797	14.11
Lot 4M*	43892	37892	39061	14.20
Lot 5M*	44157	38157	39333	14.30
Lot 6M*	82655	76655	78857	28.68
Lot 7M*	64607	58607	60328	21.94
Lot 8M*	45559	39559	40773	14.83
Lot 9M*	45559	39559	40773	14.83
Lot 10M*	45559	39559	40773	14.83
Lot 11M*	22455	17455	18053	6.56
Lot 12M*	23104	18104	18719	6.81

*"M" added to Meadows Lot Numbers for convenience as an indication that the particular lot is part of Meadows and not Village
**These include a pro-rated value (by total lot areas in applicable phase) of the park strip in the ROW for each lot.

Non-Res Lot Areas

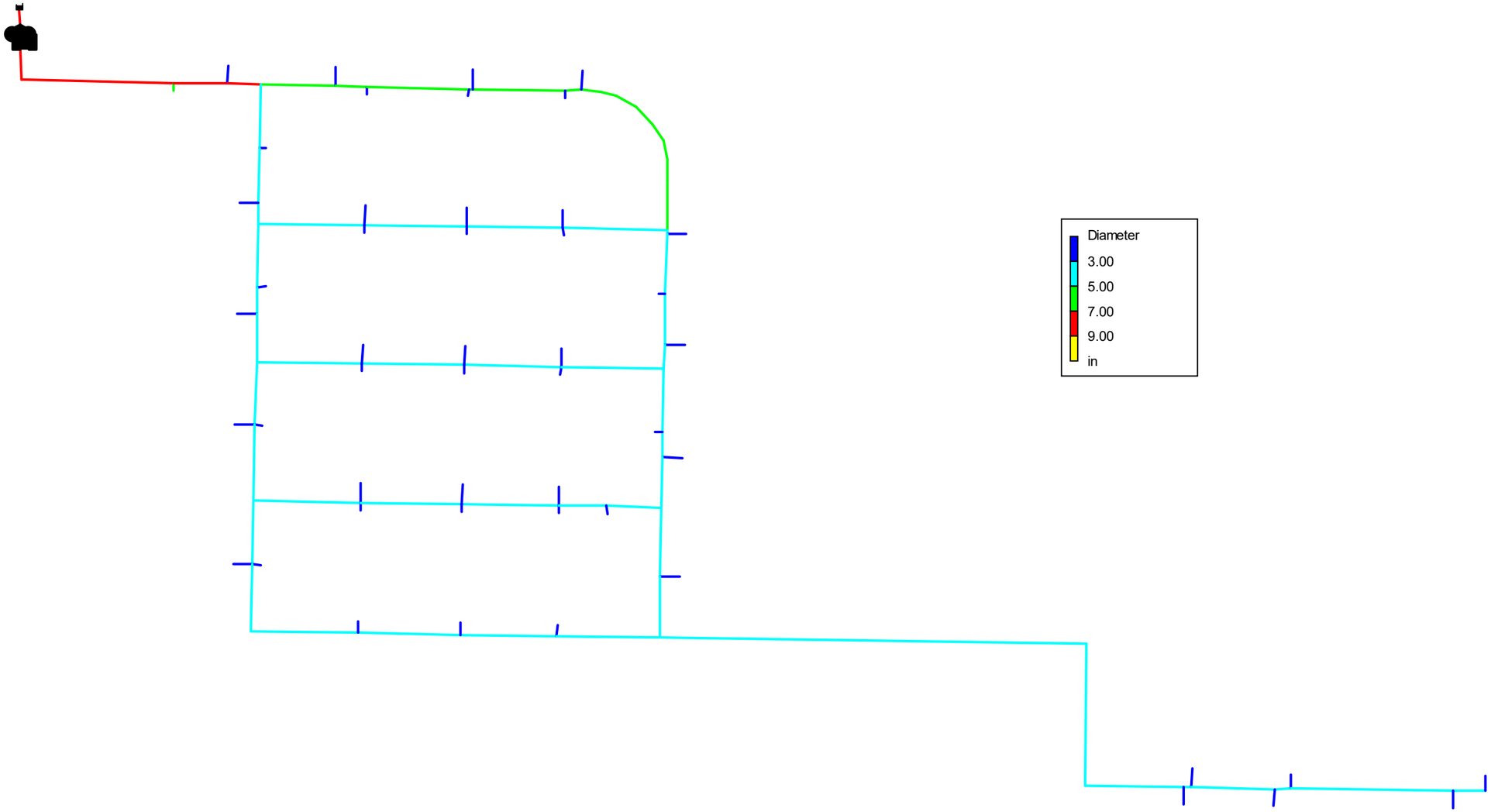
Parcel	Size (sf)	Irrigable area (sf)	Des. Peak Instant. (gpm)
Ph1 ROWs	150070	48022	0.00
Ph2 ROWs	120734	38635	0.00
Ph3 ROWs	63492	20317	0.00
Ph1M ROWs	73448	13441	0.00
Parcel A	8908	8463	3.08
Parcel B	6725	6389	2.32
Parcel C	37461	35588	12.94
Parcel D	111748	106161	38.60
Parcel E	6334	6017	2.19
Parcel F	8412	7991	2.91
Parcel G	1707	1622	0.59
Parcel H	1707	1622	0.59
Assist Liv	23941	7182	2.61
Ph2 Agric.	347003	347003	126.18
Ph3 Agric.	660216	660216	240.08

These flows are accounted for by pro-rating and adding to the Initial Lot Irrigable areas to become Adjusted Irrigable areas.

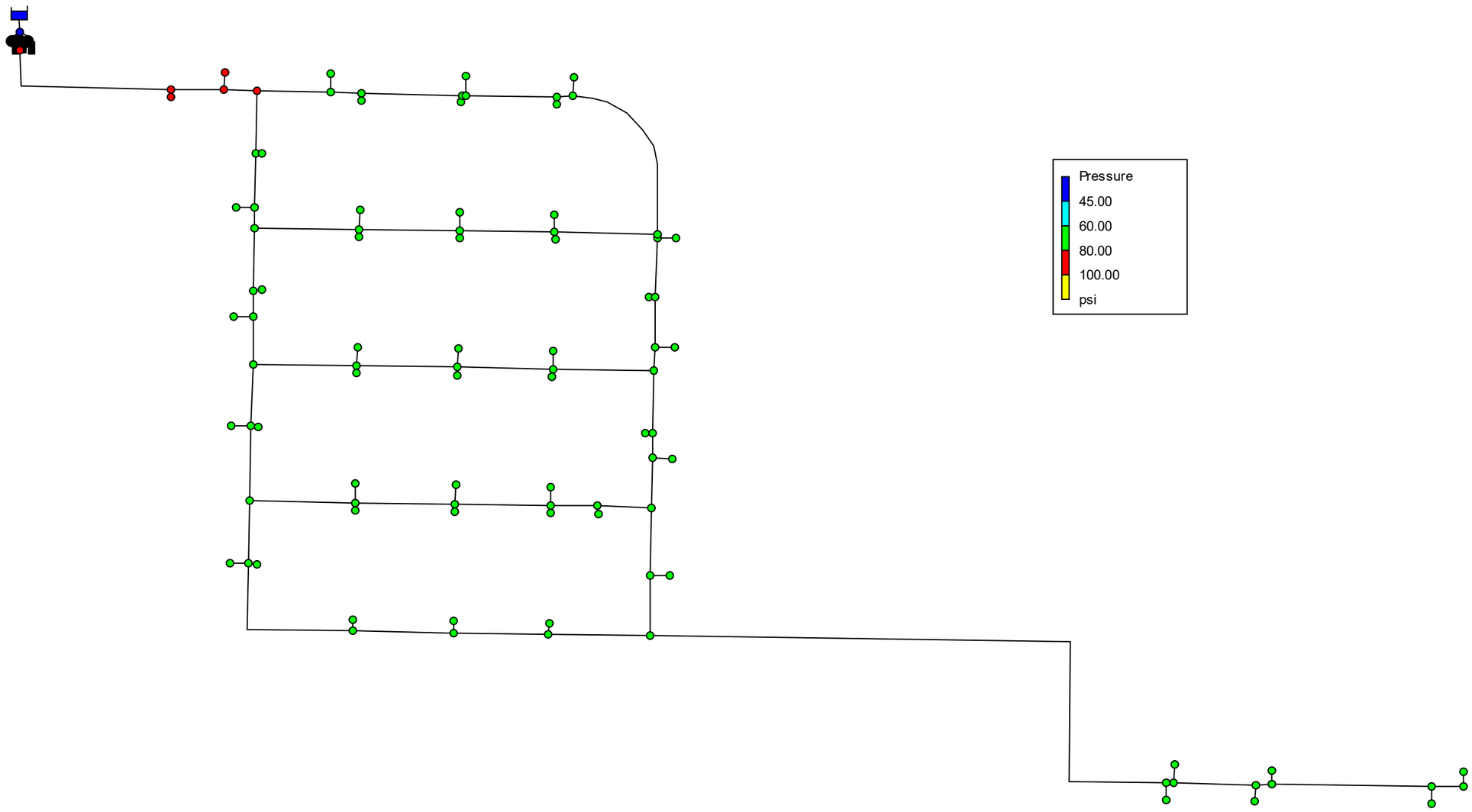
Connection #	Demand (gpm)	Responsible for providing secondary water to…				
C1	370.64	Lot 63	Ph2 Agric.	Ph3 Agric.		
C2	8.09	Lot 64	Lot 65			
C3	5.96	Lot 71	Lot 72			
C4	8.79	Lot 61	Lot 62			
C5	6.14	Lot 55	Lot 79			
C6	9.27	Lot 59	Lot 60			
C7	9.38	Lot 57	Lot 58			
C8	6.32	Lot 47	Lot 48			
C9	13.72	Lot 56	Parcel E	Parcel F	Parcel G	Parcel H
C10	4.16	Lot 40				
C11	8.09	Lot 66	Lot 67			
C12	5.47	Lot 69	Lot 70			
C13	5.57	Lot 10	Lot 68			
C14	8.31	Lot 8	Lot 9			
C15	54.38	Lot 11	Parcel C	Parcel D		
C16	6.77	Lot 7	Assist Liv			
C17	5.47	Lot 73	Lot 74			
C18	5.47	Lot 77	Lot 78			
C19	5.57	Lot 13	Lot 75			
C20	5.57	Lot 14	Lot 76			
C21	2.83	Lot 12				
C22	5.67	Lot 15	Lot 16			
C23	4.10	Lot 6				
C24	5.65	Lot 17	Lot 18			
C25	8.14	Lot 4	Lot 5			
C26	5.81	Lot 53	Lot 54			
C27	5.81	Lot 49	Lot 50			
C28	5.74	Lot 21	Lot 52			
C29	5.74	Lot 22	Lot 51			
C30	5.67	Lot 19	Lot 20			
C31	5.67	Lot 23	Lot 24			
C32	5.65	Lot 25	Lot 26			
C33	8.04	Lot 2	Lot 3			
C34	5.81	Lot 45	Lot 46			
C35	5.81	Lot 41	Lot 42			
C36	5.74	Lot 29	Lot 44			
C37	5.74	Lot 30	Lot 43			
C38	5.67	Lot 27	Lot 28			
C39	5.67	Lot 31	Lot 32			
C40	3.63	Lot 33				
C41	11.18	Lot 1	Parcel A	Parcel B		
C42	6.81	Lot 38	Lot 39			
C43	5.73	Lot 36	Lot 37			
C44	6.42	Lot 34	Lot 35			
C45	12.56	Lot 1M*	Lot 2M*			
C46	13.37	Lot 11M*	Lot 12M*			
C47	28.31	Lot 3M*	Lot 4M*			
C48	29.65	Lot 9M*	Lot 10M*			
C49	42.98	Lot 5M*	Lot 6M*			
C50	36.76	lot 7M*	Lot 8M*			

Total = 859.50

Pipe Diameters



All Pumps On



All Pumps On

Network Table - Nodes

Node ID	Base Demand GPM	Head ft	Pressure psi
Junc J.49	0	4384.58	62.65
Junc J.21.22	0	4419.95	77.97
Junc J.38.39	0	4412.21	74.62
Junc J.43	0	4410.45	73.86
Junc J.28.29	0	4415.35	75.98
Junc J.44	0	4410.07	73.69
Junc J.50	0	4384.51	62.62
Junc J.7.8	0	4413.96	75.38
Junc J.41	0	4410.81	74.01
Junc J.19.20	0	4419.87	77.94
Junc J.34.35	0	4412.35	74.68
Junc J.17.18	0	4419.85	77.93
Junc J.42	0	4410.95	74.07
Junc J.6	0	4416.79	76.60
Junc J.24	0	4417.84	77.06
Junc J.9.10	0	4411.98	74.52
Junc 104	0	4419.85	77.93
Junc J.5	0	4417.66	76.98
Junc 106	0	4412.57	74.77
Junc J.30.31	0	4415.35	75.98
Junc J.32	0	4413.82	75.32
Junc J.26.27	0	4415.35	75.98
Junc J.40	0	4412.21	74.62
Junc J.25	0	4416.12	76.31
Junc J.33	0	4413.24	75.07
Junc J.12	0	4423.84	79.66
Junc J.45	0	4388.35	64.28
Junc J.11	0	4424.23	79.83
Junc J.13	0	4422.60	79.12

All Pumps On

Node ID	Base Demand GPM	Head ft	Pressure psi
Junc J.36.37	0	4412.24	74.63
Junc 105	0	4415.41	76.01
Junc 103	0	4425.23	80.26
Junc J.1	0	4425.95	80.57
Junc 102	0	4430.43	82.51
Junc 101	0	4234.58	-2.35
Junc J.47	0	4386.20	63.35
Junc J.2	0	4425.50	80.38
Junc 108	0	4415.40	76.00
Junc 107	0	4420.09	78.03
Junc J.23	0	4419.95	77.97
Junc J.48	0	4385.95	63.24
Junc J.4	0	4420.56	78.24
Junc 110	0	4409.75	73.55
Junc J.3	0	4422.65	79.14
Junc J.15	0	4421.53	78.66
Junc J.46	0	4388.15	64.19
Junc J.14	0	4422.55	79.10
Junc 109	0	4412.21	74.62
Junc J.16	0	4421.41	78.60
Junc C21	2.83	4419.94	77.97
Junc C40	3.63	4412.20	74.61
Junc C23	4.1	4419.93	77.97
Junc C10	4.16	4411.97	74.52
Junc C12	5.47	4423.83	79.65
Junc C17	5.47	4419.82	77.92
Junc C18	5.47	4419.84	77.92
Junc C20	5.57	4419.86	77.93
Junc C19	5.57	4419.84	77.92
Junc C13	5.57	4422.59	79.12

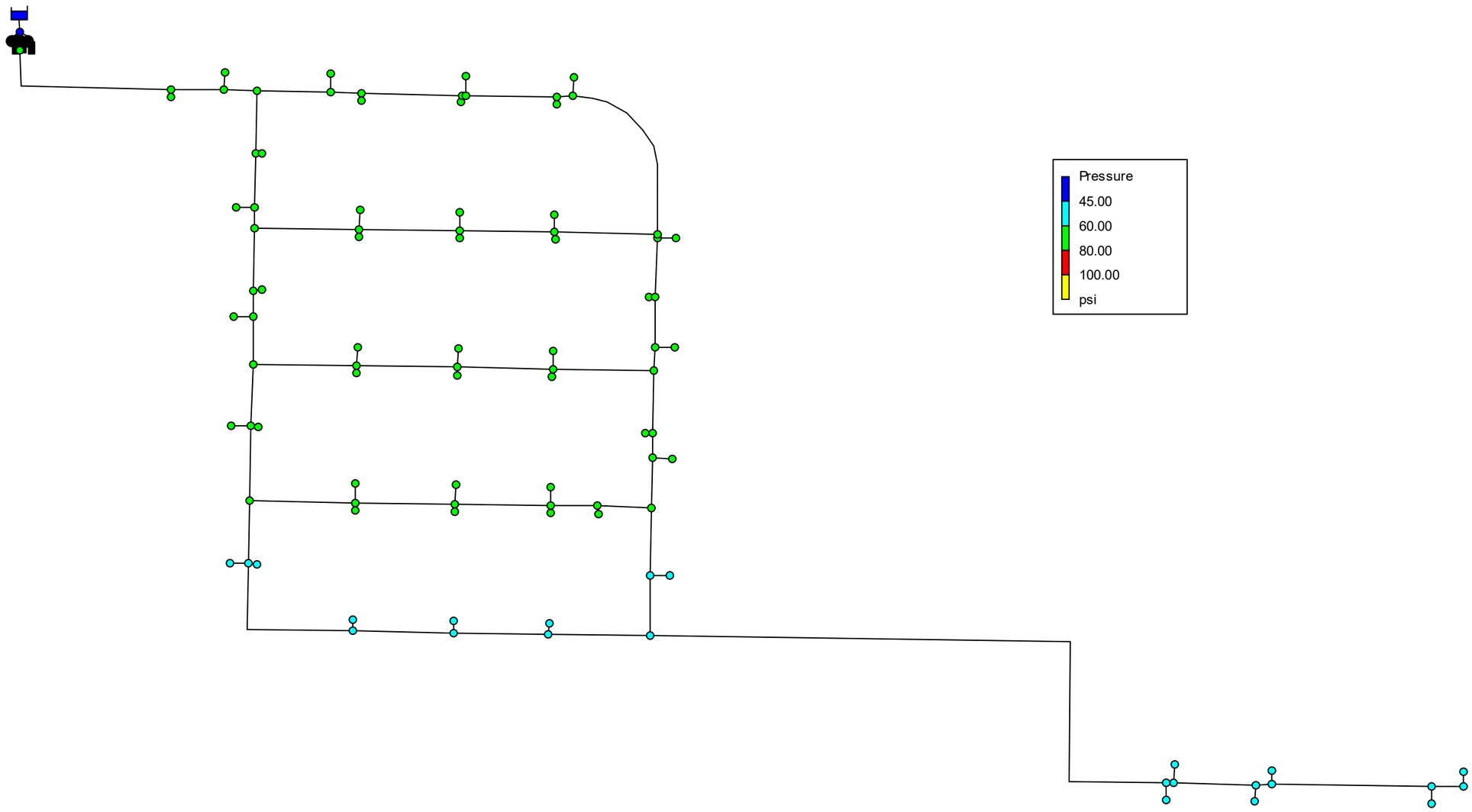
All Pumps On

Node ID	Base Demand GPM	Head ft	Pressure psi
Junc C24	5.65	4417.83	77.05
Junc C32	5.65	4413.81	75.31
Junc C38	5.67	4412.17	74.60
Junc C39	5.67	4412.19	74.61
Junc C31	5.67	4415.34	75.97
Junc C30	5.67	4415.32	75.97
Junc C22	5.67	4419.93	77.96
Junc C43	5.73	4410.43	73.85
Junc C37	5.74	4412.23	74.63
Junc C36	5.74	4412.21	74.62
Junc C28	5.74	4415.31	75.96
Junc C29	5.74	4415.33	75.97
Junc C35	5.81	4412.33	74.67
Junc C26	5.81	4415.32	75.97
Junc C27	5.81	4415.34	75.97
Junc C34	5.81	4412.31	74.66
Junc C3	5.96	4422.63	79.14
Junc C5	6.14	4417.65	76.97
Junc C8	6.32	4413.94	75.37
Junc C44	6.42	4410.04	73.68
Junc C16	6.77	4421.36	78.58
Junc C42	6.81	4410.92	74.06
Junc C33	8.04	4413.17	75.04
Junc C11	8.09	4424.16	79.80
Junc C2	8.09	4425.43	80.35
Junc C25	8.14	4416.05	76.28
Junc C14	8.31	4422.48	79.07
Junc C4	8.79	4420.49	78.20
Junc C6	9.27	4416.70	76.56
Junc C7	9.38	4413.87	75.34

All Pumps On

Node ID	Base Demand GPM	Head ft	Pressure psi
Junc C41	11.18	4410.68	73.96
Junc C45	12.56	4388.21	64.22
Junc C46	13.37	4387.98	64.12
Junc C9	13.72	4411.80	74.44
Junc C47	28.31	4385.60	63.09
Junc C48	29.65	4385.40	63.00
Junc C50	36.76	4383.63	62.23
Junc C49	42.98	4383.18	62.04
Junc C15	54.38	4420.64	78.27
Junc C1	370.64	4425.80	80.51
Resvr RES	#N/A	4235.00	0.00

Pump-1 OFF



Pump-1 OFF

Network Table - Nodes

Node ID	Base Demand GPM	Head ft	Pressure psi
Junc J.49	0	4351.05	48.12
Junc J.21.22	0	4386.41	63.44
Junc J.38.39	0	4378.68	60.09
Junc J.43	0	4376.92	59.33
Junc J.28.29	0	4381.82	61.45
Junc J.44	0	4376.54	59.16
Junc J.50	0	4350.98	48.09
Junc J.7.8	0	4380.43	60.85
Junc J.41	0	4377.28	59.48
Junc J.19.20	0	4386.34	63.41
Junc J.34.35	0	4378.82	60.15
Junc J.17.18	0	4386.32	63.40
Junc J.42	0	4377.42	59.54
Junc J.6	0	4383.25	62.07
Junc J.24	0	4384.31	62.53
Junc J.9.10	0	4378.45	59.99
Junc 104	0	4386.32	63.40
Junc J.5	0	4384.13	62.45
Junc 106	0	4379.04	60.24
Junc J.30.31	0	4381.82	61.45
Junc J.32	0	4380.29	60.79
Junc J.26.27	0	4381.82	61.45
Junc J.40	0	4378.68	60.09
Junc J.25	0	4382.58	61.78
Junc J.33	0	4379.71	60.54
Junc J.12	0	4390.31	65.13
Junc J.45	0	4354.82	49.75
Junc J.11	0	4390.70	65.30
Junc J.13	0	4389.07	64.59

Pump-1 OFF

Node ID	Base Demand GPM	Head ft	Pressure psi
Junc J.36.37	0	4378.71	60.10
Junc 105	0	4381.88	61.48
Junc 103	0	4391.70	65.73
Junc J.1	0	4392.42	66.04
Junc 102	0	4396.90	67.98
Junc 101	0	4234.58	-2.35
Junc J.47	0	4352.67	48.82
Junc J.2	0	4391.96	65.85
Junc 108	0	4381.87	61.47
Junc 107	0	4386.56	63.50
Junc J.23	0	4386.42	63.44
Junc J.48	0	4352.42	48.71
Junc J.4	0	4387.03	63.71
Junc 110	0	4376.21	59.02
Junc J.3	0	4389.12	64.61
Junc J.15	0	4388.00	64.13
Junc J.46	0	4354.62	49.66
Junc J.14	0	4389.02	64.57
Junc 109	0	4378.68	60.09
Junc J.16	0	4387.87	64.07
Junc C21	2.83	4386.40	63.44
Junc C40	3.63	4378.67	60.09
Junc C23	4.1	4386.40	63.44
Junc C10	4.16	4378.44	59.99
Junc C12	5.47	4390.30	65.12
Junc C17	5.47	4386.29	63.39
Junc C18	5.47	4386.31	63.40
Junc C20	5.57	4386.33	63.40
Junc C19	5.57	4386.31	63.39
Junc C13	5.57	4389.06	64.59

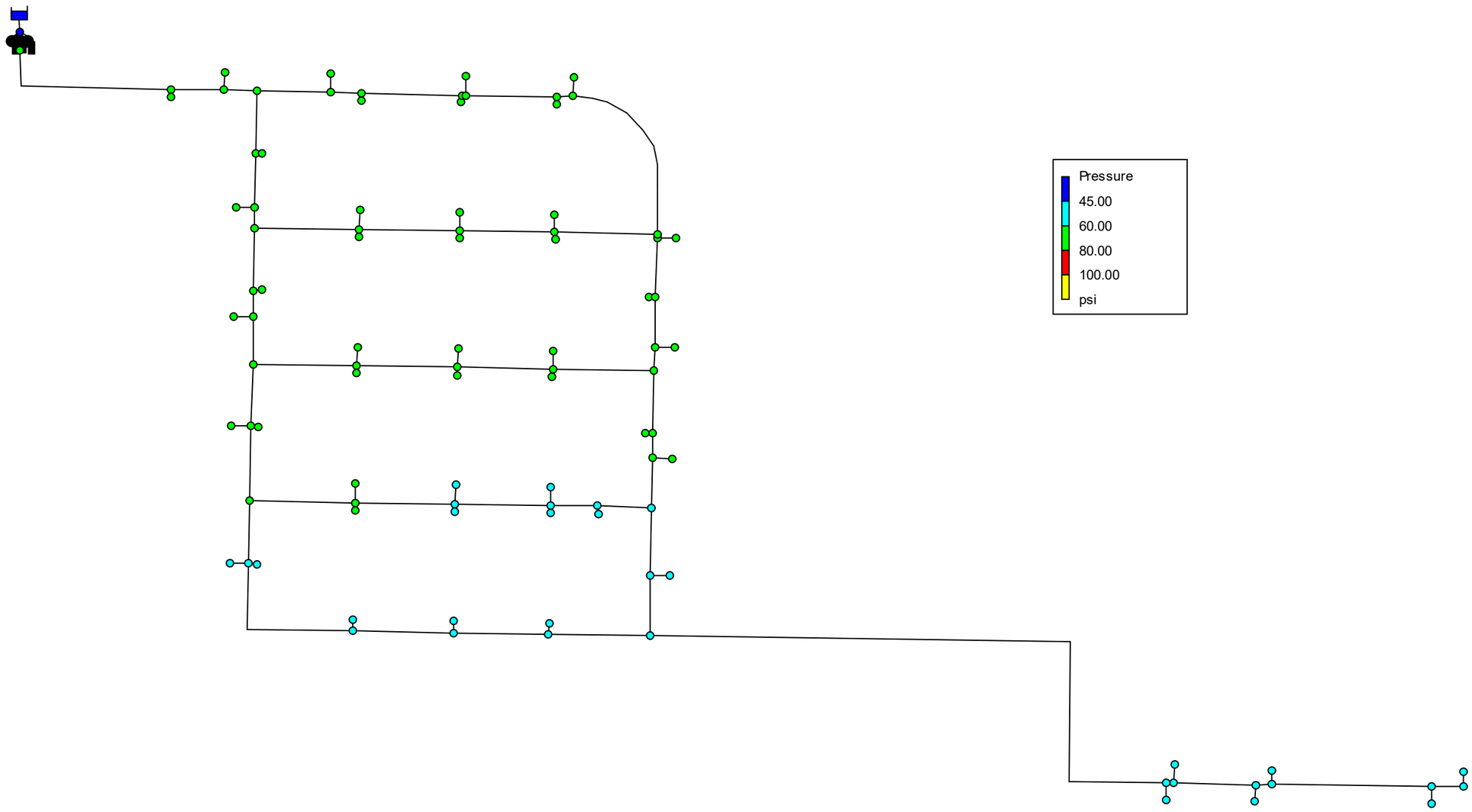
Pump-1 OFF

Node ID	Base Demand GPM	Head ft	Pressure psi
Junc C24	5.65	4384.29	62.52
Junc C32	5.65	4380.27	60.78
Junc C38	5.67	4378.64	60.07
Junc C39	5.67	4378.66	60.08
Junc C31	5.67	4381.81	61.44
Junc C30	5.67	4381.79	61.44
Junc C22	5.67	4386.40	63.44
Junc C43	5.73	4376.90	59.32
Junc C37	5.74	4378.70	60.10
Junc C36	5.74	4378.67	60.09
Junc C28	5.74	4381.78	61.43
Junc C29	5.74	4381.80	61.44
Junc C35	5.81	4378.80	60.14
Junc C26	5.81	4381.79	61.44
Junc C27	5.81	4381.81	61.45
Junc C34	5.81	4378.78	60.13
Junc C3	5.96	4389.10	64.61
Junc C5	6.14	4384.11	62.44
Junc C8	6.32	4380.41	60.84
Junc C44	6.42	4376.51	59.15
Junc C16	6.77	4387.82	64.05
Junc C42	6.81	4377.39	59.53
Junc C33	8.04	4379.64	60.51
Junc C11	8.09	4390.63	65.27
Junc C2	8.09	4391.90	65.82
Junc C25	8.14	4382.51	61.75
Junc C14	8.31	4388.95	64.54
Junc C4	8.79	4386.95	63.68
Junc C6	9.27	4383.17	62.03
Junc C7	9.38	4380.33	60.81

Pump-1 OFF

Node ID	Base Demand GPM	Head ft	Pressure psi
Junc C41	11.18	4377.15	59.43
Junc C45	12.56	4354.68	49.69
Junc C46	13.37	4354.44	49.59
Junc C9	13.72	4378.27	59.91
Junc C47	28.31	4352.07	48.56
Junc C48	29.65	4351.86	48.47
Junc C50	36.76	4350.10	47.70
Junc C49	42.98	4349.65	47.51
Junc C15	54.38	4387.11	63.74
Junc C1	370.64	4392.26	65.98
Resvr RES	#N/A	4235.00	0.00

Pump-2 OFF



Pump-2 OFF

Network Table - Nodes

Node ID	Base Demand GPM	Head ft	Pressure psi
Junc J.49	0	4350.79	48.01
Junc J.21.22	0	4386.16	63.33
Junc J.38.39	0	4378.42	59.98
Junc J.43	0	4376.67	59.22
Junc J.28.29	0	4381.56	61.34
Junc J.44	0	4376.28	59.05
Junc J.50	0	4350.73	47.98
Junc J.7.8	0	4380.18	60.74
Junc J.41	0	4377.03	59.37
Junc J.19.20	0	4386.09	63.30
Junc J.34.35	0	4378.56	60.04
Junc J.17.18	0	4386.07	63.29
Junc J.42	0	4377.17	59.43
Junc J.6	0	4383.00	61.96
Junc J.24	0	4384.05	62.42
Junc J.9.10	0	4378.20	59.88
Junc 104	0	4386.07	63.29
Junc J.5	0	4383.88	62.34
Junc 106	0	4378.78	60.14
Junc J.30.31	0	4381.57	61.34
Junc J.32	0	4380.04	60.68
Junc J.26.27	0	4381.57	61.34
Junc J.40	0	4378.42	59.98
Junc J.25	0	4382.33	61.67
Junc J.33	0	4379.46	60.43
Junc J.12	0	4390.06	65.02
Junc J.45	0	4354.57	49.64
Junc J.11	0	4390.44	65.19
Junc J.13	0	4388.81	64.48

Pump-2 OFF

Node ID	Base Demand GPM	Head ft	Pressure psi
Junc J.36.37	0	4378.46	59.99
Junc 105	0	4381.63	61.37
Junc 103	0	4391.45	65.62
Junc J.1	0	4392.16	65.93
Junc 102	0	4396.64	67.87
Junc 101	0	4234.58	-2.35
Junc J.47	0	4352.42	48.71
Junc J.2	0	4391.71	65.74
Junc 108	0	4381.61	61.36
Junc 107	0	4386.31	63.39
Junc J.23	0	4386.17	63.34
Junc J.48	0	4352.17	48.60
Junc J.4	0	4386.78	63.60
Junc 110	0	4375.96	58.91
Junc J.3	0	4388.86	64.50
Junc J.15	0	4387.74	64.02
Junc J.46	0	4354.36	49.55
Junc J.14	0	4388.77	64.46
Junc 109	0	4378.42	59.98
Junc J.16	0	4387.62	63.96
Junc C21	2.83	4386.15	63.33
Junc C40	3.63	4378.42	59.98
Junc C23	4.1	4386.15	63.33
Junc C10	4.16	4378.19	59.88
Junc C12	5.47	4390.04	65.01
Junc C17	5.47	4386.04	63.28
Junc C18	5.47	4386.06	63.29
Junc C20	5.57	4386.08	63.30
Junc C19	5.57	4386.05	63.29
Junc C13	5.57	4388.80	64.48

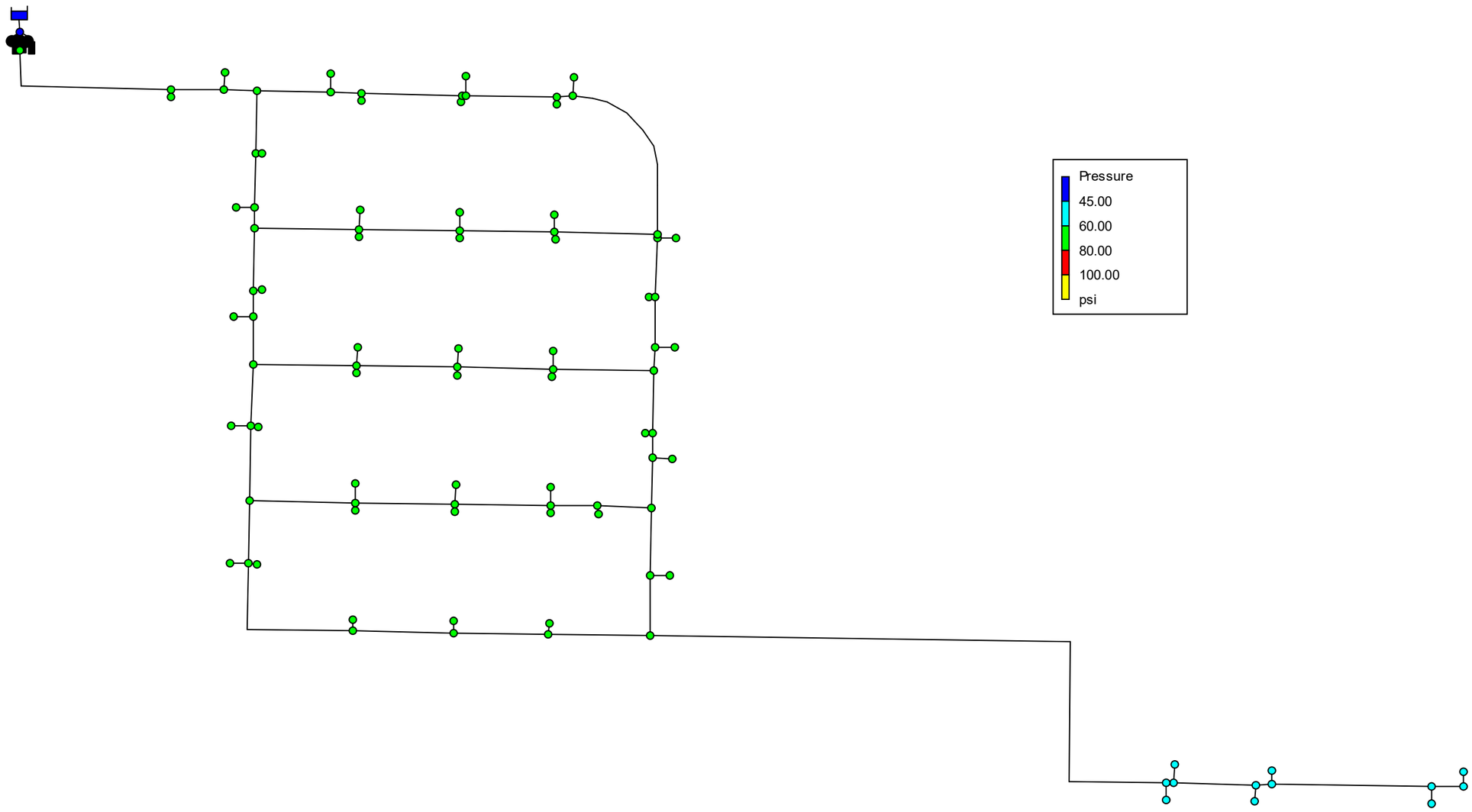
Pump-2 OFF

Node ID	Base Demand GPM	Head ft	Pressure psi
Junc C24	5.65	4384.04	62.41
Junc C32	5.65	4380.02	60.67
Junc C38	5.67	4378.39	59.96
Junc C39	5.67	4378.41	59.97
Junc C31	5.67	4381.55	61.34
Junc C30	5.67	4381.53	61.33
Junc C22	5.67	4386.15	63.33
Junc C43	5.73	4376.65	59.21
Junc C37	5.74	4378.44	59.99
Junc C36	5.74	4378.42	59.98
Junc C28	5.74	4381.53	61.32
Junc C29	5.74	4381.55	61.33
Junc C35	5.81	4378.55	60.03
Junc C26	5.81	4381.54	61.33
Junc C27	5.81	4381.56	61.34
Junc C34	5.81	4378.53	60.02
Junc C3	5.96	4388.85	64.50
Junc C5	6.14	4383.86	62.33
Junc C8	6.32	4380.16	60.73
Junc C44	6.42	4376.26	59.04
Junc C16	6.77	4387.57	63.94
Junc C42	6.81	4377.14	59.42
Junc C33	8.04	4379.39	60.40
Junc C11	8.09	4390.38	65.16
Junc C2	8.09	4391.65	65.71
Junc C25	8.14	4382.26	61.64
Junc C14	8.31	4388.69	64.43
Junc C4	8.79	4386.70	63.57
Junc C6	9.27	4382.91	61.92
Junc C7	9.38	4380.08	60.70

Pump-2 OFF

Node ID	Base Demand GPM	Head ft	Pressure psi
Junc C41	11.18	4376.90	59.32
Junc C45	12.56	4354.43	49.58
Junc C46	13.37	4354.19	49.48
Junc C9	13.72	4378.02	59.80
Junc C47	28.31	4351.81	48.45
Junc C48	29.65	4351.61	48.36
Junc C50	36.76	4349.84	47.60
Junc C49	42.98	4349.39	47.40
Junc C15	54.38	4386.85	63.63
Junc C1	370.64	4392.01	65.87
Resvr RES	#N/A	4235.00	0.00

Pump-3 OFF



Pump-3 OFF

Network Table - Nodes

Node ID	Base Demand GPM	Head ft	Pressure psi
Junc J.49	0	4372.87	57.57
Junc J.21.22	0	4408.24	72.90
Junc J.38.39	0	4400.50	69.55
Junc J.43	0	4398.75	68.79
Junc J.28.29	0	4403.64	70.91
Junc J.44	0	4398.36	68.62
Junc J.50	0	4372.81	57.55
Junc J.7.8	0	4402.26	70.31
Junc J.41	0	4399.11	68.94
Junc J.19.20	0	4408.17	72.87
Junc J.34.35	0	4400.64	69.61
Junc J.17.18	0	4408.15	72.86
Junc J.42	0	4399.25	69.00
Junc J.6	0	4405.08	71.53
Junc J.24	0	4406.13	71.99
Junc J.9.10	0	4400.28	69.45
Junc 104	0	4408.15	72.86
Junc J.5	0	4405.96	71.91
Junc 106	0	4400.86	69.70
Junc J.30.31	0	4403.65	70.91
Junc J.32	0	4402.12	70.24
Junc J.26.27	0	4403.65	70.91
Junc J.40	0	4400.50	69.55
Junc J.25	0	4404.41	71.24
Junc J.33	0	4401.54	69.99
Junc J.12	0	4412.14	74.59
Junc J.45	0	4376.65	59.21
Junc J.11	0	4412.52	74.75
Junc J.13	0	4410.90	74.05

Pump-3 OFF

Node ID	Base Demand GPM	Head ft	Pressure psi
Junc J.36.37	0	4400.54	69.56
Junc 105	0	4403.71	70.93
Junc 103	0	4413.53	75.19
Junc J.1	0	4414.24	75.50
Junc 102	0	4418.72	77.44
Junc 101	0	4234.58	-2.35
Junc J.47	0	4374.50	58.28
Junc J.2	0	4413.79	75.30
Junc 108	0	4403.69	70.93
Junc 107	0	4408.39	72.96
Junc J.23	0	4408.25	72.90
Junc J.48	0	4374.25	58.17
Junc J.4	0	4408.86	73.17
Junc 110	0	4398.04	68.48
Junc J.3	0	4410.94	74.07
Junc J.15	0	4409.82	73.58
Junc J.46	0	4376.44	59.12
Junc J.14	0	4410.85	74.03
Junc 109	0	4400.50	69.55
Junc J.16	0	4409.70	73.53
Junc C21	2.83	4408.23	72.89
Junc C40	3.63	4400.50	69.54
Junc C23	4.1	4408.23	72.89
Junc C10	4.16	4400.27	69.44
Junc C12	5.47	4412.12	74.58
Junc C17	5.47	4408.12	72.84
Junc C18	5.47	4408.14	72.85
Junc C20	5.57	4408.16	72.86
Junc C19	5.57	4408.13	72.85
Junc C13	5.57	4410.88	74.04

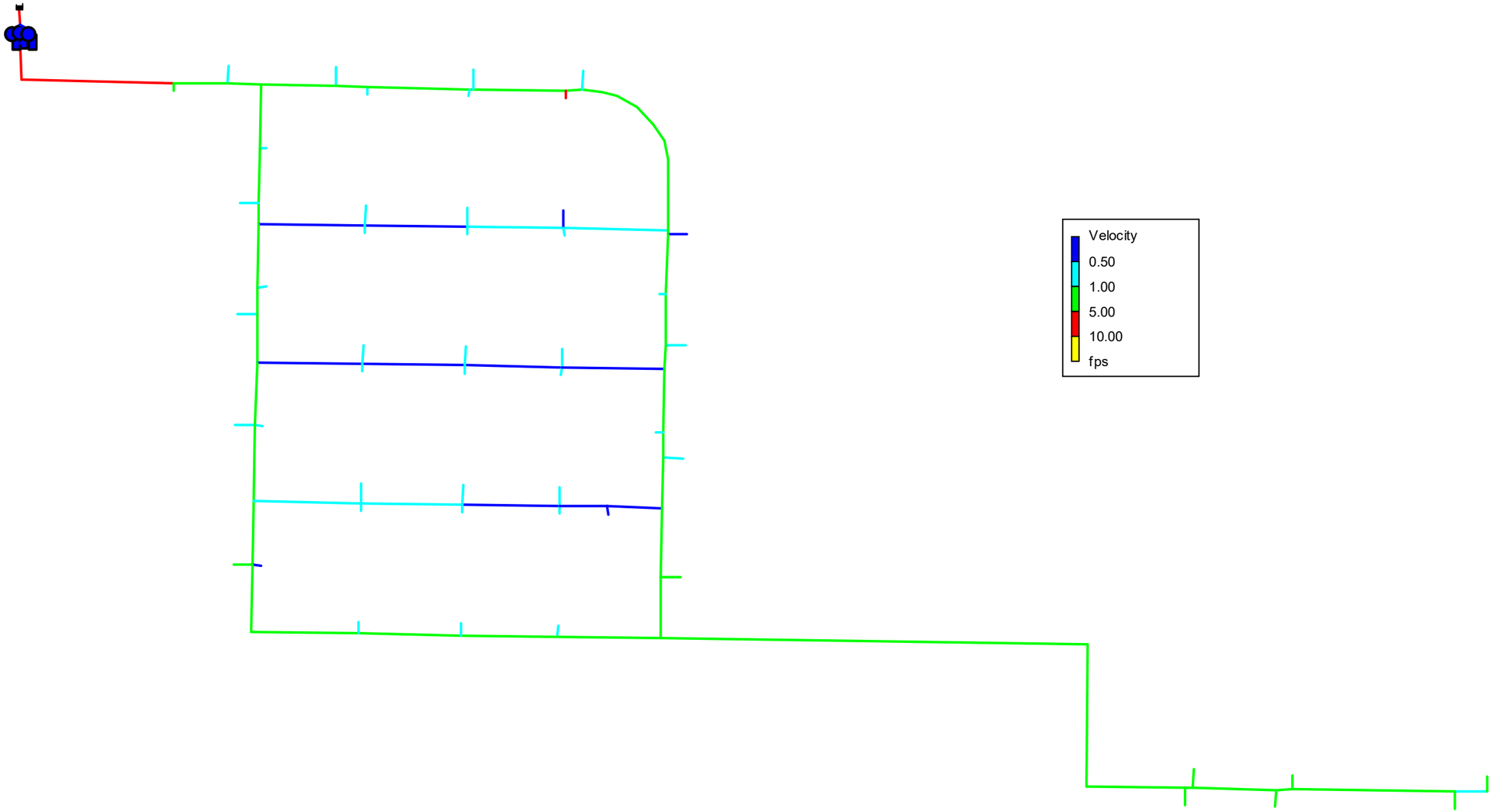
Pump-3 OFF

Node ID	Base Demand GPM	Head ft	Pressure psi
Junc C24	5.65	4406.12	71.98
Junc C32	5.65	4402.10	70.24
Junc C38	5.67	4400.47	69.53
Junc C39	5.67	4400.49	69.54
Junc C31	5.67	4403.63	70.90
Junc C30	5.67	4403.61	70.89
Junc C22	5.67	4408.23	72.89
Junc C43	5.73	4398.73	68.78
Junc C37	5.74	4400.52	69.55
Junc C36	5.74	4400.50	69.54
Junc C28	5.74	4403.61	70.89
Junc C29	5.74	4403.63	70.90
Junc C35	5.81	4400.63	69.60
Junc C26	5.81	4403.61	70.89
Junc C27	5.81	4403.64	70.90
Junc C34	5.81	4400.61	69.59
Junc C3	5.96	4410.93	74.06
Junc C5	6.14	4405.94	71.90
Junc C8	6.32	4402.24	70.30
Junc C44	6.42	4398.34	68.61
Junc C16	6.77	4409.65	73.51
Junc C42	6.81	4399.21	68.99
Junc C33	8.04	4401.47	69.96
Junc C11	8.09	4412.46	74.73
Junc C2	8.09	4413.73	75.28
Junc C25	8.14	4404.34	71.21
Junc C14	8.31	4410.77	74.00
Junc C4	8.79	4408.78	73.13
Junc C6	9.27	4404.99	71.49
Junc C7	9.38	4402.16	70.26

Pump-3 OFF

Node ID	Base Demand GPM	Head ft	Pressure psi
Junc C41	11.18	4398.98	68.89
Junc C45	12.56	4376.51	59.15
Junc C46	13.37	4376.27	59.05
Junc C9	13.72	4400.10	69.37
Junc C47	28.31	4373.89	58.02
Junc C48	29.65	4373.69	57.93
Junc C50	36.76	4371.92	57.16
Junc C49	42.98	4371.47	56.97
Junc C15	54.38	4408.93	73.20
Junc C1	370.64	4414.09	75.43
Resvr RES	#N/A	4235.00	0.00

All Pumps On



All Pumps On

Network Table - Links

Link ID	Length ft	Diameter in	Flow GPM	Velocity fps
Pipe Pz	7.23	4	176.82	4.51
Pipe Pr	7.89	6	276.29	3.14
Pipe L12	13.64	2	5.47	0.56
Pipe L13	13.66	2	5.57	0.57
Pipe L3	13.84	2	5.96	0.61
Pipe L20	13.85	2	5.57	0.57
Pipe L24	13.85	2	5.65	0.58
Pipe L15	14.35	2	54.38	5.55
Pipe P1v	14.44	4	151.07	3.86
Pipe L32	14.44	2	5.65	0.58
Pipe L31	14.45	2	5.67	0.58
Pipe L8	14.45	2	6.32	0.65
Pipe L22	14.45	2	5.67	0.58
Pipe L37	14.45	2	5.74	0.59
Pipe L1	14.81	6	370.64	4.21
Pipe L39	15.04	2	5.67	0.58
Pipe L27	15.04	2	5.81	0.59
Pipe L35	15.04	2	5.81	0.59
Pipe L29	15.65	2	5.74	0.59
Pipe L18	15.65	2	5.47	0.56
Pipe L10	16.26	2	4.16	0.42
Pipe L5	16.26	2	6.14	0.63
Pipe L40	16.26	2	3.63	0.37
Pipe L44	22.27	2	6.42	0.66
Pipe L42	22.87	2	6.81	0.70
Pipe L43	23.50	2	5.73	0.59
Pipe L48	27.68	2	29.65	3.03
Pipe L50	29.49	2	36.76	3.75
Pipe P1x	31.94	4	109.39	2.79

All Pumps On

Link ID	Length ft	Diameter in	Flow GPM	Velocity fps
Pipe L47	32.54	2	28.31	2.89
Pipe Pt	33.02	6	213.60	2.42
Pipe L45	33.70	2	12.56	1.28
Pipe Pa	34.68	8	859.50	5.49
Pipe L49	34.90	2	42.98	4.39
Pipe L2	35.30	2	8.09	0.83
Pipe L30	36.10	2	5.67	0.58
Pipe L21	36.10	2	2.83	0.29
Pipe L26	36.12	2	5.81	0.59
Pipe L11	36.60	2	8.09	0.83
Pipe L9	36.71	2	13.72	1.40
Pipe L28	36.72	2	5.74	0.59
Pipe L4	36.72	2	8.79	0.90
Pipe L34	37.31	2	5.81	0.59
Pipe L38	37.31	2	5.67	0.58
Pipe L46	37.35	2	13.37	1.37
Pipe L23	37.55	2	4.10	0.42
Pipe L25	37.91	2	8.14	0.83
Pipe L6	37.92	2	9.27	0.95
Pipe L17	37.92	2	5.47	0.56
Pipe L16	38.10	2	6.77	0.69
Pipe L33	38.51	2	8.04	0.82
Pipe L19	38.53	2	5.57	0.57
Pipe L36	38.55	2	5.74	0.59
Pipe L14	38.76	2	8.31	0.85
Pipe L7	39.11	2	9.38	0.96
Pipe L41	39.11	2	11.18	1.14
Pipe Pg	40.33	4	170.60	4.36
Pipe P1c	46.38	4	158.93	4.06
Pipe P1i	49.34	4	136.80	3.49

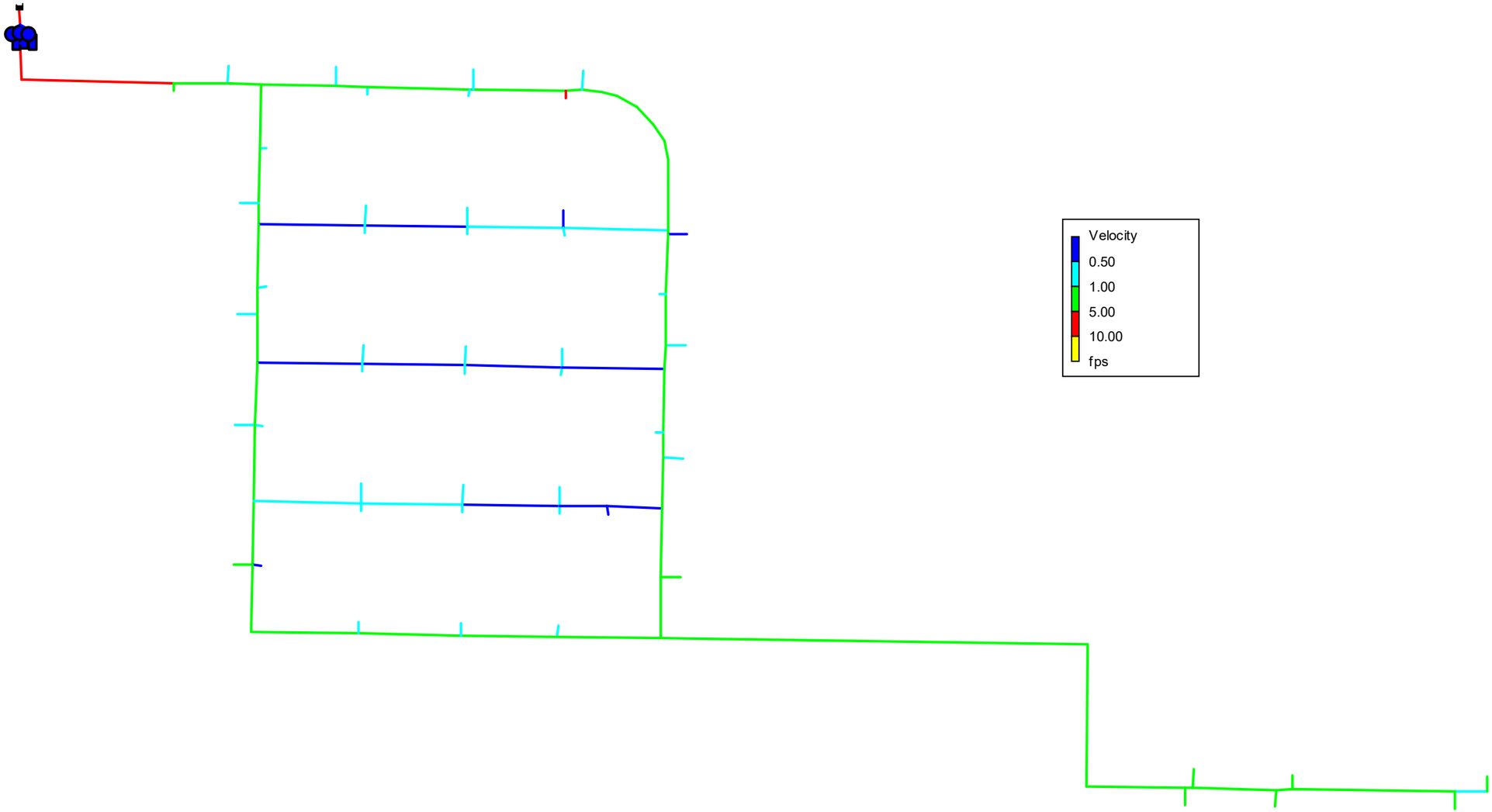
All Pumps On

Link ID	Length ft	Diameter in	Flow GPM	Velocity fps
Pipe Pi	53.56	4	163.89	4.18
Pipe Pp	60.32	6	287.33	3.26
Pipe P1z	61.37	4	36.76	0.94
Pipe Pd	64.60	8	480.77	3.07
Pipe Pj	93.61	4	154.62	3.95
Pipe P1n	94.46	4	2.93	0.07
Pipe P1j	98.96	4	128.76	3.29
Pipe P1b	101.68	4	167.07	4.27
Pipe Pc	106.83	8	488.86	3.12
Pipe Pf	107.71	4	179.39	4.58
Pipe P1o	107.73	4	-0.70	0.02
Pipe P1a	117.30	4	172.72	4.41
Pipe P1q	122.15	4	116.88	2.98
Pipe Pk	124.24	4	136.66	3.49
Pipe Ph	125.16	4	170.03	4.34
Pipe Pm	125.16	4	83.59	2.13
Pipe P1h	125.17	4	142.45	3.64
Pipe Pe	125.77	4	185.35	4.73
Pipe P1p	134.54	4	128.06	3.27
Pipe Po	148.47	6	295.42	3.35
Pipe Pl	149.24	4	120.96	3.09
Pipe P1w	164.28	4	137.70	3.52
Pipe Ps	181.60	6	267.98	3.04
Pipe P1s	188.94	4	53.17	1.36
Pipe P1f	189.55	4	-5.14	0.13
Pipe Px	190.14	4	-21.51	0.55
Pipe P1m	191.34	4	14.27	0.36
Pipe P1l	198.58	4	25.75	0.66
Pipe Pw	199.80	4	-10.37	0.26
Pipe Pq	200.27	6	281.86	3.20

All Pumps On

Link ID	Length ft	Diameter in	Flow GPM	Velocity fps
Pipe P1e	200.99	4	6.34	0.16
Pipe P1t	201.59	4	46.75	1.19
Pipe P1r	202.19	4	58.90	1.50
Pipe P1g	202.27	4	-16.48	0.42
Pipe Py	204.10	4	-30.01	0.77
Pipe P1d	207.84	4	17.96	0.46
Pipe Pv	209.40	4	0.57	0.01
Pipe P1k	209.53	4	37.37	0.95
Pipe P1y	319.53	4	79.74	2.04
Pipe Pn	342.44	4	65.71	1.68
Pipe Pb	372.37	8	859.50	5.49
Pipe Pu	376.64	6	206.83	2.35
Pipe P1u	1311.82	4	163.63	4.18
Pump PUMP-3	#N/A	#N/A	139.46	0.00
Pump PUMP-2	#N/A	#N/A	360.13	0.00
Pump PUMP-1	#N/A	#N/A	359.91	0.00

Pump-1 OFF



Pump-1 OFF

Network Table - Links

Link ID	Length ft	Diameter in	Flow GPM	Velocity fps
Pipe Pz	7.23	4	176.82	4.51
Pipe Pr	7.89	6	276.29	3.14
Pipe L12	13.64	2	5.47	0.56
Pipe L13	13.66	2	5.57	0.57
Pipe L3	13.84	2	5.96	0.61
Pipe L20	13.85	2	5.57	0.57
Pipe L24	13.85	2	5.65	0.58
Pipe L15	14.35	2	54.38	5.55
Pipe P1v	14.44	4	151.07	3.86
Pipe L32	14.44	2	5.65	0.58
Pipe L31	14.45	2	5.67	0.58
Pipe L8	14.45	2	6.32	0.65
Pipe L22	14.45	2	5.67	0.58
Pipe L37	14.45	2	5.74	0.59
Pipe L1	14.81	6	370.64	4.21
Pipe L39	15.04	2	5.67	0.58
Pipe L27	15.04	2	5.81	0.59
Pipe L35	15.04	2	5.81	0.59
Pipe L29	15.65	2	5.74	0.59
Pipe L18	15.65	2	5.47	0.56
Pipe L10	16.26	2	4.16	0.42
Pipe L5	16.26	2	6.14	0.63
Pipe L40	16.26	2	3.63	0.37
Pipe L44	22.27	2	6.42	0.66
Pipe L42	22.87	2	6.81	0.70
Pipe L43	23.50	2	5.73	0.59
Pipe L48	27.68	2	29.65	3.03
Pipe L50	29.49	2	36.76	3.75
Pipe P1x	31.94	4	109.39	2.79

Pump-1 OFF

Link ID	Length ft	Diameter in	Flow GPM	Velocity fps
Pipe L47	32.54	2	28.31	2.89
Pipe Pt	33.02	6	213.60	2.42
Pipe L45	33.70	2	12.56	1.28
Pipe Pa	34.68	8	859.50	5.49
Pipe L49	34.90	2	42.98	4.39
Pipe L2	35.30	2	8.09	0.83
Pipe L30	36.10	2	5.67	0.58
Pipe L21	36.10	2	2.83	0.29
Pipe L26	36.12	2	5.81	0.59
Pipe L11	36.60	2	8.09	0.83
Pipe L9	36.71	2	13.72	1.40
Pipe L28	36.72	2	5.74	0.59
Pipe L4	36.72	2	8.79	0.90
Pipe L34	37.31	2	5.81	0.59
Pipe L38	37.31	2	5.67	0.58
Pipe L46	37.35	2	13.37	1.37
Pipe L23	37.55	2	4.10	0.42
Pipe L25	37.91	2	8.14	0.83
Pipe L6	37.92	2	9.27	0.95
Pipe L17	37.92	2	5.47	0.56
Pipe L16	38.10	2	6.77	0.69
Pipe L33	38.51	2	8.04	0.82
Pipe L19	38.53	2	5.57	0.57
Pipe L36	38.55	2	5.74	0.59
Pipe L14	38.76	2	8.31	0.85
Pipe L7	39.11	2	9.38	0.96
Pipe L41	39.11	2	11.18	1.14
Pipe Pg	40.33	4	170.60	4.36
Pipe P1c	46.38	4	158.93	4.06
Pipe P1i	49.34	4	136.80	3.49

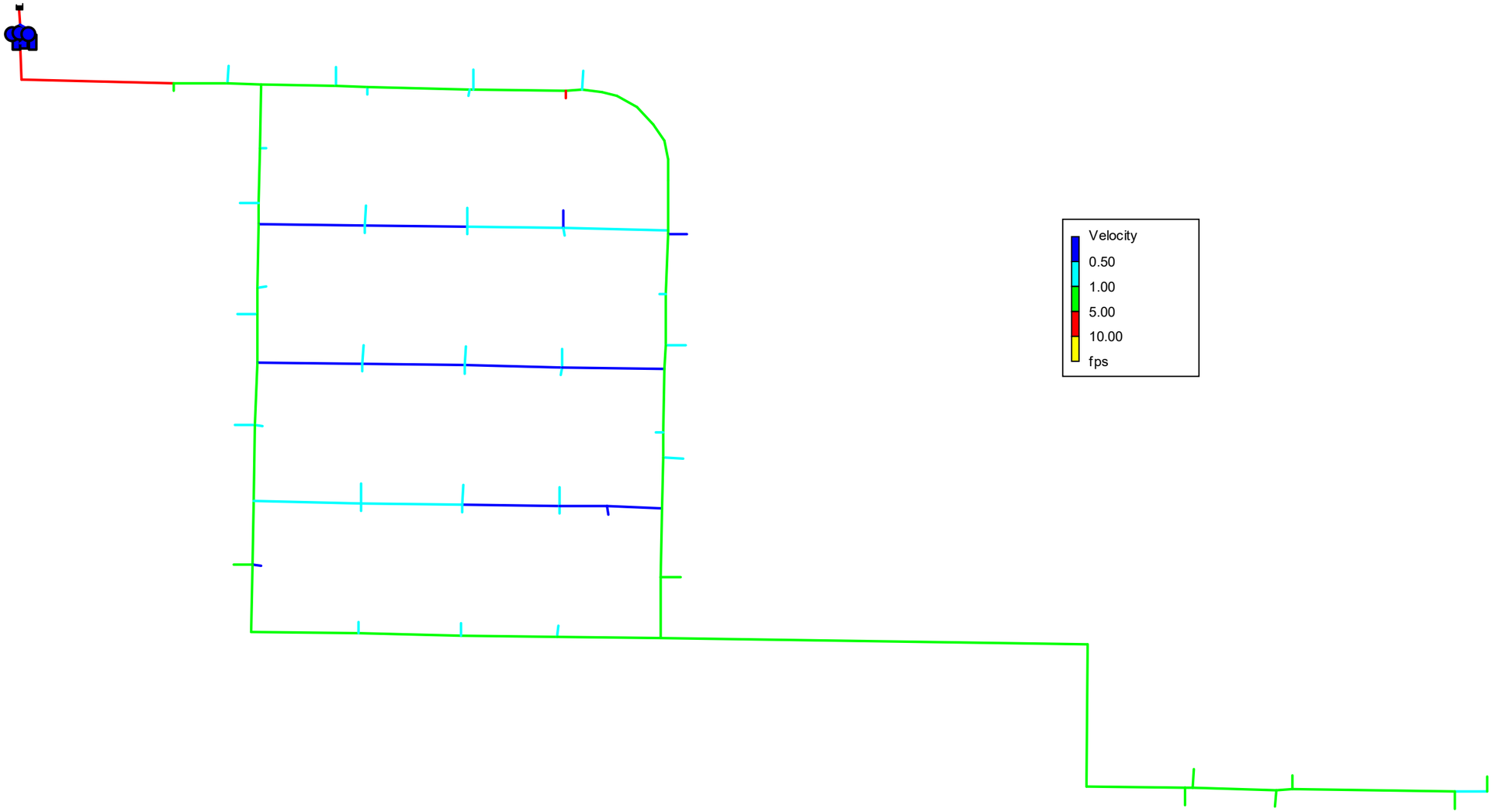
Pump-1 OFF

Link ID	Length ft	Diameter in	Flow GPM	Velocity fps
Pipe Pi	53.56	4	163.89	4.18
Pipe Pp	60.32	6	287.33	3.26
Pipe P1z	61.37	4	36.76	0.94
Pipe Pd	64.60	8	480.77	3.07
Pipe Pj	93.61	4	154.62	3.95
Pipe P1n	94.46	4	2.93	0.07
Pipe P1j	98.96	4	128.76	3.29
Pipe P1b	101.68	4	167.07	4.27
Pipe Pc	106.83	8	488.86	3.12
Pipe Pf	107.71	4	179.39	4.58
Pipe P1o	107.73	4	-0.70	0.02
Pipe P1a	117.30	4	172.72	4.41
Pipe P1q	122.15	4	116.88	2.98
Pipe Pk	124.24	4	136.66	3.49
Pipe Ph	125.16	4	170.03	4.34
Pipe Pm	125.16	4	83.59	2.13
Pipe P1h	125.17	4	142.45	3.64
Pipe Pe	125.77	4	185.35	4.73
Pipe P1p	134.54	4	128.06	3.27
Pipe Po	148.47	6	295.42	3.35
Pipe Pl	149.24	4	120.96	3.09
Pipe P1w	164.28	4	137.70	3.52
Pipe Ps	181.60	6	267.98	3.04
Pipe P1s	188.94	4	53.17	1.36
Pipe P1f	189.55	4	-5.14	0.13
Pipe Px	190.14	4	-21.51	0.55
Pipe P1m	191.34	4	14.27	0.36
Pipe P1l	198.58	4	25.75	0.66
Pipe Pw	199.80	4	-10.37	0.26
Pipe Pq	200.27	6	281.86	3.20

Pump-1 OFF

Link ID	Length ft	Diameter in	Flow GPM	Velocity fps
Pipe P1e	200.99	4	6.34	0.16
Pipe P1t	201.59	4	46.75	1.19
Pipe P1r	202.19	4	58.90	1.50
Pipe P1g	202.27	4	-16.48	0.42
Pipe Py	204.10	4	-30.01	0.77
Pipe P1d	207.84	4	17.96	0.46
Pipe Pv	209.40	4	0.57	0.01
Pipe P1k	209.53	4	37.37	0.95
Pipe P1y	319.53	4	79.74	2.04
Pipe Pn	342.44	4	65.71	1.68
Pipe Pb	372.37	8	859.50	5.49
Pipe Pu	376.64	6	206.83	2.35
Pipe P1u	1311.82	4	163.63	4.18
Pump PUMP-3	#N/A	#N/A	339.35	0.00
Pump PUMP-2	#N/A	#N/A	520.15	0.00
Pump PUMP-1	#N/A	#N/A	0.00	0.00

Pump-2 OFF



Pump-2 OFF

Network Table - Links

Link ID	Length ft	Diameter in	Flow GPM	Velocity fps
Pipe Pz	7.23	4	176.82	4.51
Pipe Pr	7.89	6	276.29	3.14
Pipe L12	13.64	2	5.47	0.56
Pipe L13	13.66	2	5.57	0.57
Pipe L3	13.84	2	5.96	0.61
Pipe L20	13.85	2	5.57	0.57
Pipe L24	13.85	2	5.65	0.58
Pipe L15	14.35	2	54.38	5.55
Pipe P1v	14.44	4	151.07	3.86
Pipe L32	14.44	2	5.65	0.58
Pipe L31	14.45	2	5.67	0.58
Pipe L8	14.45	2	6.32	0.65
Pipe L22	14.45	2	5.67	0.58
Pipe L37	14.45	2	5.74	0.59
Pipe L1	14.81	6	370.64	4.21
Pipe L39	15.04	2	5.67	0.58
Pipe L27	15.04	2	5.81	0.59
Pipe L35	15.04	2	5.81	0.59
Pipe L29	15.65	2	5.74	0.59
Pipe L18	15.65	2	5.47	0.56
Pipe L10	16.26	2	4.16	0.42
Pipe L5	16.26	2	6.14	0.63
Pipe L40	16.26	2	3.63	0.37
Pipe L44	22.27	2	6.42	0.66
Pipe L42	22.87	2	6.81	0.70
Pipe L43	23.50	2	5.73	0.59
Pipe L48	27.68	2	29.65	3.03
Pipe L50	29.49	2	36.76	3.75
Pipe P1x	31.94	4	109.39	2.79

Pump-2 OFF

Link ID	Length ft	Diameter in	Flow GPM	Velocity fps
Pipe L47	32.54	2	28.31	2.89
Pipe Pt	33.02	6	213.60	2.42
Pipe L45	33.70	2	12.56	1.28
Pipe Pa	34.68	8	859.50	5.49
Pipe L49	34.90	2	42.98	4.39
Pipe L2	35.30	2	8.09	0.83
Pipe L30	36.10	2	5.67	0.58
Pipe L21	36.10	2	2.83	0.29
Pipe L26	36.12	2	5.81	0.59
Pipe L11	36.60	2	8.09	0.83
Pipe L9	36.71	2	13.72	1.40
Pipe L28	36.72	2	5.74	0.59
Pipe L4	36.72	2	8.79	0.90
Pipe L34	37.31	2	5.81	0.59
Pipe L38	37.31	2	5.67	0.58
Pipe L46	37.35	2	13.37	1.37
Pipe L23	37.55	2	4.10	0.42
Pipe L25	37.91	2	8.14	0.83
Pipe L6	37.92	2	9.27	0.95
Pipe L17	37.92	2	5.47	0.56
Pipe L16	38.10	2	6.77	0.69
Pipe L33	38.51	2	8.04	0.82
Pipe L19	38.53	2	5.57	0.57
Pipe L36	38.55	2	5.74	0.59
Pipe L14	38.76	2	8.31	0.85
Pipe L7	39.11	2	9.38	0.96
Pipe L41	39.11	2	11.18	1.14
Pipe Pg	40.33	4	170.60	4.36
Pipe P1c	46.38	4	158.93	4.06
Pipe P1i	49.34	4	136.80	3.49

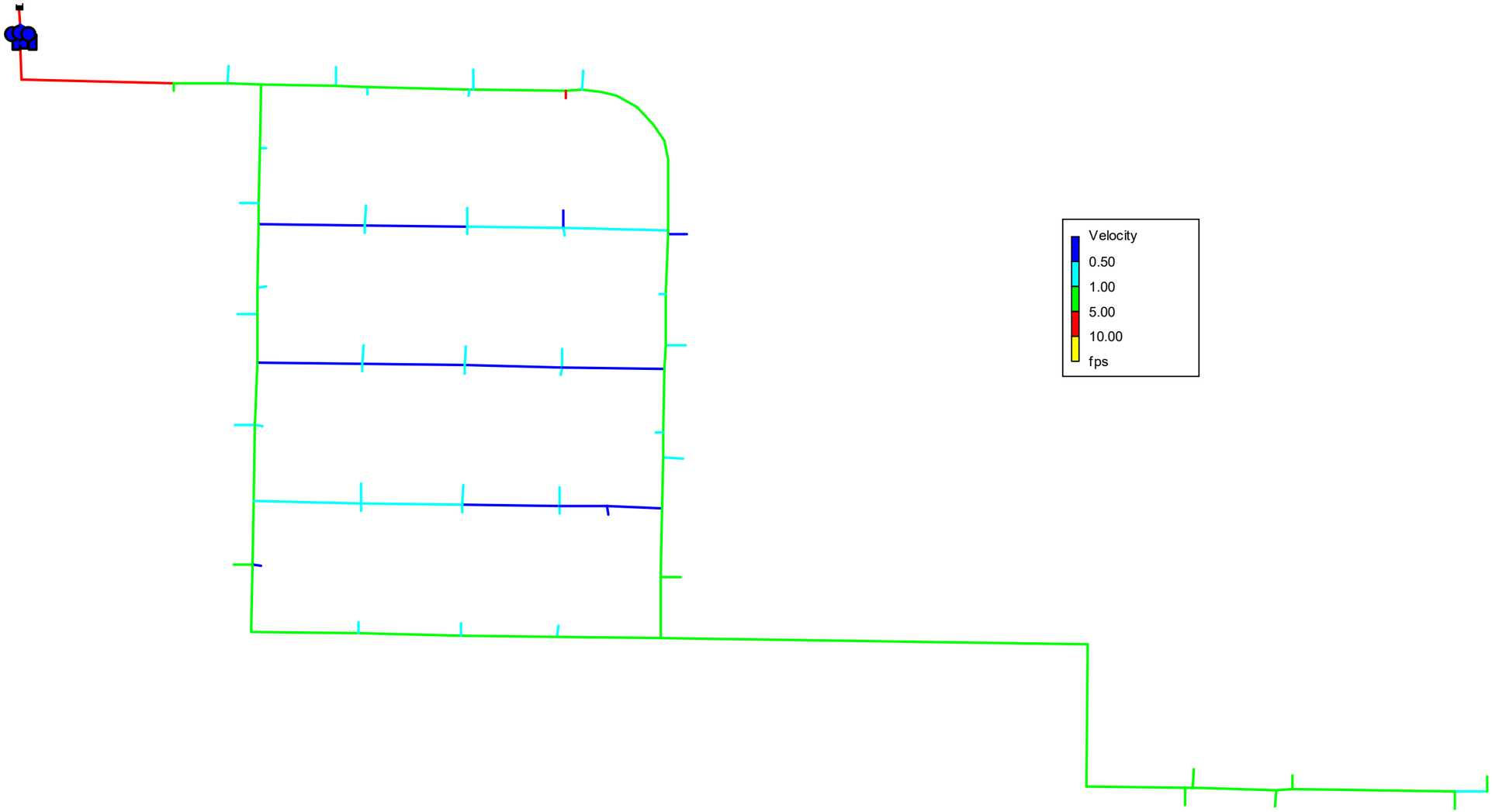
Pump-2 OFF

Link ID	Length ft	Diameter in	Flow GPM	Velocity fps
Pipe Pi	53.56	4	163.89	4.18
Pipe Pp	60.32	6	287.33	3.26
Pipe P1z	61.37	4	36.76	0.94
Pipe Pd	64.60	8	480.77	3.07
Pipe Pj	93.61	4	154.62	3.95
Pipe P1n	94.46	4	2.93	0.07
Pipe P1j	98.96	4	128.76	3.29
Pipe P1b	101.68	4	167.07	4.27
Pipe Pc	106.83	8	488.86	3.12
Pipe Pf	107.71	4	179.39	4.58
Pipe P1o	107.73	4	-0.70	0.02
Pipe P1a	117.30	4	172.72	4.41
Pipe P1q	122.15	4	116.88	2.98
Pipe Pk	124.24	4	136.66	3.49
Pipe Ph	125.16	4	170.03	4.34
Pipe Pm	125.16	4	83.59	2.13
Pipe P1h	125.17	4	142.45	3.64
Pipe Pe	125.77	4	185.35	4.73
Pipe P1p	134.54	4	128.06	3.27
Pipe Po	148.47	6	295.42	3.35
Pipe Pl	149.24	4	120.96	3.09
Pipe P1w	164.28	4	137.70	3.52
Pipe Ps	181.60	6	267.98	3.04
Pipe P1s	188.94	4	53.17	1.36
Pipe P1f	189.55	4	-5.14	0.13
Pipe Px	190.14	4	-21.51	0.55
Pipe P1m	191.34	4	14.27	0.36
Pipe P1l	198.58	4	25.75	0.66
Pipe Pw	199.80	4	-10.37	0.26
Pipe Pq	200.27	6	281.86	3.20

Pump-2 OFF

Link ID	Length ft	Diameter in	Flow GPM	Velocity fps
Pipe P1e	200.99	4	6.34	0.16
Pipe P1t	201.59	4	46.75	1.19
Pipe P1r	202.19	4	58.90	1.50
Pipe P1g	202.27	4	-16.48	0.42
Pipe Py	204.10	4	-30.01	0.77
Pipe P1d	207.84	4	17.96	0.46
Pipe Pv	209.40	4	0.57	0.01
Pipe P1k	209.53	4	37.37	0.95
Pipe P1y	319.53	4	79.74	2.04
Pipe Pn	342.44	4	65.71	1.68
Pipe Pb	372.37	8	859.50	5.49
Pipe Pu	376.64	6	206.83	2.35
Pipe P1u	1311.82	4	163.63	4.18
Pump PUMP-3	#N/A	#N/A	340.32	0.00
Pump PUMP-2	#N/A	#N/A	0.00	0.00
Pump PUMP-1	#N/A	#N/A	519.18	0.00

Pump-3 OFF



Pump-3 OFF

Network Table - Links

Link ID	Length ft	Diameter in	Flow GPM	Velocity fps
Pipe Pz	7.23	4	176.82	4.51
Pipe Pr	7.89	6	276.29	3.14
Pipe L12	13.64	2	5.47	0.56
Pipe L13	13.66	2	5.57	0.57
Pipe L3	13.84	2	5.96	0.61
Pipe L20	13.85	2	5.57	0.57
Pipe L24	13.85	2	5.65	0.58
Pipe L15	14.35	2	54.38	5.55
Pipe P1v	14.44	4	151.07	3.86
Pipe L32	14.44	2	5.65	0.58
Pipe L31	14.45	2	5.67	0.58
Pipe L8	14.45	2	6.32	0.65
Pipe L22	14.45	2	5.67	0.58
Pipe L37	14.45	2	5.74	0.59
Pipe L1	14.81	6	370.64	4.21
Pipe L39	15.04	2	5.67	0.58
Pipe L27	15.04	2	5.81	0.59
Pipe L35	15.04	2	5.81	0.59
Pipe L29	15.65	2	5.74	0.59
Pipe L18	15.65	2	5.47	0.56
Pipe L10	16.26	2	4.16	0.42
Pipe L5	16.26	2	6.14	0.63
Pipe L40	16.26	2	3.63	0.37
Pipe L44	22.27	2	6.42	0.66
Pipe L42	22.87	2	6.81	0.70
Pipe L43	23.50	2	5.73	0.59
Pipe L48	27.68	2	29.65	3.03
Pipe L50	29.49	2	36.76	3.75
Pipe P1x	31.94	4	109.39	2.79

Pump-3 OFF

Link ID	Length ft	Diameter in	Flow GPM	Velocity fps
Pipe L47	32.54	2	28.31	2.89
Pipe Pt	33.02	6	213.60	2.42
Pipe L45	33.70	2	12.56	1.28
Pipe Pa	34.68	8	859.50	5.49
Pipe L49	34.90	2	42.98	4.39
Pipe L2	35.30	2	8.09	0.83
Pipe L30	36.10	2	5.67	0.58
Pipe L21	36.10	2	2.83	0.29
Pipe L26	36.12	2	5.81	0.59
Pipe L11	36.60	2	8.09	0.83
Pipe L9	36.71	2	13.72	1.40
Pipe L28	36.72	2	5.74	0.59
Pipe L4	36.72	2	8.79	0.90
Pipe L34	37.31	2	5.81	0.59
Pipe L38	37.31	2	5.67	0.58
Pipe L46	37.35	2	13.37	1.37
Pipe L23	37.55	2	4.10	0.42
Pipe L25	37.91	2	8.14	0.83
Pipe L6	37.92	2	9.27	0.95
Pipe L17	37.92	2	5.47	0.56
Pipe L16	38.10	2	6.77	0.69
Pipe L33	38.51	2	8.04	0.82
Pipe L19	38.53	2	5.57	0.57
Pipe L36	38.55	2	5.74	0.59
Pipe L14	38.76	2	8.31	0.85
Pipe L7	39.11	2	9.38	0.96
Pipe L41	39.11	2	11.18	1.14
Pipe Pg	40.33	4	170.60	4.36
Pipe P1c	46.38	4	158.93	4.06
Pipe P1i	49.34	4	136.80	3.49

Pump-3 OFF

Link ID	Length ft	Diameter in	Flow GPM	Velocity fps
Pipe Pi	53.56	4	163.89	4.18
Pipe Pp	60.32	6	287.33	3.26
Pipe P1z	61.37	4	36.76	0.94
Pipe Pd	64.60	8	480.77	3.07
Pipe Pj	93.61	4	154.62	3.95
Pipe P1n	94.46	4	2.93	0.07
Pipe P1j	98.96	4	128.76	3.29
Pipe P1b	101.68	4	167.07	4.27
Pipe Pc	106.83	8	488.86	3.12
Pipe Pf	107.71	4	179.39	4.58
Pipe P1o	107.73	4	-0.70	0.02
Pipe P1a	117.30	4	172.72	4.41
Pipe P1q	122.15	4	116.88	2.98
Pipe Pk	124.24	4	136.66	3.49
Pipe Ph	125.16	4	170.03	4.34
Pipe Pm	125.16	4	83.59	2.13
Pipe P1h	125.17	4	142.45	3.64
Pipe Pe	125.77	4	185.35	4.73
Pipe P1p	134.54	4	128.06	3.27
Pipe Po	148.47	6	295.42	3.35
Pipe Pl	149.24	4	120.96	3.09
Pipe P1w	164.28	4	137.70	3.52
Pipe Ps	181.60	6	267.98	3.04
Pipe P1s	188.94	4	53.17	1.36
Pipe P1f	189.55	4	-5.14	0.13
Pipe Px	190.14	4	-21.51	0.55
Pipe P1m	191.34	4	14.27	0.36
Pipe P1l	198.58	4	25.75	0.66
Pipe Pw	199.80	4	-10.37	0.26
Pipe Pq	200.27	6	281.86	3.20

Pump-3 OFF

Link ID	Length ft	Diameter in	Flow GPM	Velocity fps
Pipe P1e	200.99	4	6.34	0.16
Pipe P1t	201.59	4	46.75	1.19
Pipe P1r	202.19	4	58.90	1.50
Pipe P1g	202.27	4	-16.48	0.42
Pipe Py	204.10	4	-30.01	0.77
Pipe P1d	207.84	4	17.96	0.46
Pipe Pv	209.40	4	0.57	0.01
Pipe P1k	209.53	4	37.37	0.95
Pipe P1y	319.53	4	79.74	2.04
Pipe Pn	342.44	4	65.71	1.68
Pipe Pb	372.37	8	859.50	5.49
Pipe Pu	376.64	6	206.83	2.35
Pipe P1u	1311.82	4	163.63	4.18
Pump PUMP-3	#N/A	#N/A	0.00	0.00
Pump PUMP-2	#N/A	#N/A	430.17	0.00
Pump PUMP-1	#N/A	#N/A	429.33	0.00

APPENDIX E

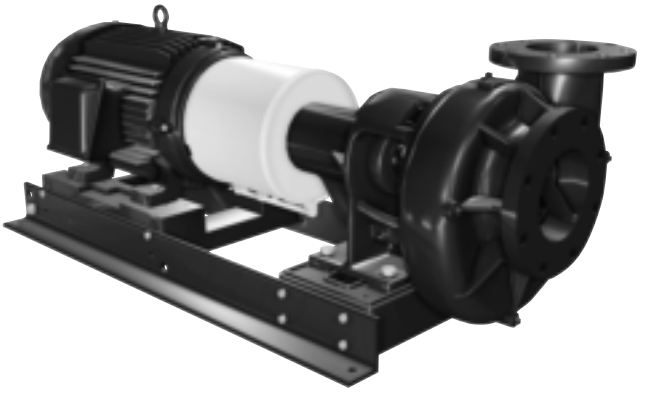
Pump and Meter O&M Manuals

TEL (801) 394-4515 • FAX (801) 392-7544 • 5746 South 1475 East • Ogden, Utah 84403 • www.greatbasinengineering.com

LC, LCV, LF, LCS

End-suction centrifugal pumps

Installation and operating instructions



be
think
innovate

GRUNDFOS

Original installation and operating instructions

These installation and operating instructions describe LC, LCV, LF, and LCS pumps.

Sections 1-6 give the information necessary to be able to unpack, install and start up the product in a safe way.

Sections 7-12 give important information about the product, as well as information on service, fault finding and disposal of the product.

CONTENTS

Prior to installation, read these installation and operating instructions. Installation and operation must comply with local regulations and accepted codes of good practice.

The use of this product requires experience with and knowledge of the product. Persons with reduced physical, sensory or mental capabilities must not use this product, unless they are under supervision or have been instructed in the use of the product by a person responsible for their safety. Children must not use or play with this product.

CAUTION

Successful operation depends on careful attention to the procedures described in this manual. Keep this manual for future use.

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 Symbols used in this document

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 text accompanying the three hazard symbols DANGER, WARNING and CAUTION will be structured in the following way:

SIGNAL WORD

Description of hazard

Consequence of ignoring the warning.

- Action to avoid the hazard.

Example

DANGER

Electric shock

Death or serious personal injury.

- Before starting any work on the product, make sure that the power supply has been switched off and that it cannot be accidentally switched on.

2.2 Other important notes

A blue or grey circle with a white graphical symbol indicates that an action must be taken to avoid a hazard.

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.

Notes or instructions that make the work easier and ensure safe operation.

3. Receiving the product

3.1 Unpacking the product

WARNING

Overhead load

Death or serious personal injury.

- Do not lift the product by the eye bolts on the motor.
  Unload and handle the product with a sling.

3.2 Inspecting the product

- Check that the product received is in accordance with the order.
- Check that the voltage, phase and frequency of the product match the voltage, phase and frequency of the installation site. See section *7.3 Pump identification*.
- Check the product for defects and damage immediately after receiving it. Any accessories ordered will be packed in a separate container and shipped with the product.
- If any equipment is damaged in transit, promptly report this to the carrier's agent. Make complete notations on the freight bill.

3.3 Temporary storage after delivery

- If the product is not to be installed and operated immediately after receiving it, store it in a clean, dry area at a moderate ambient temperature.
- Rotate the shaft by hand periodically, at least weekly, to coat the bearing with lubricant to retard oxidation and corrosion.
- Follow the motor manufacturer's storage recommendations where applicable.

4. Installing the product

4.1 Location

- Locate the pump as close as possible to the liquid supply. Use the shortest and most direct inlet pipe practical. Refer to *4.4.2 Inlet pipe*.
- Locate the pump below system level wherever possible. This will facilitate priming, assure a steady liquid flow, and provide a positive inlet pressure.
- The net positive suction head (NPSH) available must always be equal to or exceed the required NPSH specified on the pump performance curve. Make sure the required NPSH is provided at the inlet.
- Always allow sufficient accessibility space for maintenance and inspection. Provide a clearance of 24 in. (610 mm) with ample head room for use of a hoist strong enough to lift the product.
- Electrical characteristics must match those specified on the motor nameplate, within the limits covered in section *5. Starting up the product*.
- Do not expose the product to sub-zero temperatures to prevent the pumped liquid from freezing. If there is frost during shutdown periods, see sections *5. Starting up the product* and *9.2 Short-time shutdown*.

4.2 Pump foundation

- LF pumps must be grouted in order to ensure a stable pump and motor shaft alignment.
- LCS pumps do not require grouting to maintain shaft alignment, but grouting will increase pump stability within the pipe system.
- LC and LCV pumps do not need to be grouted.

Install the pump permanently on a firm, raised concrete foundation of sufficient size to dampen any vibration and prevent any deflection or shaft misalignment. The foundation may float on springs or be a raised part of the floor.

Proceed like this:

1. Pour the foundation without interruption to 0.75 - 1.5 in. (20-35 mm) below the final pump level. Leave the top of the foundation rough. Then clean and wet it down.
2. Scour and groove the top surface of the foundation before the concrete sets to provide a suitable bonding surface for the grout.
3. Place anchor bolts in pipe sleeves for positioning allowance. See fig. 1.
4. Allow enough bolt length for grout, base flange, nuts, and washers.
5. Allow the foundation to cure several days before proceeding to install the pump.

4.3 Securing the base plate

When the raised concrete foundation has been poured and allowed to set, proceed as follows:

1. Lower the base plate over the anchor bolts and rest it on loose adjustment wedges or shims placed near each anchor bolt and at intervals not exceeding 24 in. (610 mm) along each side.
2. Place the shims or wedges so that they raise the bottom of the base plate 0.75 - 1.25 in. (20-32 mm) above the foundation, allowing clearance for grout.
3. Level the pump shaft, flanges, and base plate using a spirit level, adjusting the wedges or shims, as required.

LCS pumps do not require alignment or grouting.

4. Make sure that the pipes can be aligned to the pump flanges without placing any strain on either flange.
5. After pump alignment has been established, put nuts on the anchor bolts and tighten them just enough to keep the base plate from moving.
6. Construct formwork around the concrete foundation and pour grout inside the base plate, as shown in fig. 1. The grout will compensate for uneven foundation, distribute the weight of the pump, and prevent shifting.

Use an approved, non-shrinking grout.

7. Allow at least 24 hours for the grout to set before proceeding with the pipe connections.

- After the grout has thoroughly hardened, check the foundation bolts and tighten them if necessary. Recheck the pump alignment after tightening the foundation bolts.

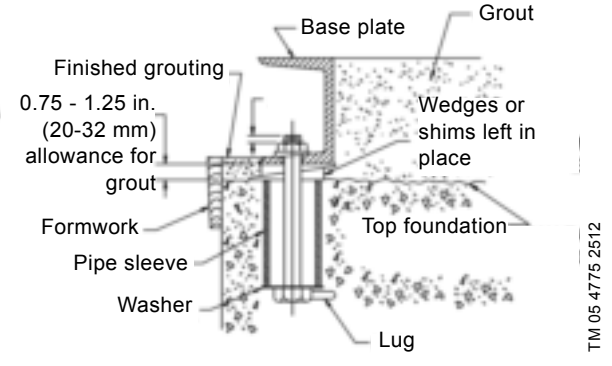


Fig. 1 Anchor bolt installation

4.4 Mechanical installation

4.4.1 Piping

Do not let the pump support the pipes. Use pipe hangers or other supports at proper intervals to provide pipe support near the pump.

- Make sure that both the inlet and outlet pipes are independently supported and properly aligned so that no strain is transmitted to the pump when flange bolts are tightened.
- Make sure the pipes are as straight as possible, so as to avoid unnecessary bends and fittings. Where necessary, use 45 ° or long-sweep 90 ° pipe bends to decrease friction loss.
- Where flanged joints are used, make sure that inside diameters match properly and that mounting holes are aligned.
- Do not apply force to pipes when making any connections!

4.4.2 Inlet pipe

The inlet pipe must be installed in a manner that minimizes pressure loss and permits sufficient liquid flow into the pump during starting and operation.

Observe the following precautions when installing the inlet pipe:

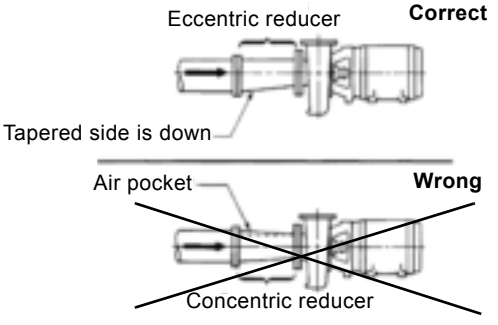


Fig. 2 Inlet pipe

- Run the inlet pipe as direct as possible, and ideally, make sure the length is at least ten times the pipe diameter. A short inlet pipe can be the same diameter as the inlet port. A long inlet pipe must be one or two sizes larger than the inlet port, depending on the length, and with a reducer between the pipe and the inlet port.
- Use an eccentric reducer, with the tapered side down. See fig. 2.

At no point must the diameter of the inlet pipe be smaller than that of the pump inlet port.

- If possible, run a horizontal inlet line along an even gradient. We recommend a gradual upward slope to the pump under suction lift conditions, and a gradual downward slope under positive inlet pressure conditions.
- Avoid any high points, such as pipe loops (see fig. 3), as this may create air pockets and throttle the system or cause erratic pumping.
- Install a gate valve in the inlet line to be able to isolate the pump during shutdown and maintenance, and to facilitate pump removal. Where two or more pumps are connected to the same inlet line, install two gate valves to be able to isolate each pump from the line.
- Always install gate or butterfly valves in positions that prevent air pockets.

Do not use globe valves, particularly when NPSH is critical.

- During pumping operation, the valves on the inlet line must always be fully open.
- Install properly sized pressure gauges in the tapped holes on the pump inlet and outlet flanges.
  Pressure gauges will enable the operator to monitor the pump performance and determine whether the pump conforms to the parameters of the performance curve. If cavitation, vapor binding, or other unstable operating situations occur, the pressure gauges will indicate wide fluctuation in the inlet and outlet pressures.

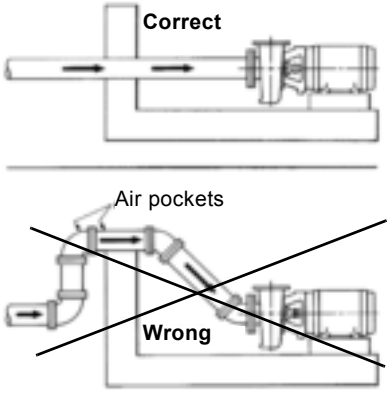


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Fig. 3 Air pocket prevention

4.4.3 Outlet pipe

- A short outlet pipe can be the same diameter as the pump outlet port. A long outlet pipe must be one or two sizes larger than the outlet port, depending on the length.
- It is best to use long horizontal outlet pipes.
- Install a gate valve near the outlet port to be able to isolate the pump during shutdown and maintenance, and to facilitate pump removal.
- Any high points in the outlet pipe may entrap air or gas and thus retard pump operation.
- If water hammer occurs, i.e. if check valves are used, close the outlet gate valve before pump shutdown.

4.4.4 Shaft seals

The pumps are available with both stuffing boxes with packing rings and mechanical shaft seals.

Stuffing boxes

The stuffing boxes are normally packed before shipment.

If the pump is installed within 60 days after shipment, the packing material will be in good condition for operation with a sufficient supply of lubricating liquid.

If the pump is stored for more than 60 days, it may be necessary to repack the stuffing boxes.

The stuffing box must be supplied at all times with a source of clean, clear liquid to flush and lubricate the packing rings.

Packing gland adjustment

With the pump running, adjust the packing gland to permit a leakage of 40 to 60 drops per minute for shaft lubrication. After initial startup, additional packing and adjustment may be required.

Mechanical shaft seals

Mechanical shaft seals require no maintenance or adjustment.

End suction pumps equipped with mechanical shaft seals are matched to the operating conditions for which the pump was sold. Observe the following precautions to avoid shaft seal damage and to obtain maximum shaft seal life:

Do not run the pump dry or against a closed valve. Dry running will cause shaft seal failure within minutes.

Do not exceed the temperature or pressure limitations for the mechanical shaft seal used.

Clean and purge the inlet pipe in new installations before installing and operating pump. Pipe scale, welding slag and other abrasives can cause rapid shaft seal failure.

4.4.5 Coupling alignment of LF pumps

The pump and motor were accurately aligned from factory, but handling during shipment usually alters this pre-alignment.

1. If the pump and motor were shipped mounted on a common base frame as an assembly, remove the coupling guard.
2. **Checking parallel alignment**
   Place a straight edge across both coupling rims at the top, the bottom and both sides. See fig. 4. After each adjustment, recheck all features of alignment. Parallel alignment is correct when the measurements show that all points of the coupling faces are within ± 0.005 in. (0.127 mm) of each other.
   If misalignment is detected, loosen the motor and shift or shim as necessary to re-align. Then re-tighten the anchor bolts. Always align the motor to the pump as pipe strain will occur if the pump is shifted. Never reposition the pump on the base frame.

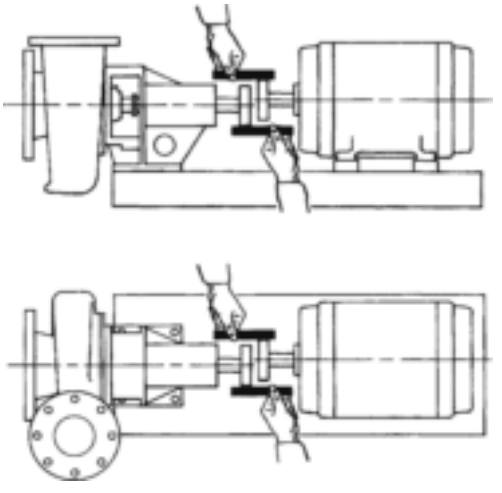


Fig. 4 Checking parallel alignment

3. **Checking angular alignment**
   Insert a pair of inside callipers or a taper gauge at four points at 90 ° intervals around the coupling. See fig. 5. Angular alignment is correct when the measurements show that all points of the coupling faces are within ± 0.005 in. (0.127 mm) of each other.
   – If misalignment is detected, loosen the motor and shift or shim as necessary to re-align. Then re-tighten the anchor bolts. Always align the motor to the pump as pipe strain will occur if the pump is shifted. Never reposition the pump on the base frame.

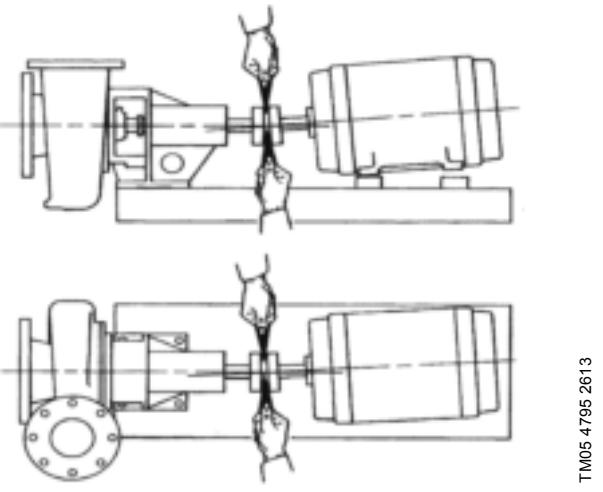


Fig. 5 Checking angular alignment

   – Check shaft alignment once again after final pipe connections to the pump have been made, motor wiring verified, correct direction of rotation has been established, and pipes have been filled with liquid.
4. Leave the coupling guards off until the pump priming procedure has been completed.
5. Install the coupling guards after installation has been completed to protect personnel from rotating machinery.

Coupling alignment of LCS pumps

Alignment of the pump and motor is not required.

4.5 Electrical connection

DANGER

Electric shock

Death or serious personal injury

- The electrical installation must be carried out by a qualified electrician in accordance with local regulations and the manuals provided with the electrical accessories.

DANGER

Electric shock

Death or serious personal injury

- Before starting any work on the product, make sure that the power supply has been switched off and that it cannot be accidentally switched on.

4.5.1 Motors

The motor control circuit must include the following components in order to comply with the National Electrical Code:

Motor disconnecting device

- Install a motor disconnecting device that is capable of disconnecting both the controller (motor starter) and the motor from their source of power.
- Locate the disconnecting device in such a way that the controller (motor starter) can be seen from the disconnecting device. In all cases, the distance from the disconnecting device to the controller must be less than 50 ft (15.24 m).

In most installations, the disconnecting device will be a circuit breaker or fusible disconnect switch.

Motor short circuit and ground fault circuit interrupter

A short circuit and ground fault circuit interrupter is usually a circuit breaker or fusible disconnect switch.

- Select the circuit breaker or fuse in accordance with section 430-52 and table 430-152 of the National Electrical Code.

Motor controller with overcurrent protection (magnetic starter)

- Install these components in accordance with applicable local and state electrical codes in addition to the National Electrical Code.

DANGER

Explosive environment

Death or serious personal injury

- Observe the rules and regulations generally or specifically imposed by the relevant responsible authorities or trade organizations in relation to running powered equipment in an explosive environment.

4.5.2 Wiring

- Mount the control panel or the motor starter(s) close to the pump to provide convenient control and easy installation.
- Wire panel or starter(s) to motor(s) and pilot device(s). Wires to the motor(s) must be sized for at least 125 % of the motor nameplate full load amps. We recommend AWG #16 Type THW stranded wire for wiring of pilot devices, such as float switches.
- Check that the voltage, phase and frequency of the incoming power source correspond to the voltage, phase and frequency of the motor(s).
- Make sure that the starters are suitable for operating the pump motors on the voltage, phase and frequency available.

5. Starting up the product

5.1 Priming

End suction pumps are non-self-priming and must be completely primed, i.e. filled with liquid, before starting.

- If the pump will be operating with a positive inlet pressure, prime it by opening the inlet valve and allowing liquid to enter the pump housing. Open the air vents and make sure all air is forced out of the pump by the liquid before closing the air vents.
- Rotate the shaft by hand to free entrapped air from the impeller passageways.
- If the pump will be operating with a suction lift, priming must be accomplished by other methods. Use foot valves or ejectors, or fill the pump housing and the inlet line manually with liquid.

Never run the pump dry in the hope that it will prime itself. The result will be serious damage to the shaft seals, pump wear rings and shaft sleeves.

5.2 Pre-start checklist

Do not operate the product above the nameplate conditions. This may damage the product.

Make the following inspections before starting your L pump:

1. Make sure the inlet and outlet pipes have been cleaned and flushed to remove dirt and debris.
2. Double check the direction of rotation which must be clockwise. Operating in reverse will destroy the impeller and shaft.
3. Make sure all wiring connections to the motor and starting device are in accordance with the wiring diagram.
4. If the motor has been in storage for a long time, either before or after installation, refer to the motor instructions before starting.
5. Check the voltage, phase and frequency with the motor nameplate. Turn the impeller by hand to make sure it rotates freely.
6. Tighten the plugs in the gauge and drain holes. If the pump is fitted with pressure gauges, keep the gauge cocks closed when they are not in use.
7. Check the inlet and outlet pipes for leaks, and make sure all flange bolts are securely tightened.

5.3 Motor direction of rotation

Never check the motor direction of rotation unless the pump and motor couplings have been disconnected and physically separated. Failure to follow this instruction can result in serious damage to the pump and the motor if the direction of rotation is wrong.

After the product has been wired and checked to ensure that all components in the system, such as disconnect devices, magnetic starters, pilot devices and motors, are properly connected, check the motor direction of rotation as follows:

- For three-phase products only, momentarily energize the motor to ensure that the direction of rotation is correct as indicated by the arrow cast into the pump housing.
  If direction of rotation is incorrect, interchange two wires at the motor starter terminals T1 and T2.

The pumps must not be operated while dry.

Use extreme caution that motors are energized only momentarily to determine proper direction of rotation.

5.4 Starting the pump

DANGER

Moving machine parts

Death or serious personal injury.

- Mount an approved coupling guard before operating the product.

1. Install a coupling guard on coupled products.
2. Fully open the gate valve (if any) in the inlet line, and close the gate valve in the outlet line.
3. Fill the inlet line with liquid and completely prime the pump.
4. Start the pump.
5. Immediately make a visual check of the pump and inlet pipe for pressure leaks.
6. Immediately after the pump has reached full operating speed, slowly open the outlet gate valve until complete system flow is achieved.
7. Check the outlet pipe for pressure leaks.
8. If the pump is fitted with pressure gauges, open gauge cocks and record pressure readings for future reference. Verify that the pump is performing in accordance with the parameters specified in the performance curves.
9. Check and record voltage, amperage per phase, and kilowatts, if a wattmeter is available.

5.5 Voltage and frequency variation

The motor will operate satisfactorily under the following voltage and frequency variations, but not necessarily in accordance with the standards established for operation under rated conditions:

- The voltage variation must not exceed 10 % above or below the rating specified on the motor nameplate.
- The frequency variation must not exceed 5 % above or below the motor rating.
- The sum of the voltage and frequency variations must not exceed 10 % above or below the motor rating, provided the frequency variation does not exceed 5 %.

6. Storing and handling the product

See sections *3.3 Temporary storage after delivery*, *9.2 Short-time shutdown* and *9.3 Long-term shutdown*.

7. Product introduction

7.1 Applications

We recommend the L pumps for these applications:

- commercial and industrial cooling systems
  – pumping both primary and secondary cooling water
- condenser water systems
- district cooling systems
- water distribution systems
- irrigation systems.

7.2 Pumped liquids

Clean, thin, non-aggressive liquids, not containing solid particles or fibers. Do not pump liquids that will attack the pump materials chemically.

7.3 Pump identification

All pumps are identified by catalog and serial numbers. These numbers are stamped on the pump nameplate, as shown in fig. 6, affixed to the pump housing. Refer to these numbers in all correspondence with Grundfos.

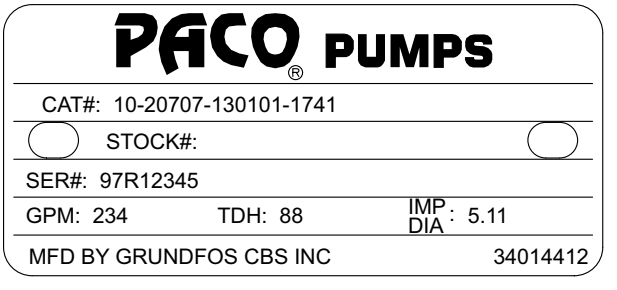


Fig. 6 Nameplate

8. Servicing the product

8.1 Maintaining the product

DANGER

Moving machine parts

Death or serious personal injury.

- Before any inspection, maintenance, service or repair of the product, make sure the motor controls are in the "OFF" position, locked and tagged.

8.2 Lubricating the product

8.2.1 Lubricating the motor

Always follow the motor manufacturer's lubricating instructions, if they are available, and periodically check grease fittings and drain plugs for leaks. If the lubricating instructions are not available, refer to the table below for recommended lubricating intervals.

- The motor can be lubricated both when it is running or when it is at rest.
  Remove the grease drain plug, if any, and filler plug on the grease fitting. Grease with clean lubricant until grease appears at the drain hole or along the motor shaft.

Recommended lubricating intervals

Motor rpm	Motor hp	Operating conditions		
		Standard	Severe	Extreme
1750 and below	0.33 - 7.50	3 years	1 year	6 months
	10-40	1-3 years	6 months - 1 year	3 months
	50-150	1 year	6 months	3 months
	200 and up	1 year	6 months	3 months
above 1750	all hp	6 months	3 months	3 months

Standard conditions:

Operating 8 hours per day, normal or light load, clean air, 100 °F (37 °C) maximum ambient temperature.

Severe conditions:

Operating continuously 24-hours, shock loads or vibrations, poor ventilation, 100-150 °F (37-65 °C) ambient temperature.

Extreme conditions:

Operating continuously, heavy shocks or vibrations, dirt or dust in the air, extremely high ambient temperature.

One-half to one cubic inch (0.5^3 - 1^3 in.) of grease is sufficient for motors of 5 hp and lower, with proportionately more grease for bigger hp motors.

Most fractional and some integral frame motors have "sealed-for-life" bearings, and do not require further lubrication throughout motor life.

If lubricating instructions are not available, refer to the table *Recommended lubricating intervals* on page 11 for recommended lubrication periods.

The table *Approved grease lubricants* in section *8.2.2 Lubricating the pump* lists the recommended types of grease for both pump and motor lubrication. These grease types have all been thoroughly tested and must be used whenever possible.

8.2.2 Lubricating the pump

Grease lubrication

In the standard configuration, LF pumps on horizontal base frames have sealed-for-life bearings. For customized pumps with regreasable bearings, use an approved grease and proceed as described below.

Approved grease lubricants

Manufacturer	Lubricant
Shell	Dolium® R
Exxon	Polyrex®
Chevron	SRI Grease NLGI 2
	Black Pearl - NLGI 2
Philips	Polytac™
Texaco	Polystar RB

- Remove the drain plug, if any, and the filler plug. Add clean lubricant until grease appears at the drain hole or along the pump shaft. On pumps with drain hole, all old grease can be purged. In such cases, the drain hole must be left unplugged for several minutes during pump operation to allow excess grease to be forced out.
- Lubricate the pump bearings at 1-3 month intervals, depending on the severity of the environment. Pumps in a clean, dry, moderate-temperature (100 °F (65 °C) maximum) environment must be regreased at 3-month intervals.

Do not over-grease! Too much grease can cause overheating and premature bearing failure.

Oil lubrication

LF pumps with oil lubricated bearings are fitted with a transparent reservoir, a constant-level oiler, that maintains the oil level about the centerline of the bearing. See fig. 7.

- Follow a regular oil maintenance program. When necessary, renew the oil supply in the reservoir of the constant-level oiler.
- Change the oil after the first 200 hours of operation. To change the oil, remove the drain plug at the bottom of the bearing cover and the filler plug, that also acts as a vent plug, at the top of the bearing frame. After draining the oil, replace the drain plug and refill the reservoir with an oil from the table *List of acceptable oil lubricants* on page 12. After the first oil change, the oil must be changed again at 2000 hours and then at intervals of 8000 hours or once a year, thereafter.

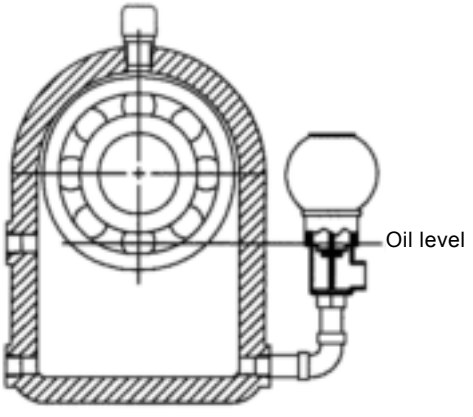


Fig. 7 Oil lubrication

List of acceptable oil lubricants	
Lubricant manufacturer	**Bearing oil brand name**
Aral Refining Co.	Aral Oil CMU
	Aral Oil TU 518
British Petroleum Co.	BP Energol
	TH 100-HB
Calypsol Oil Co.	Calypsol Bison Oil
	SR 25 or SR 36
Standard Oil Co.	Chevron
	Hydraulic Oil 11
	Circulating Oil 45
Esso Corp	Esso-Mar 25
	Teresso 47
	Esstic 50
Fina Oil Co.	Fina Hydran 34
	Fina Cirkan 32
Gulf Refining Co.	Gulf Harmony 47
	Gulf Paramount 45
Socony Mobil Oil Co.	Vac hlp 25
	Mobulix D.T.E. 25
Shell Oil Co.	Shell Tellus Oil 29
Sundco Oil Co.	Sunvis 821
The Texas Co.	Texaco Ursa Oil P 20
	Dea Viscobil Sera 4

8.3 Disassembling the pump

8.3.1 Preparations before disassembling the pump

DANGER

Electric shock

Death or serious personal injury.

- Before starting any work on the product, make sure that the power supply has been switched off and that it cannot be accidentally switched on.

CAUTION

Toxic material

Minor or moderate personal injury.

- Wash down the pump before doing any work on it.

DANGER

Hot, caustic, flammable or toxic materials, including vapors

Death or serious personal injury.

- Be extremely cautious when venting and/or draining hazardous liquids.
  Wear protective clothing when there are caustic, corrosive, volatile, flammable, or hot liquids.
  Do not breathe toxic vapors.
  Do not allow sparks, open fire, or hot surfaces near the equipment.

Complete disassembly instructions are outlined below. Proceed only as far as required to perform the maintenance work needed.

1. Switch off the power supply.
2. Drain the system.
3. Flush the system, if necessary.
4. For close-coupled pumps: Remove the motor fixation bolts.

8.3.2 Disassembling the pump

1. Remove the pump housing screws (8B).
2. Remove the back pull-out bearing frame (20Y) from the pump housing (1A).
3. Remove the impeller screw (8A).
   If necessary, use a strap wrench around the impeller or shaft to prevent rotation.

WARNING

Moving machine parts

Death or serious personal injury.

- Do not insert a screwdriver between the impeller vanes to prevent rotation.

4. Use an appropriately sized puller aligned behind the impeller vanes to remove the impeller (3A) from the shaft (6A).
5. Remove the impeller key (12A).
6. Remove the back plate screws (8D). Remove the back plate (2K) and the seal housing (26P).
7. Place the seal housing on a flat surface and press out the shaft seal (14A).
8. If the shaft sleeve (5A) requires replacement, heat it evenly to approximately 350 °F (176 °C) to loosen the thread-locking fluid. Twist the sleeve off the shaft (6A).

8.3.3 Disassembling the bearing frame (LF)

1. Remove the slinger (13G).
2. Remove the lip seal(s) (14S), if any.
3. Remove the bearing housing locking ring (61K).
4. Press or tap on the pump end of the bearing-shaft assembly until one bearing is out.
5. When one bearing is out, remove the second locking ring (61F), then remove the complete bearing-shaft assembly from bearing housing.
6. Remove the shaft locking ring (61C) and press off the bearings.
7. Press new bearings on to the shaft; remember to press only on the inner race of the bearings while pressing them on.
8. Assemble the bearing frame in the reverse procedure used for disassembling.
9. Observe the following when reassembling the bearing frame:
   – Replace the lip seals (14S) if they are worn or damaged.
   – Replace the bearings (18A) and (18B) if they are loose, rough or noisy when rotated.
   – Check the shaft (6A) for shaft runout at the shaft sleeve (5A) area. Maximum permissible runout is 0.002 in. (0.05 mm) total indicator runout.

8.4 Replacing the shaft seal (LCS pumps)

1. Complete the preparations listed in section *8.3 Disassembling the pump*.
2. Remove the coupling guard screws (8E).
3. Remove the coupling guard (34F).
4. Remove the nut (35E) and the bolt (8E) that hold the coupling halves together.
5. Pry apart the coupling halves (23D), remove the coupling key (12B).

Mark or measure the original position of the pump coupling on the motor side.

6. Unscrew the tubing connector from the pipe tee of the air vent assembly. Thread sealing compound was applied to the threads during factory assembly, and the resulting bond may retard but will not prevent manual disassembling.
7. Remove the seal housing cap screws and slide the seal housing (2N) up the shaft to remove it.
8. Remove the shaft seal manually from the shaft (6A). Apply water-soluble lubricant to the shaft, if necessary, to ease the removal of the shaft seal (14A). Pull the shaft seal manually from the shaft, using a slight twisting motion (as necessary) to loosen the bellows from the shaft.
9. Remove and discard the shaft seal spring and the shaft seal retainer.
10. Remove and discard the shaft seal seat from the seal housing (2N) and thoroughly clean the inside cavity of the seal housing.
11. The interior surface of the bellows on a new shaft seal is coated with a bonding agent that adheres to the motor shaft. When the old shaft seal is removed, the bonding agent no longer exists and the bellows may crack or split during removal. We always recommend that you install a new mechanical shaft seal if it becomes necessary to remove the existing shaft seal from the shaft.
12. Clean and lubricate the shaft (6A) with a water-soluble lubricant and make sure no sharp edges can cut or scratch the bellows of the new shaft seal.
13. Press the new shaft seal seat firmly into the seal housing. Avoid direct contact between the seal face and metallic or abrasive objects, and wipe the seal face clean after installation to ensure an abrasive-free sealing surface.
14. Slide the new shaft seal onto the shaft by applying even pressure to the shaft seal.
15. Install the shaft seal housing (2N) on the shaft.
16. See the reassembly instructions in section *8.6 Reassembling the pump*.

8.5 Replacing the wear ring

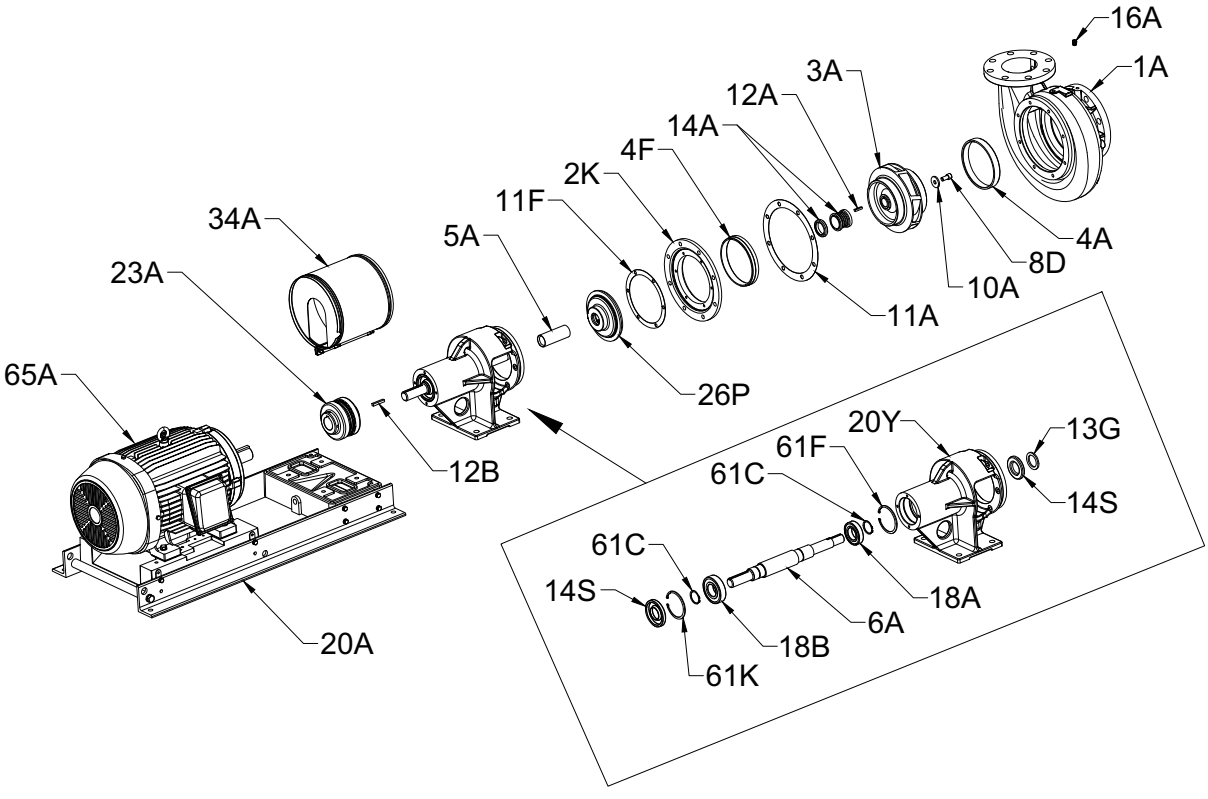
1. Complete the preparations in sections *8.3.1 Preparations before disassembling the pump* and *8.3.2 Disassembling the pump*.
2. Remove the rotating assembly.
3. Remove the pump housing (1A) from the pipes, if necessary, to facilitate easy access to the interior of the pump housing. If necessary, remove the flange bolts at the pipes.
4. Remove a worn wear ring (4A) by drilling two holes slightly smaller than the width of the wear ring into the exposed edge of the wear ring. Insert a chisel into the holes to completely sever the wear ring at the holes and break the wear ring into two halves for easy removal.
5. Clean the wear ring cavity in the pump housing prior to installing a new wear ring to ensure a properly aligned fit.
6. To reassemble, press fit the new wear ring squarely into the pump housing cavity. Tap the wear ring into place to make sure it is pressed home into the cavity.

Do not use metal tools on the wear ring surfaces. Use only rubber, rawhide, wood or other soft material to prevent damage to the wear ring.

8.6 Reassembling the pump

1. Clean all parts before reassembly.
2. Refer to the parts list to identify required replacement items. Specify the pump serial or catalog number when ordering parts.
3. Reassemble the pump in the reverse procedure used for disassembling.
4. Observe the following when reassembling the pump:
   – All mechanical seal components must be in good condition or leakage may result. We recommend that you replace the complete shaft seal.
   – Install new shaft sleeves by bonding them to the shaft with a thread-locking fluid.
5. Re-install the coupling guards on coupled pumps.

8.7 LF, exploded view and parts list



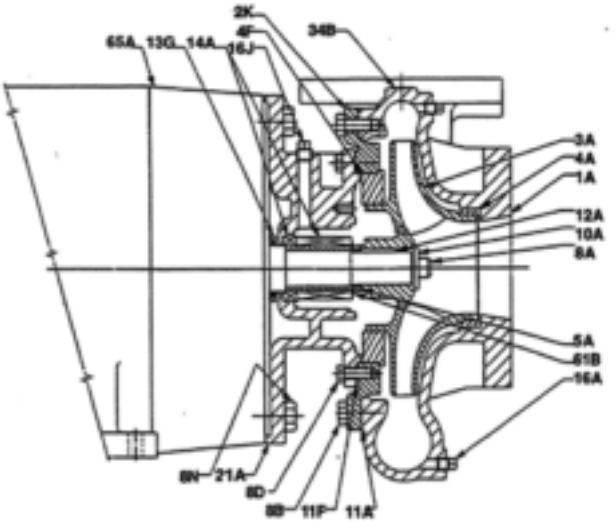
Pos.	Description
1A	Pump housing
2K	Back plate
3A	Impeller
4A	Wear ring
4F*	Balance wear ring
5A	Shaft sleeve
6A	Shaft
8D	Cap screw
10A	Washer
11A	Gasket
11F	Gasket
12A	Key
12B	Key
13G	Slinger

Pos.	Description
14A	Shaft seal
14S	Lip seal
16A	Drain plug
18A	Bearing, inboard
18B	Bearing, outboard
20A	Baseplate
20Y	Bearing frame
23A	Coupling hub
26P	Seal housing
34A	Coupling guard
61C	Locking ring
61F	Locking ring
61K	Locking ring
65A	Motor

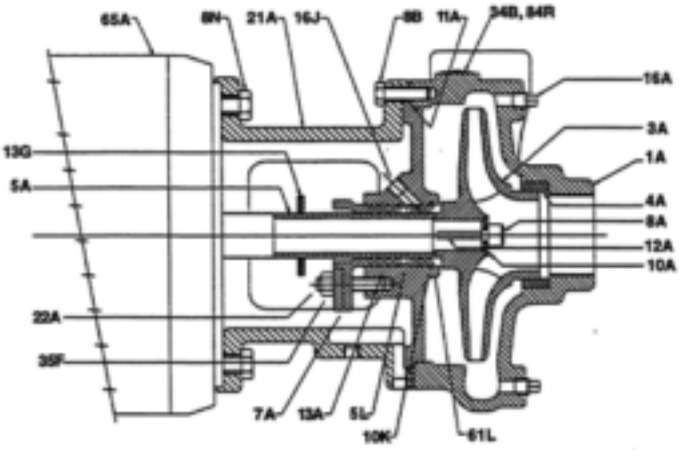
* If applicable

8.8 LC, cross section and parts list

Pump with shaft seal



Pump with stuffing box



TM05 8911 2913

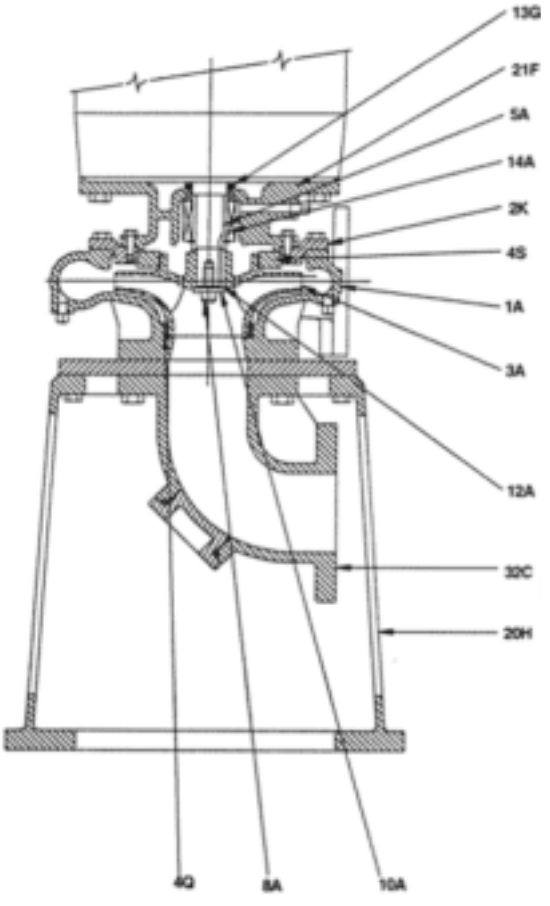
Pos.	Description
1A*	Pump housing
2K**	Back plate
3A	Impeller
4A	Wear ring
4F	Wear ring
5A	Shaft sleeve
5L*	Distribution ring
7A*	Stuffing box gland
8A	Cap screw
8B	Cap screw
8D	Cap screw
8N	Cap screw
10A	Washer
10K*	Washer
11A	Gasket

Pos.	Description
11F**	Gasket
12A	Key
13A*	Stuffing box
13G	Slinger
14A**	Mechanical shaft seal
16A	Drain plug
16J*	Plug
21A	Motor stool
22A*	Stud
34B	Nameplate
35F*	Nut
61B	Locking ring
61L*	Locking ring
65A	Motor
84R	Screws

* Pumps with stuffing box only

** Pumps with shaft seal only

8.9 LCV, cross section and parts list

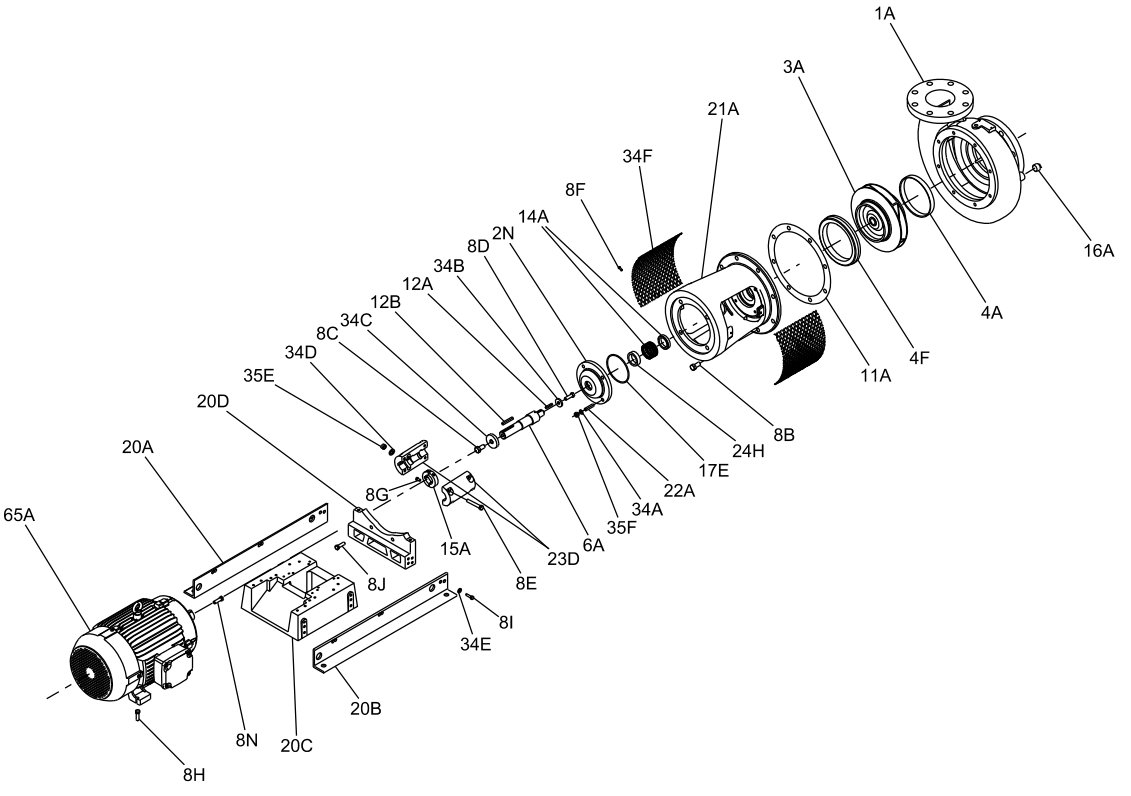


TM05 8910 2913

Pos.	Description
1A	Pump housing
2H	Hand hole cover (not shown)
2K	Back plate
3A	Impeller
4Q	Wear ring
4S	Wear ring
5A	Shaft sleeve
8A	Cap screw

Pos.	Description
10A	Washer
12A	Key
13G	Slinger
14A	Single mechanical shaft seal
20H	Stand
21F	Motor stool
32C	Elbow with cleanout port

8.10 LCS, exploded view and parts list



TM06 4374 2115

Pos.	Description
1A	Pump housing
2N	Shaft seal housing
3A	Impeller
4A	Wear ring
4F	Balance wear ring
6A	Pump shaft
8B	Cap screw
8C	Screw
8D	Screw
8E	Bolt
8F	Screw
8G	Screw
8H	Cap screw
8I	Cap screw
8J	Cap screw
8N	Screw
11A	Gasket
12A	Key
12B	Key
14A	Shaft seal

Pos.	Description
15A	Locating ring
16A	Drain plug
17E	O-ring
20 A + 20B	Base plate profile
20C	Base plate
20D	Pump support
21A	Motor stool
22A	Stud
23D	Coupling halves
24H	Bushing
34A	Washer
34B	Washer
34C	Washer
34D	Washer
34E	Washer
34F	Coupling guard
35E	Nut
35F	Nut
65A	Motor

9. Taking the product out of operation

The following shutdown procedures will apply for the L pumps in most normal shutdown situations. If the pump will be inoperative for a long time, follow the storage procedures in section *9.3 Long-term shutdown*.

9.1 General procedure

- Always close the outlet gate valve before stopping the pump. Close the valve slowly to prevent hydraulic shock.
- Switch off and lock off the power supply to the motor.

9.2 Short-time shutdown

- For overnight or temporary shutdown periods under non-freezing conditions, the pump may remain filled with liquid. Make sure the pump is fully primed before restarting.
- For short or frequent shutdown periods under freezing conditions, keep the liquid moving within the pump housing and insulate or heat the pump exterior to prevent freezing.

9.3 Long-term shutdown

- For long shutdown periods, or to isolate the pump for maintenance, close the inlet gate valve. If no inlet valve is used and the pump has positive inlet pressure, drain all liquid from the inlet line to stop the liquid flow into the pump inlet. Remove the plugs in the pump drain and vent holes, as required, and drain all liquid from the pump housing.
- If there will be freezing conditions during long shutdown periods, completely drain the pump and blow out all liquid passages and pockets with compressed air. Freezing of the pumped liquid can also be prevented by filling the pump with antifreeze solution.

10. Fault finding

DANGER

Electric shock

Death or serious personal injury.

- Before starting any work on the product, make sure that the power supply has been switched off and that it cannot be accidentally switched on.

CAUTION

Toxic material

Minor or moderate personal injury.

- Wash down the pump before doing any work on it.

DANGER

Hot, caustic, flammable or toxic materials, including vapors

Death or serious personal injury.

- Be extremely cautious when venting and/or draining hazardous liquids.
  Wear protective clothing when there are caustic, corrosive, volatile, flammable, or hot liquids.
  Do not breathe toxic vapors.
  Do not allow sparks, open fire, or hot surfaces near the equipment.

Fault	Cause	Remedy
1. Outlet pressure is too low.	a) The speed of rotation is too low.	Reestablish correct speed and direction of rotation.
	b) The system pressure is lower than anticipated.	Check the system curve.
	c) There is air or gas in the pumped liquid.	Remove the air from the pumped liquid.
	d) The wear rings are worn.	Replace the wear rings.
	e) The impeller is damaged.	Repair or replace the impeller.
	f) The impeller diameter is too small.	Replace the impeller with one of the correct diameter.
	g) Wrong direction of rotation.	Interchange two wires in the power supply.
	h) The pump has lost its prime.	Re-prime the pump.
	i) There is insufficient NPSH.	Restore required NPSH.
	j) Passages are restricted.	Clean the impeller and pump housing passages.
	k) Joints or the stuffing box are leaking.	• Tighten the joints or the stuffing box gland. • Replace the shaft sleeve. • Replace the gaskets.
2. Insufficient inlet pressure.	a) The inlet line is drawing air.	Tighten the connections.
	b) The suction lift is too high or there is insufficient NPSH.	Reduce the suction lift or restore required NPSH.
	c) Air or gas is trapped in the pumped liquid.	Remove the trapped air or gas from liquid.
	d) The strainer is clogged.	Clean the strainer.
3. Noise level has increased.	a) Poor alignment of the pump. Inlet and outlet pipe clamps are loose.	• Reestablish proper alignment of the pump and the motor. • Support the inlet and outlet pipes. • Make sure the vibration dampers, flexible pipes and conduit connectors are installed correctly.
	b) Cracked foundation.	Repair the foundation.
	c) Worn ball bearings.	• Replace the worn bearings. • Renew the lubrication.
	d) The motor is unbalanced.	• Disconnect the motor and operate it alone. • Remove large pieces of debris, such as wood or rags from the pump. • Clean out the pump, if necessary.
	e) Hydraulic resonance.	• Alter the resonant pipes. • Change the pump speed. • Insert a pulsation damper on the pump or the pipes. • Insert a flow straightener.

Fault	Cause	Remedy
4. Insufficient flow.	a) The pump is not primed.	Prime the pump.
	b) The system pressure exceeds the shut off pressure.	• Increase the liquid level on the inlet side. • Open the isolating valve in the inlet pipe.
	c) The speed of rotation is too low.	Reestablish the correct speed of rotation.
	d) The suction lift is too high or there is insufficient NPSH.	Reduce the suction lift or restore required NPSH.
	e) The strainer or the impeller is clogged.	Clean the strainer and the impeller passages.
	f) Wrong direction of rotation.	Reestablish the correct direction of rotation.
	g) Leaking joints.	Tighten the joints.
	h) Broken shaft or coupling	Repair or replace damaged parts.
	i) Closed inlet valve.	If the inlet valve is closed, open it slowly.
	j) There is not enough inlet pressure for hot or volatile liquids.	Reestablish required inlet pressure.
	k) Foot valve is too small.	Replace the foot valve.
	l) Worn or damaged hydraulic parts.	Repair or replace the worn parts.
	m) Excessive clearance between the wear surfaces.	See section *8.5 Replacing the wear ring*.
5. The pump loses its prime after starting.	a) Joints or the stuffing box are leaking.	• Tighten the joints or the stuffing box gland. • Replace the shaft sleeve. • Replace the gaskets.
	b) The suction lift is too high or there is insufficient NPSH.	Reduce the suction lift or restore required NPSH.
6. Excessive power required.	a) The speed of rotation is too high.	Reduce the speed of rotation.
	b) The pump is operating beyond its recommended performance range.	Set the duty point in accordance with the recommended performance range.
	c) The specific gravity or viscosity of the pumped liquid is too high.	If less flow is sufficient, reduce the flow on the outlet side, or fit the pump with a more powerful motor.
	d) The shaft is bent.	Replace the shaft.
	e) The stuffing-box is too tight.	Retighten the stuffing box if possible. Alternatively, repair or replace the stuffing box.
	f) The impeller clearance is too small causing rubbing or worn wear surfaces.	Adjust the impeller clearance, if possible, or replace the wear ring.
	g) There is an electrical or mechanical defect in the motor.	Contact your local service center for diagnostics.
	h) The pump is restricted in its rotation.	Remove any obstacles or replace any worn parts.
	i) Incorrect lubrication of the motor.	Reestablish correct lubrication of the motor.

11. Technical data

11.1 Operating conditions

11.1.1 Flow rate

Minimum flow rate

The pump must not run against closed outlet valve as this will cause an increase in temperature or formation of steam in the pump.

This may cause shaft damage, impeller erosion, short life of bearings, damage to stuffing boxes or mechanical shaft seals due to stress or vibrations.

The minimum continuous flow rate is shown when selecting the pump in Grundfos Express online selection tool.

Maximum flow rate

The maximum flow rate must not exceed the value stated on the nameplate. If the maximum flow rate is exceeded, cavitation and overload may occur.

11.1.2 Ambient temperature and altitude

The ambient temperature and the installation altitude are important factors for the motor life, as they affect the life of the bearings and the insulation system.

Too high ambient temperature or low density and consequently low cooling effect of the air may result in overheating.

In such cases, it may be necessary to use a motor with a higher output.

11.1.3 Liquid temperature

The maximum liquid temperature depends on the material of the mechanical shaft seal, O-rings and gaskets used:

- Temperature range for BUNA:
  32-212 °F (0-100 °C).
- Temperature range for FKM:
  59-275 °F (15-135 °C).
- Temperature range for EPDM:
  59-275 °F (15-135 °C).

11.1.4 Outlet pressure

Maximum outlet pressure

The maximum outlet pressure is the pressure (total dynamic head or TDH) stated on the pump nameplate.

11.1.5 Inlet pressure

Minimum inlet pressure

The minimum inlet pressure must correspond to the NPSH curve for the pump + a safety margin of minimum 1.6 ft (0.5 m) head.

Pay attention to the minimum inlet pressure to avoid cavitation. The risk of cavitation is higher in the following situations:

- The liquid temperature is high.
- The flow rate is considerably higher than the pump's rated flow rate.
- The pump is operating in an open system with suction lift.
- The inlet conditions are poor.
- The operating pressure is low.

Maximum inlet pressure

Inlet pressure + pump pressure must be lower than maximum pressure (total dynamic head or TDH) of the pump.

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.

Subject to alterations.

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Brookshire, TX 77423 USA
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Fax: 1-800-945-4777

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Phone: 011-52-81-8144 4000
Fax: 011-52-81-8144 4010

www.grundfos.mx

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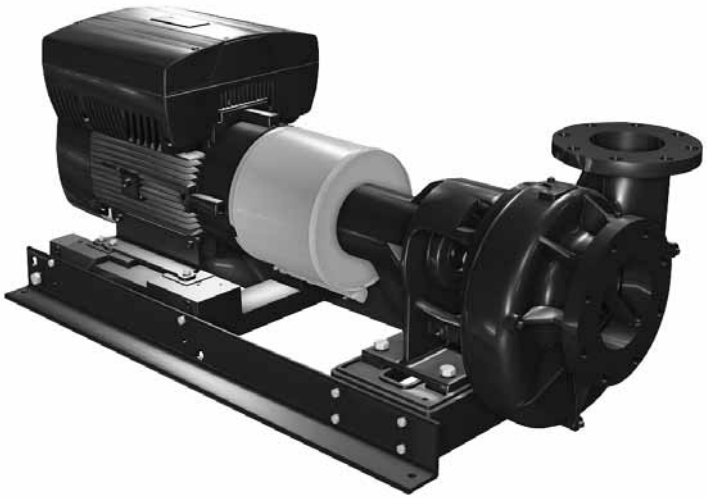
ECM: 1214834

LFE, LCSE

End-suction, frame-mounted pumps with integrated VFD
End-suction, close-coupled, split-coupling pumps with integrated VFD

Installation and operating instructions



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GRUNDFOS

LFE, LCSE

Original installation and operating instructions

These installation and operating instructions describe LFE, LCSE.

Sections 1-5 give the information necessary to be able to unpack, install and start up the product in a safe way.

Sections 6-30 give important information about the product, as well as information on service, fault finding and disposal of the product.

CONTENTS

Prior to installation, read these installation and operating instructions. Installation and operation must comply with local regulations and accepted codes of good practice.

The use of this product requires experience with and knowledge of the product. Persons with reduced physical, sensory or mental capabilities must not use this product, unless they are under supervision or have been instructed in the use of the product by a person responsible for their safety. Children must not use or play with this product.

CAUTION

Successful operation depends on careful attention to the procedures described in this manual. Keep this manual for future use.

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 Symbols used in this document

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 text accompanying the three hazard symbols DANGER, WARNING and CAUTION will be structured in the following way:

SIGNAL WORD

Description of hazard

Consequence of ignoring the warning.

- Action to avoid the hazard.

Example

DANGER

Electric shock

Death or serious personal injury.

- Before starting any work on the product, make sure that the power supply has been switched off and that it cannot be accidentally switched on.

2.2 Other important notes

A blue or grey circle with a white graphical symbol indicates that an action must be taken to avoid a hazard.

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.

Notes or instructions that make the work easier and ensure safe operation.

3. Receiving the product

3.1 Unpacking the product

WARNING

Overhead load

Death or serious personal injury

- Do not lift the unit by the eye bolts on the motor. Unload and handle the unit with a sling.

3.2 Inspecting the product

- Check that the product received is in accordance with the order.
- Check that the voltage, phase and frequency of the product match the voltage, phase and frequency of the installation site. See section *7.3 Pump identification*.
- Check the product for defects and damage immediately upon arrival. Any accessories ordered will be packed in a separate container and shipped with the product.
- If any equipment is damaged in transit, promptly report this to the carrier's agent. Make complete notations on the freight bill.

3.3 Temporary storage after delivery

- If the product is not to be installed and operated immediately after receiving it, store it in a clean, dry area at a moderate ambient temperature.
- Rotate the shaft by hand periodically, at least weekly, to coat the bearing with lubricant to retard oxidation and corrosion.
- Follow the motor manufacturer's storage recommendations where applicable.
- During storage and transport maintain an ambient temperature from -13 to +158 °F (-25 to +70 °C) for the E-motor. At temperatures below the prescribed temperature, the E-motor must be equipped with a anti-condensation heater. This could be an external heating element or an incorporated functionality of the E-motor.

4. Installing the product

4.1 Location

- Locate the pump as close as possible to the liquid supply. Use the shortest and most direct inlet pipe practical. Refer to section *4.4.2 Inlet pipe*.
- Locate the pump below system level wherever possible. This will facilitate priming, assure a steady liquid flow, and provide a positive inlet pressure.
- The net positive suction head (NPSH) available must always be equal to or exceed the required NPSH specified on the pump performance curve. Make sure the required NPSH is provided at the inlet.
- Always allow sufficient accessibility space for maintenance and inspection. Provide a clearance of 24 in. (610 mm) with ample head room for use of a hoist strong enough to lift the product.
- Electrical characteristics must match those specified on the motor nameplate, within the limits covered in section *5. Starting up the product*.
- Do not expose the product to sub-zero temperatures to prevent the pumped liquid from freezing and to prevent damage to the e-motor. If there is frost during shutdown periods, see sections *5. Starting up the product* and *9.2 Short-term shutdown*.

4.2 Horizontal pump foundation

Install horizontal pumps permanently on a firm, raised concrete foundation of sufficient size to dampen any vibration and prevent any deflection or shaft misalignment. The foundation may float on springs or be a raised part of the equipment room floor.

Proceed like this:

1. Pour the foundation without interruption to 0.75 - 1.5 in. (20-35 mm) below the final pump level. Leave the top of the foundation rough. Then clean and wet it down.
2. Score and groove the top surface of the foundation before the concrete sets to provide a suitable bonding surface for the grout.
3. Place anchor bolts in pipe sleeves for positioning allowance. See fig. 1.
4. Allow enough bolt length for grout, lower base plate flange, nuts, and washers.
5. Allow the foundation to cure several days before proceeding to install the pump.

4.3 Securing the base plate

LFE pumps require grouting in order to ensure a stable pump and motor shaft alignment.

LCSE pumps do not require alignment or grouting.

When the raised concrete foundation has been poured and allowed to set, proceed as follows:

1. Lower the pump base plate over the anchor bolts and rest it on loose adjustment wedges or shims placed near each anchor bolt and at intervals not exceeding 24 in. (610 mm) along each side.
2. Place the shims or wedges so that they raise the bottom of the base 0.75 - 1.25 in. (20-32 mm) above the foundation, allowing clearance for grout.
3. Level the pump shaft, flanges, and base plate using a spirit level, adjusting the wedges or shims, as required.
4. Make sure that the pipes can be aligned to the pump flanges without placing any strain on either flange.
5. For LFE, after pump alignment has been established, put nuts on foundation bolts and tighten them just enough to keep the base plate from moving.
6. Construct a formwork around the concrete foundation and pour grout inside the base plate, as shown in fig. 1. The grout will compensate for uneven foundation, distribute the weight of the pump, and prevent shifting.

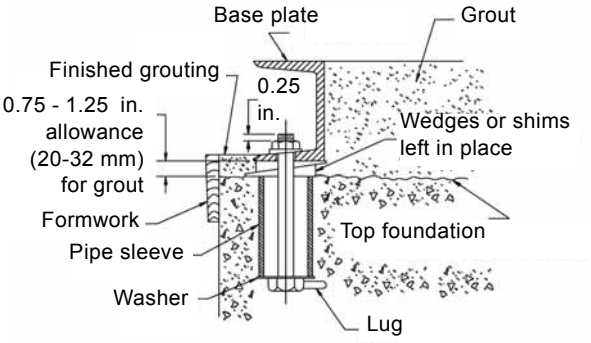

Fig. 1 Anchor bolt installation

Use an approved, non-shrinking grout.

7. Allow at least 24 hours for this grout to set before proceeding with pipe connections.
8. After the grout has thoroughly hardened, check the foundation bolts and tighten them if necessary. Recheck the pump alignment after tightening the foundation bolts.

4.4 Mechanical installation

4.4.1 Piping

Do not let the pump support the pipes. Use pipe hangers or other supports at proper intervals to provide pipe support near the pump.

- Make sure that both the inlet and outlet pipes are independently supported and properly aligned so that no strain is transmitted to the pump when flange bolts are tightened.
- Make sure the pipes are as straight as possible, so as to avoid unnecessary bends and fittings. Where necessary, use 45 ° or long-sweep 90 ° pipe bends to decrease friction loss.
- Where flanged joints are used, make sure that inside diameters match properly and that mounting holes are aligned.
- Do not apply force to pipes when making any connections!

4.4.2 Inlet pipe

The inlet pipe must be selected and installed in a manner that minimizes pressure loss and permits sufficient liquid flow into the pump during starting and operation.

Observe the following precautions when installing the inlet pipe:

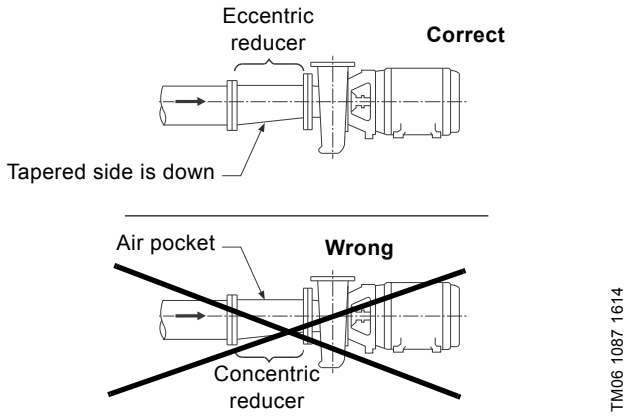

Fig. 2 Inlet pipe

- Run the inlet pipe as direct as possible, and ideally, make sure the length is at least ten times the pipe diameter. A short inlet pipe can be the same diameter as the inlet port. A long inlet pipe must be one or two sizes larger (depending on length) than the inlet port, and with a reducer between the pipe and the inlet port.
- Use an eccentric reducer, with the tapered side down. See fig. 2.

At no point must the diameter of the inlet pipe be smaller than that of the pump inlet port.

- If possible, run a horizontal inlet line along an even gradient. We recommend a gradual upward slope to the pump under suction lift conditions, and a gradual downward slope for positive inlet pressure conditions.
- Avoid any high points, such as pipe loops (see fig. 3), as this may create air pockets and throttle the system or cause erratic pumping.
- Install a gate valve in the inlet line to be able to isolate the pump during shutdown and maintenance, and to facilitate pump removal. Where two or more pumps are connected to the same inlet line, install two gate valves to be able to isolate each pump from the line.
- Always install gate or butterfly valves in positions that prevent air pockets.

Do not use globe valves, particularly when NPSH is critical.

- During pumping operation, the valves on the inlet line must always be fully open.
- Install properly sized pressure gauges in the tapped holes on the pump inlet and outlet flanges.
  Pressure gauges will enable the operator to monitor the pump performance and determine whether the pump conforms to the parameters of the performance curve. If cavitation, vapor binding, or other unstable operating situations occur, pressure gauges will indicate wide fluctuation in the inlet and outlet pressures.

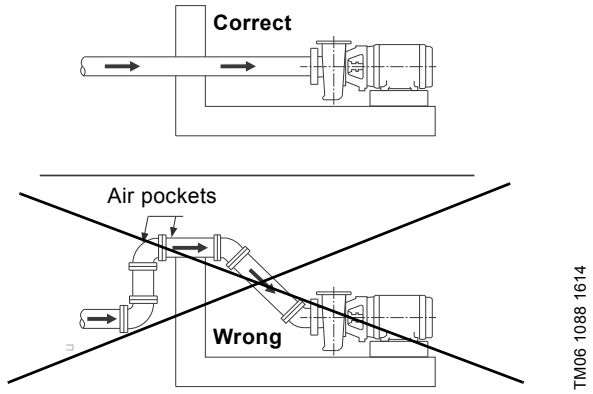

Fig. 3 Air pocket prevention

4.4.3 Outlet pipe

- A short outlet pipe can be the same diameter as the pump outlet port. A long outlet pipe must be one or two sizes larger than the outlet port, depending on the length.
- An even gradient is best for long horizontal outlet pipes.
- Install a gate valve near the outlet port to be able to isolate the pump during shutdown and maintenance, and to facilitate pump removal.
- Any high points in the outlet pipe may entrap air or gas and thus retard pump operation.
- If water hammer occurs (i.e. if check valves are used), close the outlet gate valve before pump shutdown.

Shaft seals

The pumps are available with stuffing boxes with packing rings or mechanical shaft seals.

Stuffing boxes

The stuffing boxes are normally packed before shipment.

If the pump is installed within 60 days after shipment, the packing material will be in good condition for operation with a sufficient supply of lubricating liquid.

If the pump is stored for more than 60 days, it may be necessary to repack the stuffing boxes.

The stuffing box must be supplied at all times with a source of clean, clear liquid to flush and lubricate the packing rings.

Packing gland adjustment

With the pump running, adjust the packing gland to permit 40 to 60 drops per minute for shaft lubrication. After initial start up, additional packing and adjustment may be required.

Mechanical shaft seals

Mechanical shaft seals require no maintenance or adjustment.

End suction pumps equipped with mechanical shaft seals are matched to the operating conditions for which the pump was sold. Observe the following precautions to avoid shaft seal damage and obtain maximum shaft seal life.

Do not run the pump dry or against a closed valve! Dry running will cause seal failure within minutes.

Do not exceed the temperature or pressure limitations for the mechanical shaft seal used.

Clean and purge the inlet pipe in new installations before installing and operating pump. Pipe scale, welding slag and other abrasives can cause rapid shaft seal failure.

4.4.4 Coupling alignment of LCSE pumps

No alignment of the pump and motor is required.

4.4.5 Coupling alignment of LFE pumps

The pump and motor were accurately aligned from factory, but handling during shipment could alter this pre-alignment.

1. If the pump and motor were shipped mounted on a common base frame as an assembly, remove the coupling guard.
2. **Checking parallel alignment**
   Place a straight edge across both coupling rims at the top, the bottom, and both sides. See fig. 4. After each adjustment, recheck all features of alignment. Parallel alignment is correct when the measurements show that all points of the coupling faces are within ± 0.005 in. (0.127 mm) of each other. If misalignment is detected, loosen the motor and shift or shim as necessary to re-align. Then re-tighten the bolts. Always align the motor to the pump as pipe strain will occur if the pump is shifted. Never reposition the pump on the base frame.

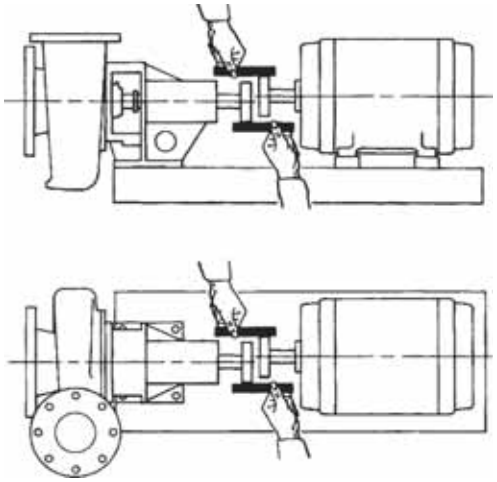

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Fig. 4 Checking parallel alignment

3. **Checking angular alignment**
   Insert a pair of inside callipers or a taper gauge at four points at 90 ° intervals around the coupling. See fig. 5. Angular alignment is correct when the measurements show that all points of the coupling faces are within ± 0.005 in. (0.127 mm) of each other.
   – If misalignment is detected, loosen the motor and shift or shim as necessary to re-align. Then re-tighten the bolts. Always align the motor to the pump as pipe strain will occur if the pump is shifted. Never reposition the pump on the base frame.

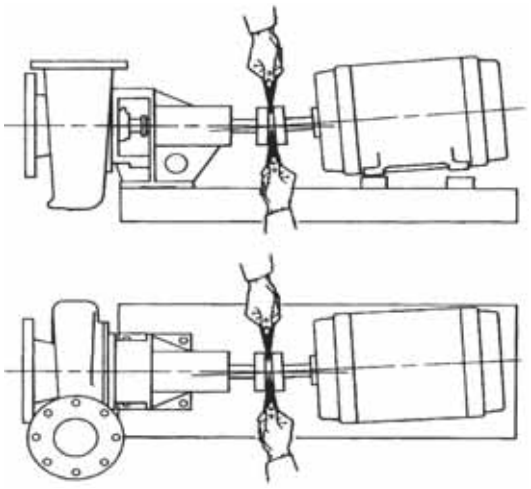

Fig. 5 Checking angular alignment

- Check shaft seal alignment once again after final pipe connections to the pump have been made, motor wiring has been checked, correct direction of rotation has been established, and pipes have been filled with liquid.
- Leave the coupling guards off until the pump priming procedure has been completed.
- Install the coupling guards after installation has been completed to protect personnel from rotating machinery.

4.5 Electrical connections

DANGER

Electric shock

Death or serious personal injury
- The electrical installation must be carried out by a qualified electrician in accordance with local regulations and the manuals provided with the electrical accessories.

DANGER

Electric shock

Death or serious personal injury
- Before starting any work on the product, be sure the power supply has been switched off and that it cannot be accidentally switched on.

4.6 Motors

See also section *11. PACO MLE motors*.

The motor control circuit must include the following components in order to comply with the National Electrical Code:

Motor disconnecting device

- Install a motor disconnecting device that is capable of disconnecting both the controller (motor starter) and the motor from their source of power.
- Locate the disconnecting device in such a way that the controller (motor starter) can be seen from the disconnecting device. In all cases, the distance from the disconnecting device to the controller must be less than 50 ft (15.24 m).
- In most installations the disconnecting device will be a circuit breaker or fusible disconnect switch.

Motor short circuit and ground fault circuit interrupter

- A short circuit and ground fault circuit interrupter is usually a circuit breaker or fusible disconnect switch.
- Select the circuit breaker or fuse in accordance with applicable local and state electrical codes in addition to the National Electrical Code.

Motor controller with current protection (magnetic starter)

- Install these components in accordance with applicable local and state electrical codes in addition to the National Electrical Code.

DANGER

Explosive environment

Death or serious personal injury
- Observe the rules and regulations generally or specifically imposed by the relevant responsible authorities or trade organizations in relation to running powered equipment in an explosive environment.

4.6.1 Wiring

- Mount the control panel or the motor starter(s) close to the pump to provide convenient control and easy installation.
- Wire panel or starter(s) to motor(s) and pilot device(s). Wires to the motor(s) must be sized for at least 125 % of the motor nameplate full load amps. We recommend AWG #16 Type THW stranded wire for wiring of pilot devices, such as float switches.
- Check that the voltage, phase and frequency of the incoming power source correspond to the voltage, phase and frequency of the motor(s).
- Make sure that the starters are suitable for operating the pump motors on the voltage, phase and frequency available.

5. Starting up the product

5.1 Priming

- End suction pumps are non-self-priming, and must be completely primed, i.e. filled with liquid, before starting.
- If the pump will be operated with a positive inlet pressure, prime it by opening the inlet valve and allowing liquid to enter the pump housing. Open the air vents at this time, and make sure all air is forced out of pump by the liquid before closing the air vents.
- Rotate the shaft by hand to free entrapped air from the impeller passageways.
- If the pump will be operating with a suction lift, priming must be accomplished by other methods. Use foot valves or ejectors, or fill the pump housing and the inlet line manually with liquid.

Never run the pump dry in the hope that it will prime itself. The result will be serious damage to the shaft seals, pump wear rings and shaft sleeves.

5.2 Pre-start checklist

WARNING

Product failure

Death or serious personal injury

- Do not operate the product above the nameplate conditions.

Make the following inspections before starting your end suction pump:

1. Make sure the inlet and outlet pipes have been cleaned and flushed to remove dirt and debris.
2. Double check the direction of rotation is clockwise. Operating in reverse will destroy the impeller and shaft.
3. Make sure all wiring connections to the motor and starting device are in accordance with the wiring diagram.
4. If the motor has been in storage for a long time, either before or after installation, refer to the motor instructions before starting.
5. Check the voltage, phases, and frequency with the motor nameplate. Turn the impeller by hand to make sure it rotates freely.
6. Tighten the plugs in the gauge and drain holes. If the pump is fitted with pressure gauges, keep the gauge cocks closed when they are not in use.
7. Check the inlet and outlet pipes for leaks, and make sure all flange bolts are securely tightened.

5.3 Motor direction of rotation

Never check the motor direction of rotation unless the pump and motor couplings have been disconnected and physically separated. Failure to follow this instruction can result in serious damage to the pump and the motor if the direction of rotation is wrong.

5.4 Starting the pump

DANGER

Moving machine parts

Death or serious personal injury

- Mount an approved coupling guard before operating the product.

1. Install the factory-provided coupling guard on coupled products.
2. Fully open the gate valve (if any) in the inlet line, and close the gate valve in the outlet line.
3. Fill the inlet line with liquid and completely prime the pump.
4. Start the pump.
5. Immediately make a visual check of the pump and inlet pipe for pressure leaks.
6. Immediately after the pump has reached full operating speed, slowly open the outlet gate valve until complete system flow is achieved.
7. Check the outlet pipe for pressure leaks.
8. If the pump is fitted with pressure gauges, open gauge cocks and record pressure readings for future reference. Verify that the pump is performing in accordance with the parameters specified in the performance curves.
9. Check and record voltage, amperage per phase, and kilowatts, if a wattmeter is available.

5.5 Voltage and frequency variation

The motor will operate satisfactorily under the following voltage and frequency variations, but not necessarily in accordance with the standards established for operation under rated conditions:

- The voltage variation may not exceed 10 % above or below the rating specified on the motor nameplate.
- The frequency variation may not exceed 5 % above or below the motor rating.
- The sum of the voltage and frequency variations may not exceed 10 % above or below the motor rating, provided the frequency variation does not exceed 5 %.

6. Storing and handling the product

See sections *3.3 Temporary storage after delivery*, *9.2 Short-term shutdown* and *9.3 Long-term shutdown*.

7. Product introduction

This data booklet describes:

- LFE end-suction, frame-mounted pumps with integrated VFD
- LCSE end-suction, close-coupled, split-coupling pumps with integrated VFD.

7.1 Applications

We recommend the integrated VFD end suction pumps for these applications:

- commercial and industrial cooling systems
  – pumping both primary and secondary cooling water
- condenser water systems
- district cooling systems
- water distribution systems
- irrigation systems.

7.2 Pumped liquids

Clean, thin, non-aggressive liquids, not containing solid particles or fibers. Do not pump liquids that will attack the pump materials chemically.

7.3 Pump identification

Pumps are identified by catalog and serial numbers (LFE nameplate shown in fig. 6). These numbers are stamped on the pump nameplate as shown in fig. 6, affixed to each pump volute casing, and should be referred to in all correspondence with Grundfos.

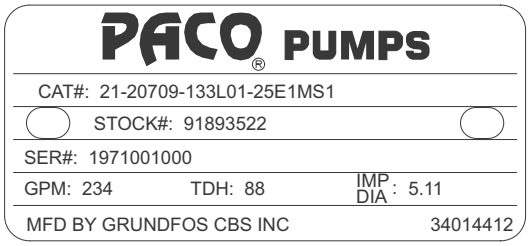

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Fig. 6 Nameplate

8. Servicing the product

8.1 Maintaining the product

WARNING

Moving machine parts

Death or serious personal injury

- Before any inspection, maintenance, service or repair of the product, make sure the motor controls are in the "OFF" position, locked and tagged.

8.2 Lubricating the product

8.2.1 Lubricating the motor

Always follow the motor manufacturer's lubricating instructions, if they are available, and periodically check grease fittings and drain plugs for leaks. Use the standard lubrication interval. See the installation and operating instructions or the lubrication plate on the E-motor. If the lubricating instructions are not available, refer to the table below for recommended lubricating intervals.

Recommended lubricating intervals

Motor rpm	Motor hp	Operating conditions		
		Standard	Severe	Extreme
1750 and below	3.00-7.50	3 yrs	1 yr	6 mo
	10-30	1-3 yrs	6 mo-1 yr	3 mo
above 1750	all hp	6 mo	3 mo	3 mo

Standard conditions:
Operating 8 hours per day operation, normal or light load, clean air, 100 °F (37 °C), maximum ambient temperature.
Severe conditions:
Operating continuously 24 hours, shock loads or vibrations, poor ventilation, 100-150 °F (37-65 °C), ambient temperature.
Extreme conditions:
Continuous operation, heavy shocks or vibrations, dirt or dust in the air, extremely high ambient temperature.

8.2.2 Lubricating the pump

Grease lubrication

In the standard configuration, LFE pumps with horizontal bearing frames have sealed-for-life bearings (requiring no lubrication). For customized pumps with regreasable bearings, use an approved grease and proceed as described below.

Approved grease lubricants	
Manufacturer	**Lubricant**
Shell	Dolium® R
Exxon	Polyrex®
Chevron	SRI GreaseNLGI 2
	Black Pearl - NLGI 2
Philips	Polytac™
Texaco	Polystar RB

- Remove the drain plug, if any, and the filler plug. Add clean lubricant until grease appears at the drain hole or along the pump shaft. On pumps with drain hole, all old grease can be purged. In such cases, the drain hole must be left unplugged for several minutes during pump operation to allow excess grease to be forced out.
- Lubricate the pump bearings at 1-3 month intervals, depending on the severity of the environment. Pumps in a clean, dry, moderate temperature (100 °F (37 °C) maximum) environment must be regreased at 3-month intervals.

Do not over-grease! Too much grease can cause overheating and premature bearing failure.

Oil lubrication

LFE pumps with oil lubricated bearings are fitted with a transparent reservoir, a constant-level oiler, that maintains the oil level about the centerline of the bearing. See fig. 7.

- Follow a regular maintenance program. When necessary, renew the oil supply in the reservoir of the constant-level oiler.
- Change the oil after the first 200 hours of operation. To change the oil, remove the drain plug at the bottom of the bearing cover and the filler plug, that also acts as a vent plug, at the top of the bearing frame. After draining the oil, replace the fittings and refill the reservoir with an acceptable oil from the table *List of acceptable oil lubricants* on page 12. After the first oil change, the oil must be changed again at 2000 hours and then at intervals of 8000 hours or once a year, thereafter.

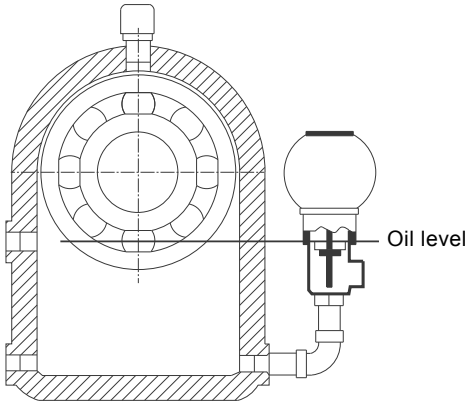


Fig. 7 Oil lubrication

List of acceptable oil lubricants	
Lubricant manufacturer	**Bearing oil brand name**
Aral Refining Co.	Aral Oil CMU
	Aral Oil TU 518
British Petroleum Co.	BP Energol
	TH 100-HB
Calypsol Oil Co.	Calypsol Bison Oil
	SR 25 or SR 36
Standard Oil Co.	Chevron
	Hydraulic Oil 11
	Circulating oil 45
Esso Corp	Esso-Mar 25
	Teresso 47
	Esstic 50
Fina Oil Co.	Fina hydran 34
	Fina Cirkan 32
Gulf Refining Co.	Gulf Harmony 47
	Gulf Paramount 45
Socony Mobil Oil Co.	Vac hlp 25
	Mobulix D.T.E. 25
Shell Oil Co.	Shell Tellus oil 29
Sundco Oil Co.	Sunvis 821
The Texas Co.	Texaco ursa oil P 20
	Dea viscobil sera 4

8.3 Disassembling the pump

8.3.1 Preparations before disassembling the pump

DANGER

Electric shock

Death or serious personal injury

- Before starting any work on the product, be sure the power supply has been switched off and that it cannot be accidentally switched on.

CAUTION

Toxic material

Minor or moderate personal injury.

- Wash down the pump before doing any work on it.

DANGER

Hot, caustic, flammable or toxic materials, including vapors

Death or serious personal injury

- Be extremely cautious when venting and/or draining hazardous liquids.
- Wear protective clothing when there are caustic, corrosive, volatile, flammable, or hot liquids.
- DO NOT breathe toxic vapors.
- DO NOT allow sparks, open fire, or hot surfaces near the equipment.

Complete disassembly instructions are outlined below. Proceed only as far as required to perform the maintenance work needed.

1. Switch off the power supply.
2. Drain the system.
3. Flush the system, if necessary.
4. For closed coupled units: Remove the motor fixation bolts.

8.3.2 Disassembling the liquid end

1. Remove the pump housing screws (8B).
2. Remove the back pull-out bearing frame (20Y) from the pump housing (1A).
3. Remove the impeller screw (8A).If necessary, use a strap wrench around the impeller or shaft to prevent rotation.

WARNING

Moving machine parts

Death or serious personal injury

- Do not insert a screwdriver between the impeller vanes to prevent rotation.

4. Use an appropriately sized puller aligned behind the impeller vanes to remove the impeller (3A) from the shaft (6A).
5. Remove the impeller key (12A).
6. Remove the back plate screws (8D). Remove the back plate (2K) and the seal housing (26P).
7. Place the seal housing on a flat surface and press out the shaft seal (14A).
8. If the shaft sleeve (5A) requires replacement, heat it evenly to approximately 350 °F (176 °C) to loosen the thread-locking fluid. Twist the sleeve off the shaft (6A).

8.3.3 Disassembling the bearing frame (LFE)

1. Remove the slinger (13G).
2. Remove the lip seal(s) (14S), if any.
3. Remove the bearing housing locking ring (61K).
4. Press or tap on the pump end of the bearing-shaft assembly until one bearing is out.
5. When one bearing is out, remove the second locking ring (61F), then remove the complete bearing-shaft assembly from the bearing housing.
6. Remove the shaft locking ring (61C) and press off the bearings.
7. Press new bearings onto the shaft; remember to press only on the inner race of the bearings while pressing them on.
8. Assemble the bearing frame in the reverse procedure used for disassembling.
9. Observe the following when reassembling the bearing frame.
   – Replace the lip seals (14S) if they are worn or damaged.
   – Replace the bearings (18A) and (18B) if they are loose, rough or noisy when rotated.
   – Check the shaft (6A) for shaft runout at the sleeve (5A) area. Maximum permissible runout is 0.002 in. (0.0508 mm) total indicator runout.

8.4 Replacing the shaft seal (LCSE pumps)

1. Complete preparations listed in section *8.3 Disassembling the pump*.
2. Remove the coupling guard screws (8E).
3. Remove the coupling guard (34F).
4. Remove the nut (35E) and the bolt (8E) that hold the coupling halves together.
5. Pry apart the coupling halves (23D), remove the coupling key (12B).

Mark or measure the original position of the pump coupling on the motor side.

6. For pumps with lubrication lines, unscrew the tubing connector from the pipe tee of the air vent assembly. Thread sealing compound was applied to the threads during factory assembly, and the resulting bond may retard but will not prevent manual disassembling.
7. Remove the seal housing cap screws and slide the seal housing (2N) up the shaft to remove it.
8. Remove the shaft seal (14A) manually from the shaft (6A). Apply water-soluble lubricant to the shaft, if necessary, to ease the removal of the shaft seal. Pull the seal head assembly manually from the shaft, using a slight twisting motion (as necessary) to loosen bellows from shaft.
9. Remove and discard the shaft seal spring and the shaft seal retainer.
10. Remove and discard the shaft seal seat from the seal housing (2N) and thoroughly clean the inside cavity of the seal housing.
11. The interior surface of the bellows on a new shaft seal is coated with a bonding agent that adheres to the motor shaft. When the old shaft seal is removed, the bonding agent no longer exists and the bellows may crack or split during removal. We always recommend that you install a new mechanical shaft seal if it becomes necessary to remove the existing shaft seal from the shaft.
12. Clean and lubricate the shaft (6A) with a water-soluble lubricant and make sure no sharp edges can cut or scratch the bellows of the new shaft seal.
13. Press the new shaft seal seat firmly into the seal housing. Avoid direct contact between the seal face and metallic or abrasive objects, and wipe the seal face clean after installation to ensure an abrasive-free sealing surface.
14. Slide the new shaft seal (14A) onto the shaft by applying even pressure to the shaft seal.
15. Install the shaft seal housing (2N) on the shaft.
16. See the reassembly instructions in section *8.6 Reassembling the pump*.

8.5 Replacing the wear ring

1. Complete preparations in sections *8.3.1 Preparations before disassembling the pump* and *8.3.2 Disassembling the liquid end*.
2. Remove the rotating assembly.
3. Remove the pump housing (1A) from the pipes, if necessary, to facilitate easy access to the interior of the pump housing. If necessary, remove the flange bolts at the pipes.
4. Remove a worn wear ring (4A) by drilling two holes slightly smaller than the width of the wear ring into the exposed edge of the wear ring. Insert a chisel into the holes to completely sever the wear ring at the holes and break the wear ring into two halves for easy removal.
5. Clean the wear ring cavity in the pump housing prior to installing a new wear ring to ensure a properly aligned fit.
6. To reassemble, press fit the new wear ring squarely into the pump housing cavity. Tap the wear ring into place to make sure it is pressed home into the cavity.

Do not use metal tools on the wear ring surfaces. Use only rubber, rawhide, wood or other soft material to prevent damage to the wear ring.

8.6 Reassembling the pump

WARNING

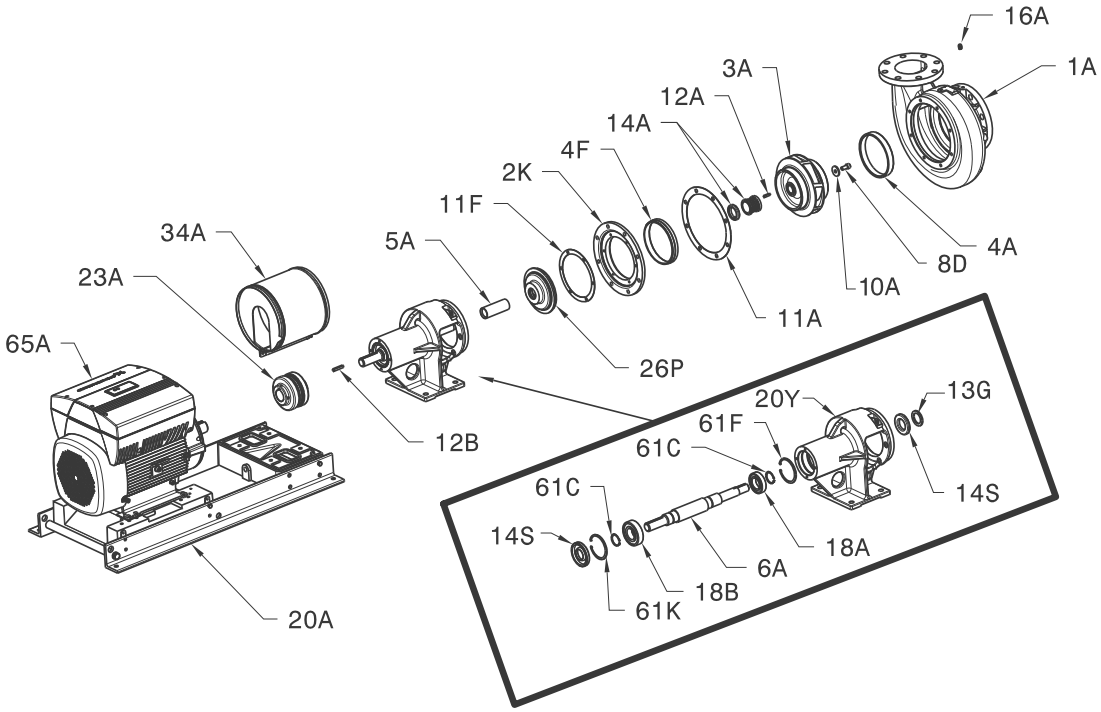
Moving machine parts

Death or serious personal injury

- Reinstall approved coupling guards and make sure they are in place prior to operation.

1. Clean all parts before reassembly.
2. Refer to the parts list to identify required replacement items.
3. Specify the pump serial or catalog number when ordering parts.
4. Reassemble the pump in the reverse procedure used for disassembling.
5. Observe the following when reassembling the pump:
   – All mechanical seal components must be in good condition or leakage may result. We recommend that you replace the complete shaft seal.
   – Install new shaft sleeves by bonding them to the shaft with a thread-locking fluid.
6. Re-install the coupling guards on coupled pumps.

8.7 LFE, exploded view and parts list



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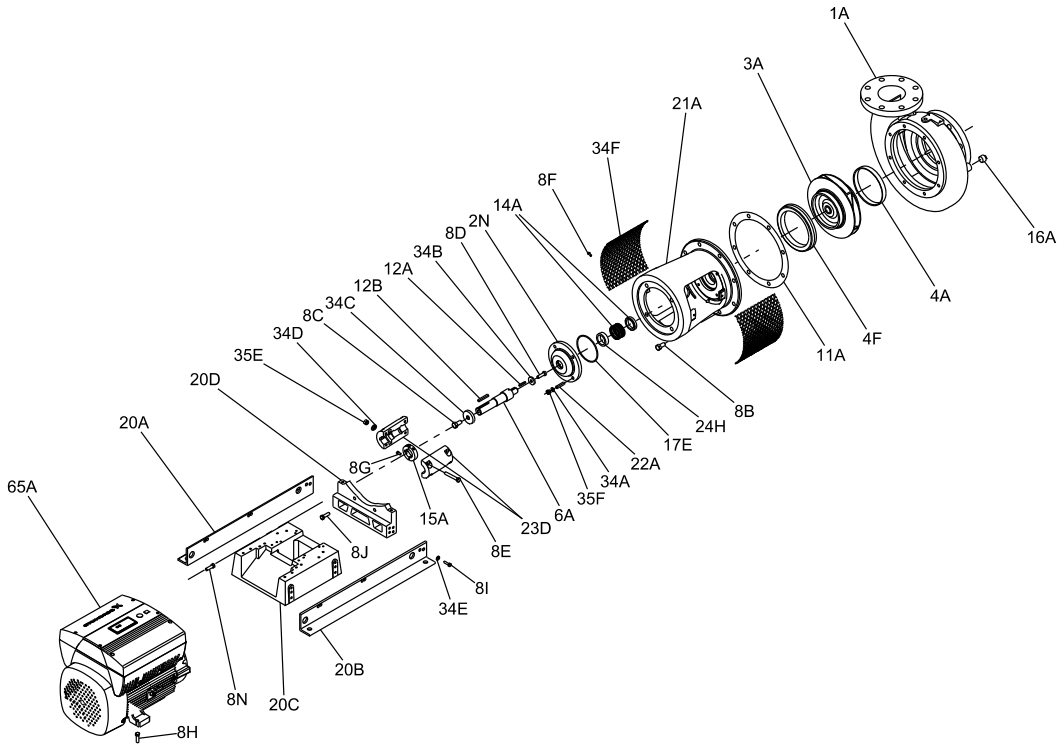
Pos.	Description
1A	Pump housing
2K	Backplate
3A	Impeller
4A	Wear ring
4F*	Balance wear ring
5A	Shaft sleeve
6A	Shaft
8D	Cap screw
10A	Washer
11A	Gasket

Pos.	Description
11F	Gasket
12A	Key
12B	Key
13G	Slinger
14A	Shaft seal
14S	Lip seal
16A	Drain plug
18A	Bearing, inboard
18B	Bearing, outboard

Pos.	Description
20A	Base plate
20Y	Bearing frame
23A	Coupling hub
26P	Seal housing
34A	Coupling guard
61C	Locking ring
61F	Locking ring
61K	Locking ring
65A	Motor

* If applicable

8.8 LCSE, exploded view and parts list



Pos.	Description
1A	Pump housing
2N	Shaft seal housing
3A	Impeller
4A	Wear ring
4F	Balance wear ring
6A	Pump shaft
8B	Cap screw
8C	Screw
8D	Screw
8E	Bolt
8F	Screw
8G	Screw
8H	Cap screw
8I	Cap screw
8J	Screw
8N	Screw
11A	Gasket
12A	Key
12B	Key
14A	Shaft seal

Pos.	Description
15A	Locating ring
16A	Drain plug
17E	O-ring
20A+20B	Base plate rails
20C	Base plate
20D	Pump support
21A	Motor stool
22A	Stud
23D	Coupling halves
24H	Bushing
34A	Washer
34B	Washer
34C	Washer
34D	Washer
34E	Washer
34F	Coupling guard
35E	Nut
35F	Nut
65A	Motor

9. Taking the product out of operation

The following shutdown procedures will apply for the L pumps in most normal shutdown situations. If the pump will be inoperative for a long time, follow the storage procedures in section *9.3 Long-term shutdown*.

9.1 General procedure

- Always close the outlet gate valve before stopping the pump. Close the valve slowly to prevent hydraulic shock.
- Disconnect and lock off the power to the motor.

9.2 Short-term shutdown

- For overnight or temporary shutdown periods under non-freezing conditions, the pump may remain filled with liquid. Make sure the pump is fully primed before restarting.
- For short or frequent shutdown periods under freezing conditions, keep the liquid moving within the pump housing and insulate or heat the pump exterior to prevent freezing.

9.3 Long-term shutdown

- For long shutdown periods, or to isolate the pump for maintenance, close the inlet gate valve. If no inlet valve is used and the pump has positive inlet pressure, drain all liquid from the inlet line to stop the liquid flow into the pump inlet. Remove the plugs in the pump drain and vent holes, as required, and drain all liquid from the pump housing.
- If there will be freezing conditions during long shutdown periods, completely drain the pump and blow out all liquid passages and pockets with compressed air. Freezing of the pumped liquid can also be prevented by filling the pump with antifreeze solution.

10. Fault finding

DANGER

Electric shock

Death or serious personal injury

- Before starting any work on the product, be sure the power supply has been switched off and that it cannot be accidentally switched on.

CAUTION

Toxic material

Minor or moderate personal injury.

- Wash down the pump before doing any work on it.

DANGER

Hot, caustic, flammable or toxic materials, including vapors

Death or serious personal injury

- Be extremely cautious when venting and/or draining hazardous liquids.
- Wear protective clothing when there are caustic, corrosive, volatile, flammable, or hot liquids.
- DO NOT breathe toxic vapors.
- DO NOT allow sparks, open fire, or hot surfaces near the equipment.

Fault	Cause	Remedy
1. Outlet pressure is too low.	a) The speed of rotation is too low.	Reestablish correct speed and direction of rotation.
	b) The system pressure is lower than anticipated.	Check the system curve.
	c) There is air or gas in the pumped liquid.	Remove the air from the pumped liquid.
	d) The wear rings are worn.	Replace the wear rings.
	e) The impeller is damaged.	Repair or replace the impeller.
	f) The impeller diameter is too small.	Replace the impeller with one of the correct diameter.
	g) Wrong direction of rotation.	Interchange two wires in the power supply.
	h) The pump has lost its prime.	Re-prime the pump.
	i) There is insufficient NPSH.	Restore required NPSH.
	j) Passages are restricted.	Clean the impeller and pump housing passages.
	k) Joints or the stuffing box are leaking.	• Tighten the joints or the stuffing box gland. • Replace the shaft sleeve. • Replace the gaskets.
2. Insufficient inlet pressure.	a) The inlet line is drawing air.	Tighten the connections.
	b) The suction lift is too high or there is insufficient NPSH.	Reduce the suction lift or restore required NPSH.
	c) Air or gas is trapped in the pumped liquid.	Remove the trapped air/gas from liquid.
	d) The strainer is clogged.	Clean the strainer.
3. Noise level has increased.	a) Poor alignment of the pump. Inlet and outlet pipe clamps are loose.	• Ensure proper alignment of the pump and the motor. • Support the inlet and outlet pipes. • Make sure the vibration dampers, flexible pipes, and conduit connectors are installed correctly.
	b) Cracked foundation.	Repair the foundation.
	c) Worn ball bearings.	• Replace the worn bearings. • Renew the lubrication.
	d) The motor is unbalanced.	• Disconnect the motor and operate it alone. • Remove large pieces of debris, such as wood or rags from the pump. • Clean out the pump, if necessary.
	e) Hydraulic resonance.	• Alter the resonant pipes. • Change the pump speed. • Insert a pulsation damper on the pump or the pipes. • Insert a flow straightener.

Fault	Cause	Remedy
4. Insufficient flow.	a) The pump is not primed.	Prime the pump.
	b) The system pressure exceeds the shut off pressure.	• Increase the liquid level on the inlet side. • Open the isolating valve in the inlet pipe.
	c) The rotation speed is too low.	Reestablish the correct speed of rotation.
	d) The suction lift is too high or there is insufficient NPSH.	Reduce the suction lift or restore required NPSH.
	e) The strainer or impeller is clogged.	Clean the strainer and impeller passages.
	f) Wrong direction of rotation.	Reestablish the correct direction of rotation.
	g) Leaking joints.	Tighten the joints.
	h) Broken shafting or coupling.	Repair or replace damaged parts.
	i) Closed inlet valve.	If the inlet valve is closed, open it slowly.
	j) There is not enough inlet pressure for hot or volatile liquids.	Reestablish required inlet pressure.
	k) Foot valve is too small.	Replace the foot valve.
	l) Worn or damaged hydraulic parts.	Repair or replace the worn parts.
	m) Excessive clearance between the wear surfaces.	See section *8.5 Replacing the wear ring*.
5. Pump loses its prime after starting.	a) Joints or the stuffing box are leaking.	• Tighten the joints or the stuffing box gland. • Replace the shaft sleeve. • Replace the gaskets.
	b) The suction lift is too high or there is insufficient NPSH.	Reduce the suction lift or restore required NPSH.
6. Excessive power required.	a) The speed of rotation is too high.	Reduce the speed of rotation.
	b) The pump is operating beyond its recommended performance range.	Set the duty point in accordance with the recommended performance range.
	c) The specific gravity or the viscosity of the pumped liquid is too high.	If less flow is sufficient, reduce the flow on the outlet side, or fit the pump with a more powerful motor.
	d) The shaft is bent.	Replace the shaft.
	e) Stuffing-boxes too tight.	Retighten the stuffing box if possible. Alternatively, repair or replace the stuffing box.
	f) Impeller clearances are too small causing rubbing or worn wear surfaces.	Adjust the impeller clearance, if possible, or replace the wear ring.
	g) There is an electrical or mechanical defect in the motor.	Contact your local service center for diagnostics.
	h) The pump is restricted in its rotation.	Remove any obstacles or replace any worn parts.
	i) Incorrect lubrication of the motor.	Reestablish correct lubrication of the motor.

11. PACO MLE motors

Grundfos E-pumps have standard motors with integrated variable frequency drive. The pumps are for a single-phase or three-phase power supply connection.

11.1 Pumps without factory-fitted sensor

The pumps have a built-in PI controller and can be set up for an external sensor enabling control of the following parameters:

- pressure
- differential pressure
- temperature
- differential temperature
- flow rate
- liquid level in a tank.

From the factory, the pumps have been set to control mode uncontrolled. The PI controller can be activated by means of the Grundfos GO Remote or R100.

11.2 Pumps with pressure sensor

The pumps have a built-in PI controller and are set up with a pressure sensor enabling control of the pump outlet pressure.

The pumps are set to control mode controlled. The pumps are typically used to hold a constant pressure in variable-demand systems or differential pressure in closed-loop applications.

11.3 Settings

The description of settings apply both to pumps without factory-fitted sensor and to pumps with a factory-fitted pressure sensor.

Setpoint

The desired setpoint can be set in three different ways:

- directly on the pump control panel
- via an input for external setpoint signal
- by means of the Grundfos GO remote or wireless remote control.

Other settings

All other settings can only be made by means of the Grundfos GO Remote or R100.

Important parameters such as actual value of control parameter, power consumption, etc. can be read via the Grundfos GO remote or R100.

If special or customized settings are required, use Grundfos PC Tool E-products. Contact Grundfos for more information.

12. Installing the motor

The pump must be secured to a firm, raised concrete foundation by means of bolts through the holes in the flange or baseplate.

In order to retain the UL/cUL approval, follow the additional installation procedures on page 54.

12.1 Motor cooling

To ensure sufficient cooling of motor and electronics, observe the following requirements:

- Make sure that sufficient cooling air is available.
- Keep the temperature of the cooling air below 104 °F (40 °C).
- Keep cooling fins and fan blades clean.

12.2 Outdoor installation

When installed outdoors, the pump must be provided with a suitable cover to avoid condensation on the electronic components. See fig. 8.

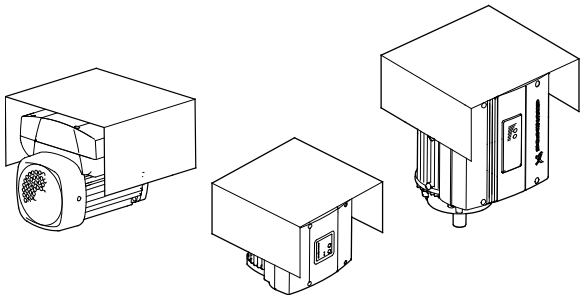


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Fig. 8 Examples of covers

Remove the drain plug pointing downwards in order to avoid moisture and water build-up inside the motor.

Vertically mounted pumps are IP55 after removal of the drain plug. Horizontally mounted pumps change enclosure class to IP54.

13. Electrical connection

For description of how to connect E-pumps electrically, see the following sections:

13.1 Three-phase pumps, 3-10 hp.

13.2 Three-phase pumps, 15-30 hp.

13.1 Three-phase pumps, 3-10 hp

DANGER

Electric shock

Death or serious personal injury

- The user or the installer is responsible for the installation of correct grounding and protection according to current national and local standards.
- All operations must be carried out by qualified personnel.

DANGER

Electric shock

Death or serious personal injury

- Disconnect all electric supply circuits and ensure these have been switched off for at least 5 minutes before making any connections in the pump terminal box. For instance, the signal relay may be connected to an external supply which is still connected when the power supply is disconnected.

The above warning is indicated on the motor terminal box by this yellow label:

13.1.1 Preparation

Before connecting the E-pump to the power supply, take the issues illustrated in the figure below into consideration.

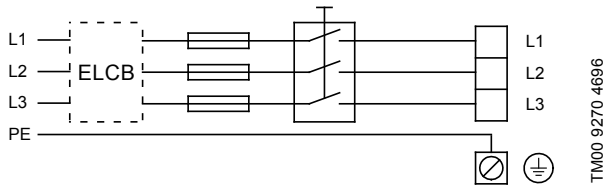

Fig. 9 Power supply-connected pump with power switch, backup fuses, additional protection and protective grounding

13.1.2 Protection against electric shock - indirect contact

DANGER

Electric shock

Death or serious personal injury

- Ensure the pump is grounded in accordance with national regulations. As the leakage current of 5-10 hp (4-7.5 kW) motors is > 3.5 mA, take extra precautions when grounding these motors.

EN 50178 and BS 7671 specify the following precautions when leakage current > 3.5 mA:

- Install the pump in a stationary, permanent position.
- Connect the pump permanently to the power supply.
- Carry out the grounding connection as duplicate leads.

Mark the protective ground leads with a yellow/green (PE) or yellow/green/blue (PEN) color marking.

13.1.3 Backup fuses

For recommended fuse sizes, see section *28.1.1 Supply voltage*.

13.1.4 Additional protection

If the pump is connected to an electric installation where an ground leakage circuit breaker (ELCB) is used as additional protection, use a circuit breaker of a type marked with the following symbols:

This circuit breaker is **type B.**

Take into account the total leakage current of all the electrical equipment in the installation.

Check the leakage current of the motor in normal operation; see section *28.1.3 Leakage current*.

During start and at asymmetrical supply systems, the leakage current can be higher than normal and may cause the ELCB to trip.

13.1.5 Motor protection

The pump requires no external motor protection. The motor incorporates thermal protection against slow overloading and blocking (IEC 34-11, TP 211).

13.1.6 Protection against voltage transients

The pump is protected against voltage transients by built-in varistors between the phases and between phases and ground.

13.1.7 Supply voltage and power supply

3 x 440-480 V - 10 %/+ 10 %, 60 Hz, PE.

3 x 208-230 V - 10 %/+ 10 %, 60 Hz, PE.

The supply voltage and frequency are marked on the pump nameplate. Make sure that the pump is suitable for the power supply of the installation site.

The wires in the terminal box must be as short as possible. Excepted from this is the protective ground lead which must be long enough that it is the last one to be disconnected in case the cable is inadvertently pulled out of the cable entry.

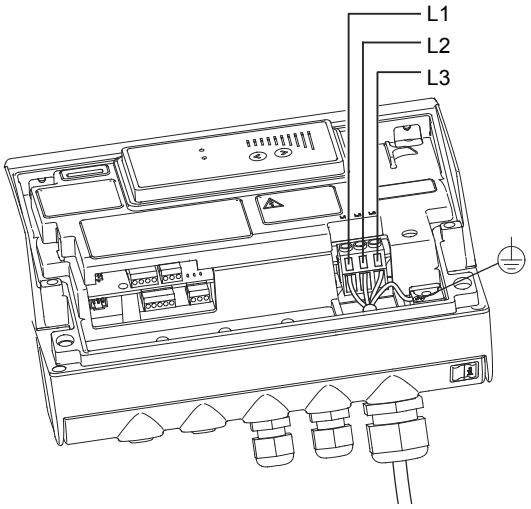

Fig. 10 Power connection

Cable glands

Cable glands comply with EN 50626.

- 2 x M16 cable gland
- 1 x M20 cable gland
- 2 x M16 knock-out cable entries.

DANGER

Electric shock, malfunction or damage

Death or serious personal injury; product damage or failure

- Replace power supply cable immediately if damaged. Only qualified personnel must replace it.

Grid types

Three-phase E-pumps can be connected to all grid types.

DANGER

Electric shock

Death or serious personal injury; product damage or failure

- Do not connect three-phase E-pumps to a power supply with a voltage between phase and ground of more than 440 V.

13.1.8 Start/stop of pump

The number of starts and stops via the power supply must not exceed 4 times per hour.

When the pump is switched on via the power supply, it will start after approximately 5 seconds.

If a higher number of starts and stops is desired, use the input for external start/stop when starting/stopping the pump.

When the pump is switched on via an external On/Off switch, it will start immediately.

Automatic restart

If a pump set up for automatic restart is stopped due to a fault, it will restart automatically when the fault has disappeared.

However, automatic restart only applies to fault types set up to automatic restart. These faults could typically be one of these faults:

- temporary overload
- fault in the power supply.

13.1.9 Connections

If no external On/Off switch is connected, connect terminals 2 and 3 using a short wire.

As a precaution, the wires to be connected to the following connection groups must be separated from each other by reinforced insulation in their entire lengths:

Group 1: Inputs

- start/stop terminals 2 and 3
- digital input terminals 1 and 9
- setpoint input terminals 4, 5 and 6
- sensor input terminals 7 and 8
- GENIbus terminals B, Y and A

All inputs (group 1) are internally separated from the power-conducting parts by reinforced insulation and galvanically separated from other circuits.

All control terminals are supplied with protective extra-low voltage (PELV), thus ensuring protection against electric shock.

Group 2: Output (relay signal, terminals NC, C, NO)

The output (group 2) is galvanically separated from other circuits. Therefore, the supply voltage or protective extra-low voltage can be connected to the output as desired.

13.1.10 Three-phase pumps, 3-10 hp

Group 3: Power supply (terminals L1, L2, L3)

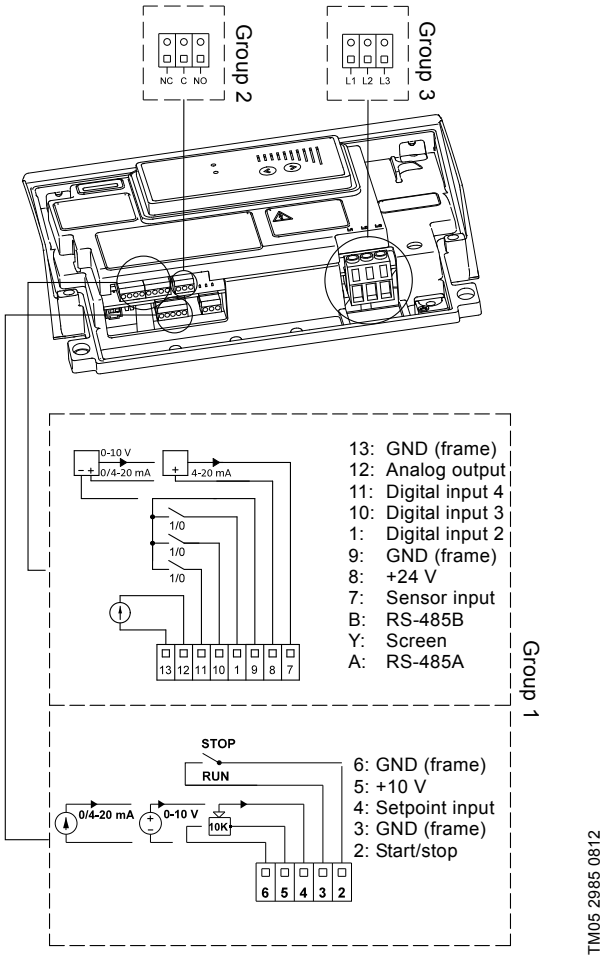

Fig. 11 Connection terminals

A galvanic separation must fulfill the requirements for reinforced insulation including creepage distances and clearances specified in EN 60335.

13.2 Three-phase pumps, 15-30 hp

DANGER

Electric shock

Death or serious personal injury

- The user or the installer is responsible for the installation of correct grounding and protection according to current national and local standards.
- All operations must be carried out by qualified personnel.

DANGER

Electric shock

Death or serious personal injury

- Disconnect all electric supply circuits and ensure these have been switched off for at least 5 minutes before making any connections in the pump terminal box. For instance, the signal relay may be connected to an external supply which is still connected when the power supply is disconnected.

CAUTION

Hot surface

Minor or moderate personal injury

- Wear hand protection and use care when handling terminal box when product is operating. The surface of the terminal box may be above 158 °F (70 °C) when the pump is operating.

13.2.1 Preparation

Before connecting the E-pump to the power supply, take the issues illustrated in the figure below into consideration.

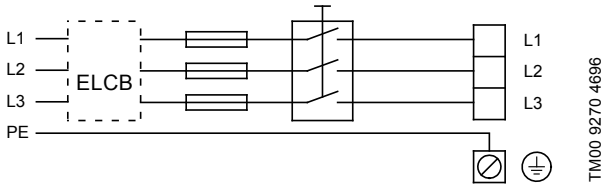

Fig. 12 Power supply-connected pump with power switch, backup fuses, additional protection and protective grounding

13.2.2 Protection against electric shock - indirect contact

DANGER

Electric shock

Death or serious personal injury

- Ensure the pump is grounded in accordance with national regulations. As the leakage current of 5-10 hp (4-7.5 kW) motors is > 3.5 mA, take extra precautions when grounding these motors.

EN 61800-5-1 specifies that the pump must be stationary and installed permanently when the leakage current is > 10 mA.

One of the following requirements must be fulfilled:

- A single protective ground lead (7 AWG minimum copper)

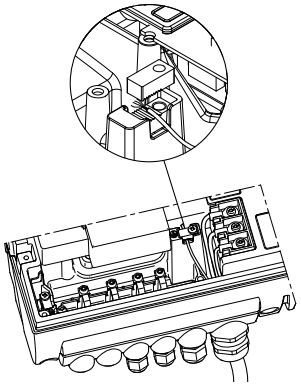

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Fig. 13 Connection of a single protective ground lead using one of the leads of a 4-core power cable (7 AWG minimum)

- Two protective ground leads of the same cross-sectional area as the power supply leads, with one lead connected to an additional ground terminal in the terminal box.

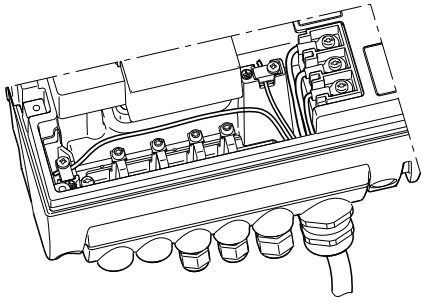

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Fig. 14 Connection of two protective ground leads using two of the leads of a 5-core power supply cable

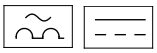
Protective ground leads must always have a yellow/green (PE) or yellow/green/blue (PEN) color marking.

13.2.3 Backup fuses

For recommended fuse sizes, see section *28.2.1 Supply voltage*.

13.2.4 Additional protection

If the pump is connected to an electric installation where an ground leakage circuit breaker (ELCB) is used as additional protection, use a circuit breaker of a type marked with the following symbols:



ELCB

This circuit breaker is **type B.**

Take into account the total leakage current of all the electrical equipment in the installation.

Check the leakage current of the motor in normal operation. See section *28.2.3 Leakage current*.

During start and at asymmetrical supply systems, the leakage current can be higher than normal and may cause the ELCB to trip.

13.2.5 Motor protection

The pump requires no external motor protection. The motor incorporates thermal protection against slow overloading and blocking (IEC 34-11, TP 211).

13.2.6 Protection against voltage transients

The pump is protected against voltage transients in accordance with EN 61800-3 and is capable of withstanding a VDE 0160 pulse.

The pump has a replaceable varistor which is part of the transient protection.

Over time this varistor will become worn and will need to be replaced. When the time comes for replacement, Grundfos GO, R100 and PC Tool E-products will indicate this as a warning. See section *27. Maintaining and servicing the motor*.

13.2.7 Supply voltage

3 x 440-480 V - 10 %/+ 10 %, 60 Hz, PE.

The supply voltage and frequency are marked on the pump nameplate. Make sure that the motor is suitable for the power supply of the installation site.

The wires in the terminal box must be as short as possible. Excepted from this is the protective ground lead which must be so long that it is the last one to be disconnected in case the cable is inadvertently pulled out of the cable entry.

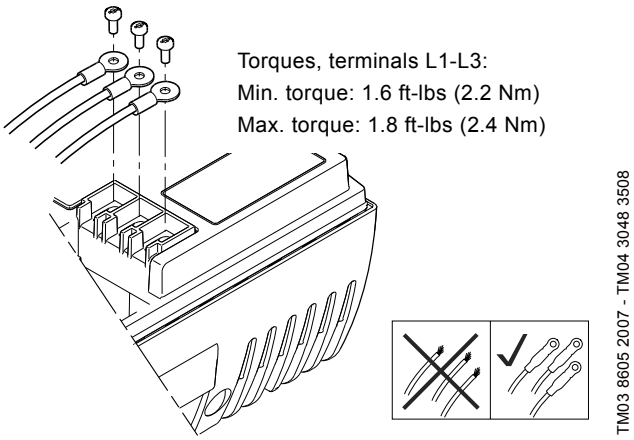


Fig. 15 Power connection

Cable glands

Cable glands comply with EN 50626.

- 1 x M40 cable gland
- 1 x M20 cable gland
- 2 x M16 cable gland
- 2 x M16 knock-out cable entries.

DANGER

Electric shock, malfunction or damage

Death or serious personal injury; product damage or failure

- Replace power supply cable immediately if damaged.
- Only qualified personnel must replace it.

Grid types

Three-phase E-pumps can be connected to all grid types.

DANGER

Electric shock

Death or serious personal injury; product damage or failure

- Do not connect three-phase E-pumps to a power supply with a voltage between phase and ground of more than 440 V.

13.2.8 Start/stop of pump

The number of starts and stops via the power supply must not exceed 4 times per hour.

When the pump is switched on via the power supply, it will start after approx. 5 seconds.

If a higher number of starts and stops is desired, use the input for external start/stop when starting/stopping the pump.

When the pump is switched on via an external On/Off switch, it will start immediately.

13.2.9 Connections

If no external On/Off switch is connected, connect terminals 2 and 3 using a short wire.

As a precaution, the wires to be connected to the following connection groups must be separated from each other by reinforced insulation in their entire lengths:

Group 1: Inputs

- start/stop terminals 2 and 3
- digital input terminals 1 and 9
- setpoint input terminals 4, 5 and 6
- sensor input terminals 7 and 8
- GENIbus terminals B, Y and A

All inputs (group 1) are internally separated from the power-conducting parts by reinforced insulation and galvanically separated from other circuits.

All control terminals are supplied with protective extra-low voltage (PELV), thus ensuring protection against electric shock.

Group 2: Output (relay signal, terminals NC, C, NO)

The output (group 2) is galvanically separated from other circuits. Therefore, the supply voltage or protective extra-low voltage can be connected to the output as desired.

Group 3: Power supply (terminals L1, L2, L3)

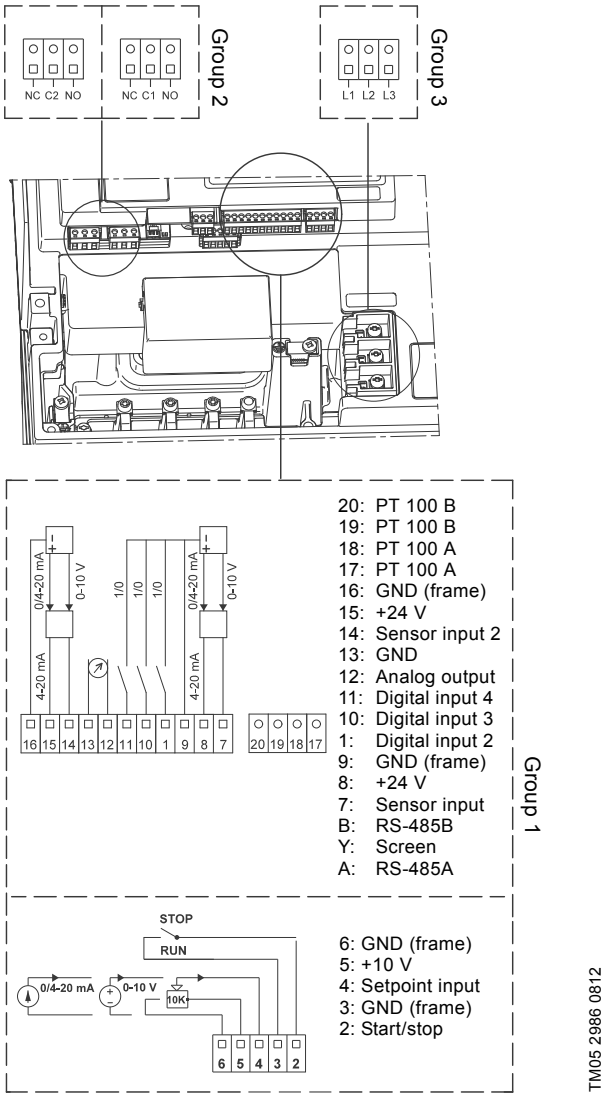


Fig. 16 Connection terminals

A galvanic separation must fulfill the requirements for reinforced insulation including creepage distances and clearances specified in EN 61800-5-1.

13.3 Signal cables

- Use screened cables with a conductor cross-section of min. 28 AWG and maximum 16 AWG for external On/Off switch, digital input, setpoint and sensor signals.
- Connect the screens of the cables to frame at both ends with good frame connection. The screens must be as close as possible to the terminals. See fig. 17.

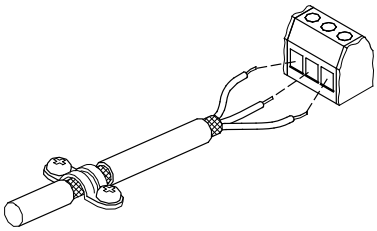


Fig. 17 Stripped cable with screen and wire connection

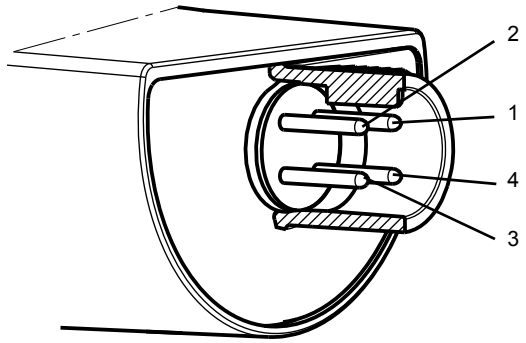
- Always tighten screws for frame connections whether a cable is fitted or not.
- Make the wires in the pump terminal box as short as possible.

13.4 E-pump electrical connections

13.4.1 Type key

	DPI	+T	0-6	G 1/2"	020	E,	Set
Type							
Temperature sensor: +T = with temperature Sensor							
Flow range [m^3/h]							
Thread size							
Output signal: 020 = 4-20 mA							
O-ring material: E = EPDM F = FKM							
Set = Complete pressure transmitter							

13.4.2 Electrical connections



TM04 7156 1610

Fig. 18 Electrical connections

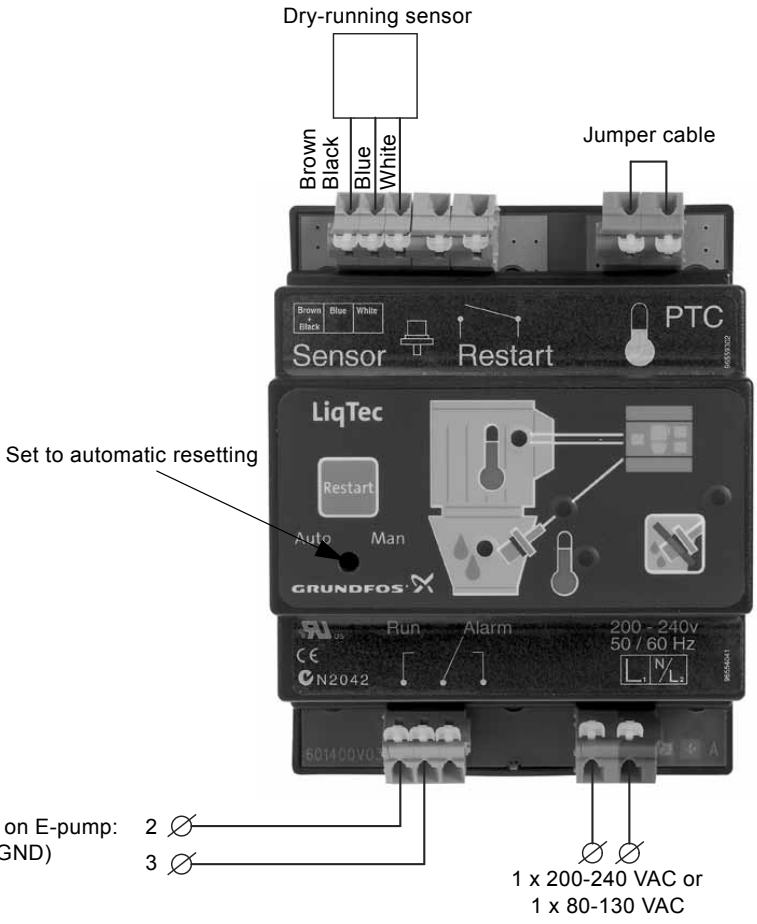
PIN	1	2	3	4
Wire color	Brown	Grey	Blue	Black
Output 4-20 mA	+	Not used	-	Not used
Output 2 x 0-10 V	+	Pressure signal	-*	Temperature signal

* Common ground for both pressure and temperature signal.

* Power supply (screened cable): SELV or PELV.

* Grundfos will not be liable for damage or wear to products caused by abnormal operating conditions, accident abuse, misuse unauthorized alteration or repair, or if the product was not installed in accordance with Grundfos' printed installation and operating instructions. Splicing of the supplied cable would void any warranty.

13.4.3 Connection of E-pump to LiqTec®



TM03 0437 5104

Fig. 19 Connection of E-pump to LiqTec

13.5 Bus connection cable

13.5.1 New installations

For the bus connection, use a screened 3-core cable with a conductor cross-section of 28-16 AWG.

- If the pump is connected to a unit with a cable clamp which is identical to the one on the pump, connect the screen to this cable clamp.
- If the unit has no cable clamp as shown in fig. 20, leave the screen unconnected at this end.

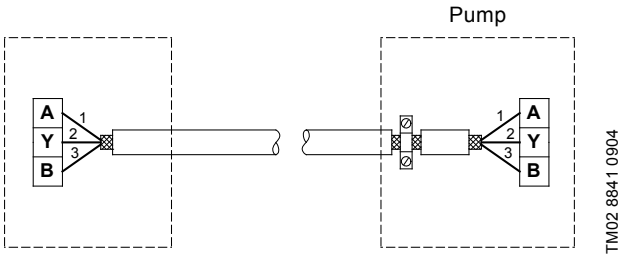


Fig. 20 Connection with screened 3-core cable

13.5.2 Replacing an existing pump

- If a screened 2-core cable is used in the existing installation, connect it as shown in fig. 21.

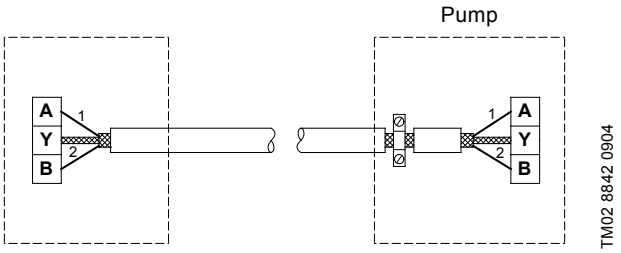


Fig. 21 Connection with screened 2-core cable

- If a screened 3-core cable is used in the existing installation, follow the instructions in section *13.5.1 New installations*.

14. Modes

Grundfos E-pumps are set and controlled according to operating and control modes.

14.1 Overview of modes

Operating modes	Normal	— Stop	— Min.	— Max.
Control modes	Uncontrolled	— Controlled		
	Constant curve	Constant pressure[1)]		

1) For this control mode the pump is equipped with a pressure sensor. The pump may also be equipped with a temperature sensor in which case the description would be constant temperature in control mode controlled.

14.2 Operating mode

When the operating mode is set to Normal, the control mode can be set to controlled or uncontrolled. See section *14.3 Control mode*.

The other operating modes that can be selected are Stop, Min. or Max.

- Stop: the pump has been stopped
- Min.: the pump is operating at its minimum speed
- Max.: the pump is operating at its maximum speed.

Figure 22 is a schematic illustration of minimum and maximum curves.

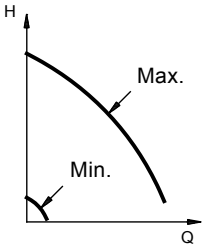


Fig. 22 Minimum and maximum curves

The maximum curve can for instance be used in connection with the venting procedure during installation.

The minimum curve can be used in periods in which a minimum flow is required.

If the power supply to the pump is disconnected, the mode setting will be stored.

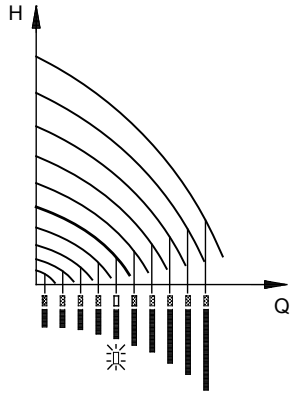
The Grundfos GO and R100 offer additional possibilities of setting and status displays. See section *17. Setting by means of R100* for setting by means of R100. See section *17.6 Grundfos GO Remote* for setting by means of Grundfos GO.

14.3 Control mode

14.3.1 Pumps without factory-fitted sensor

The pumps are factory-set to control mode **uncontrolled**.

In control mode uncontrolled, the pump will operate according to the constant curve set, fig. 23.



TM00 7746 1304

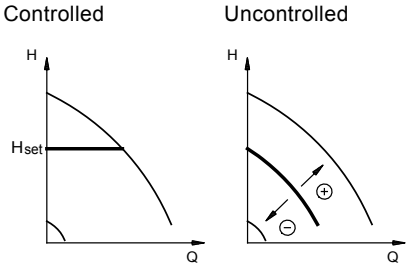
Fig. 23 Pump in control mode **uncontrolled** (constant curve)

14.3.2 Pumps with pressure sensor

The pump can be set to one of two control modes, i.e. controlled and uncontrolled, fig. 24.

In control mode **controlled**, the pump will adjust its performance, i.e. pump discharge pressure, to the desired setpoint for the control parameter.

In control mode **uncontrolled**, the pump will operate according to the constant curve set.



TM00 7668 0404

Fig. 24 Pump in control mode **controlled** (constant pressure) or **uncontrolled** (constant curve)

15. Setting up the pump

15.1 Factory setting

Pumps without factory-fitted sensor

The pumps have been factory-set to control mode **uncontrolled**. The setpoint value corresponds to 100 % of the maximum pump performance (see data sheet for the pump).

Pumps with pressure sensor

The pumps have been factory-set to control mode **controlled**. The setpoint value corresponds to 50 % of the sensor measuring range (see sensor nameplate).

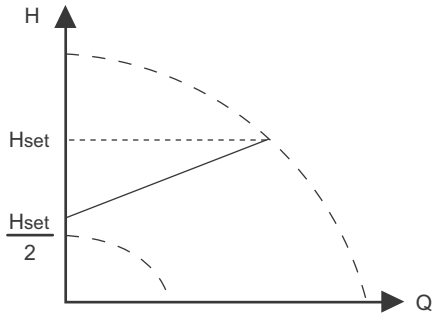
16. Setting by means of control panel

Proportional pressure

The pump head is reduced at decreasing water demand and increased at rising water demand. See fig. 25.

This control mode is especially suitable in systems with relatively large pressure losses in the distribution pipes. The head of the pump will increase proportionally to the flow in the system to compensate for the large pressure losses in the distribution pipes.

The setpoint can be set with an accuracy of 0.33 ft (0.1 m). The head against a closed valve is half the setpoint, H_{set}.



TM05 7909 1613

Fig. 25 Proportional pressure

This control mode requires a factory-fitted differential-pressure sensors as shown in the example below:

Example

- Factory-fitted differential-pressure sensor.

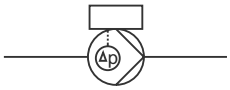


Fig. 26 Proportional pressure

16.1 Setting of operating mode

Settings available:

- Normal
- Stop
- Min.
- Max.

Start/stop of pump

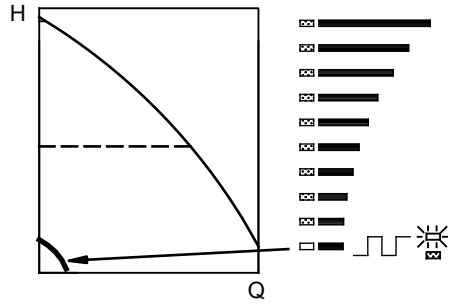
Start the pump by continuously pressing ⊛ until the desired setpoint is indicated. This is operating mode Normal.

Stop the pump by continuously pressing ⊛ until none of the light fields are activated and the green indicator light flashes.

Setting to Minimum

Press ⊙ continuously to change to the minimum curve of the pump (bottom light field flashes). When the bottom light field is on, press ⊙ for 3 seconds until the light field starts flashing.

To return to uncontrolled or controlled operation, press ⊙ continuously until the desired setpoint is indicated.



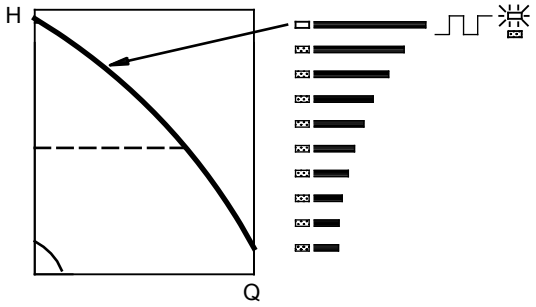
TM00 7346 1304

Fig. 27 Minimum curve duty

Setting to Maximum

Press ⊙ continuously to change to the maximum curve of the pump (top light field flashes). When the top light field is on, press ⊙ for 3 seconds until the light field starts flashing.

To return to uncontrolled or controlled operation, press ⊙ continuously until the desired setpoint is indicated.



TM00 7345 1304

Fig. 28 Maximum curve duty

16.2 Setpoint setting

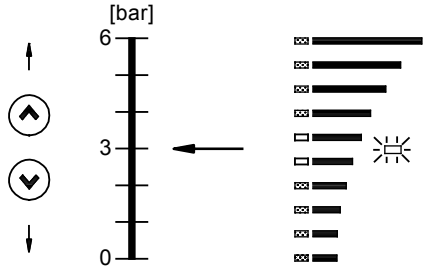
Set the desired setpoint by pressing the button ⊙ or ⊙.

The light fields on the control panel will indicate the setpoint set. See examples in sections *16.2.1 Pump in control mode controlled (pressure control)* and *16.2.2 Pump in control mode uncontrolled*.

16.2.1 Pump in control mode controlled (pressure control)

Example

Figure 29 shows that the light fields 5 and 6 are activated, indicating a desired setpoint of 43 psi (3 bar). The setting range is equal to the sensor measuring range (see sensor nameplate).



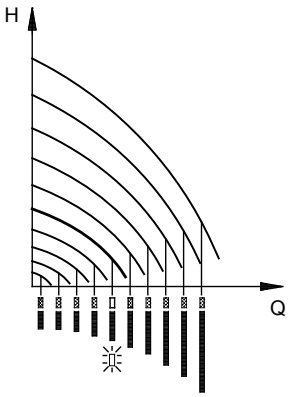
TM00 7743 0904

Fig. 29 Setpoint set to 3 bar, pressure control

16.2.2 Pump in control mode uncontrolled

Example

In control mode uncontrolled, the pump performance is set within the range from minimum to maximum curve. See fig. 30.

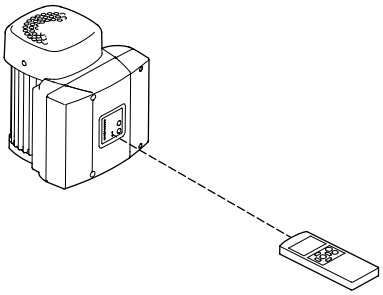


TM00 7746 1304

Fig. 30 Pump performance setting, control mode uncontrolled

17. Setting by means of R100

The pump is designed for wireless communication with Grundfos remote control R100.



TM02 0936 0501

Fig. 31 R100 communicating with the pump via infra-red light

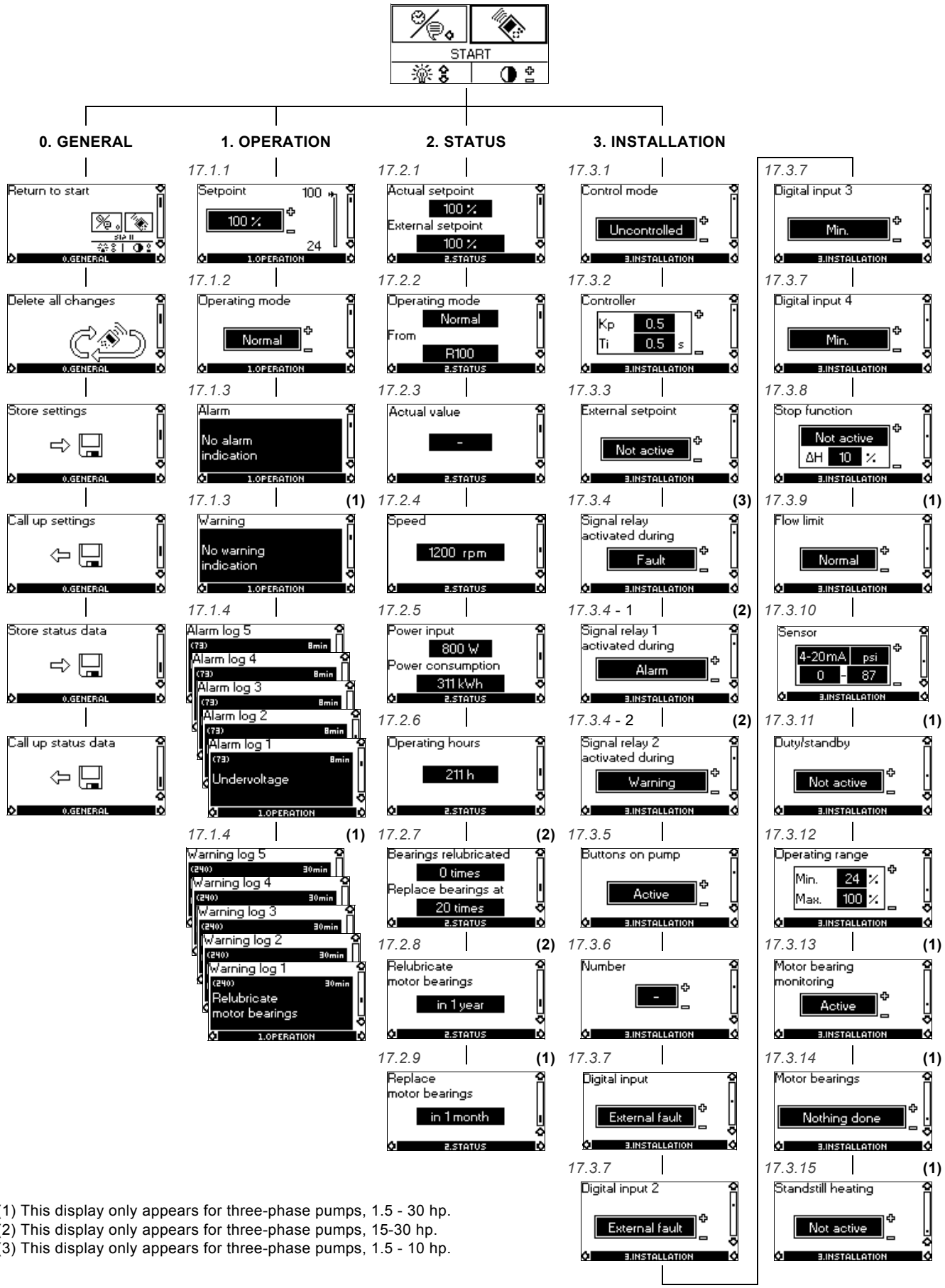
During communication, the R100 must be pointed at the control panel. When the R100 communicates with the pump, the red indicator light will flash rapidly. Keep pointing the R100 at the control panel until the red LED diode stops flashing.

The R100 offers setting and status displays for the pump.

The displays are divided into four parallel menus (see fig. 39):

0. GENERAL (see operating instructions for the R100)
1. OPERATION
2. STATUS
3. INSTALLATION

The figure above each individual display in fig. 39 refers to the section in which the display is described.



(1) This display only appears for three-phase pumps, 1.5 - 30 hp.
(2) This display only appears for three-phase pumps, 15-30 hp.
(3) This display only appears for three-phase pumps, 1.5 - 10 hp.

Displays in general

In the following explanation of the functions, one or two displays are shown.

One display

Pumps without or with factory-fitted sensor have the same function.

Two displays

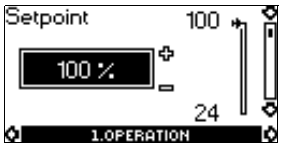
Pumps without or with factory-fitted pressure sensor have different functions and factory settings.

17.1 Menu OPERATION

The first display in this menu is this:

17.1.1 Setpoint

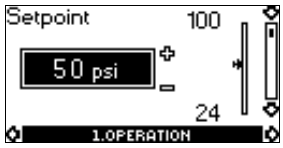
Without sensor (uncontrolled)



- Setpoint set
- Actual setpoint
- Actual value

Set the setpoint in %.

With pressure sensor (controlled)



- Setpoint set
- Actual setpoint
- Actual value

Set the desired pressure in bar.

In control mode **uncontrolled**, the setpoint is set in % of the maximum performance. The setting range will lie between the minimum and maximum curves.

In control mode **controlled**, the setting range is equal to the sensor measuring range.

If the pump is connected to an external setpoint signal, the value in this display will be the maximum value of the external setpoint signal. See section *21. External setpoint signal*.

Setpoint and external signal

The setpoint cannot be set if the pump is controlled via external signals (Stop, Min. curve or Max. curve). R100 will give this warning: External control!

Check if the pump is stopped via terminals 2-3 (open circuit) or set to min. or max. via terminals 1-3 (closed circuit).

See fig. 40.

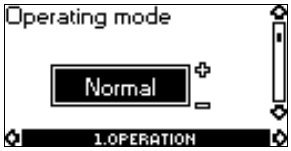
Setpoint and bus communication

The setpoint cannot be set either if the pump is controlled from an external control system via bus communication. R100 will give this warning: Bus control!

To override bus communication, disconnect the bus connection.

See fig. 40.

17.1.2 Operating mode



Set one of the following operating modes:

- Normal (duty)
- Stop
- Min.
- Max.

The operating modes can be set without changing the setpoint setting.

17.1.3 Fault indications

In E-pumps, faults may result in two types of indication: alarm or warning.

An "alarm" fault will activate an alarm indication in R100 and cause the pump to change operating mode, typically to stop. However, for some faults resulting in alarm, the pump is set to continue operating even if there is an alarm.

A "warning" fault will activate a warning indication in R100, but the pump will not change operating or control mode.

The indication, Warning, only applies to three-phase pumps.

Alarm

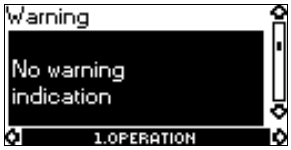
In case of alarm, the cause will appear in this display.

Possible causes:

- No alarm indication
- Too high motor temperature
- Undervoltage
- Mains voltage asymmetry (15-30 hp)
- Overvoltage
- Too many restarts (after faults)
- Overload
- Underload
- Sensor signal outside signal range
- Setpoint signal outside signal range
- External fault
- Duty/standby, communication fault
- Dry running
- Other fault.

If the pump has been set up to manual restart, an alarm indication can be reset in this display if the cause of the fault has disappeared.

Warning (only three-phase pumps)



In case of warning, the cause will appear in this display.

Possible causes:

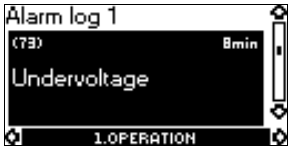
- No warning indication.
- Sensor signal outside signal range.
- Relubricate motor bearings, see section *27.2 Relubrication of motor bearings*.
- Replace motor bearings, see section *27.3 Replacement of motor bearings*.
- Replace varistor, see section *27.4 Replacement of varistor (only 15-30 hp)*.

A warning indication will disappear automatically once the fault has been remedied.

17.1.4 Fault log

For both fault types, alarm and warning, the R100 has a log function.

Alarm log

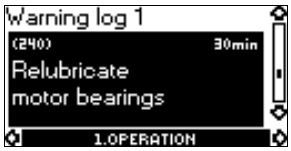


In case of "alarm" faults, the last five alarm indications will appear in the alarm log. "Alarm log 1" shows the latest fault, "Alarm log 2" shows the latest fault but one, etc.

The example above gives this information:

- the alarm indication Undervoltage
- the fault code (73)
- the number of minutes the pump has been connected to the power supply after the fault occurred, 8 min.

Warning log



In case of "warning" faults, the last five warning indications will appear in the warning log. "Warning log 1" shows the latest fault, "Warning log 2" shows the latest fault but one, etc.

The example above gives this information:

- the warning indication Relubricate motor bearings
- the fault code (240)
- the number of minutes the pump has been connected to the power supply since the fault occurred, 30 min.

17.2 Menu STATUS

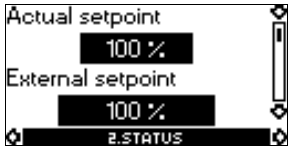
The displays appearing in this menu are status displays only. It is not possible to change or set values.

The displayed values are the values that applied when the last communication between the pump and the R100 took place. If a status value is to be updated, point the R100 at the control panel and press "OK". If a parameter, e.g. speed, should be called up continuously, press "OK" constantly during the period in which the parameter in question should be monitored.

The tolerance of the displayed value is stated under each display. The tolerances are stated as a guide in % of the maximum values of the parameters.

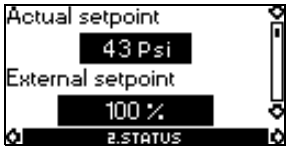
17.2.1 Actual setpoint

Without sensor (uncontrolled)



Tolerance: ± 2 %.

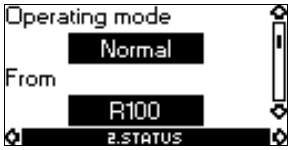
With pressure sensor (controlled)



Tolerance: ± 2 %.

This display shows the actual setpoint and the external setpoint in % of the range from minimum value to the setpoint set. See section *21. External setpoint signal*.

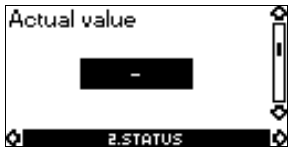
17.2.2 Operating mode



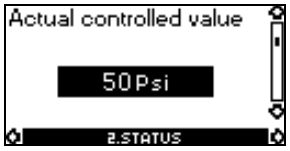
This display shows the actual operating mode (Normal (duty), Stop, Min., or Max.). Furthermore, it shows where this operating mode was selected (R100, Pump, Bus, External or Stop func.). For further details about the stop function (Stop func.), see section *17.3.8 Stop function*.

17.2.3 Actual value

Without sensor (uncontrolled)



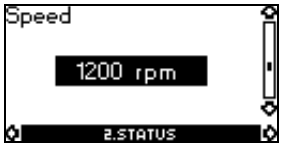
With pressure sensor (controlled)



This display shows the value actually measured by a connected sensor.

If no sensor is connected to the pump, "-" will appear in the display.

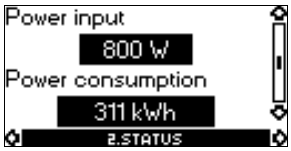
17.2.4 Speed



Tolerance: ± 5 %

The actual pump speed will appear in this display.

17.2.5 Power input and power consumption



Tolerance: ± 10 %

This display shows the actual pump input power from the power supply. The power is displayed in W or kW.

The pump power consumption can also be read from this display. The value of power consumption is an accumulated value calculated from the pump's birth and it cannot be reset.

17.2.6 Operating hours

Tolerance: ± 2 %

The value of operating hours is an accumulated value and cannot be reset.

17.2.7 Lubrication status of motor bearings (only 15-30 hp)

This display shows how many times the motor bearings have been relubricated and when to replace the motor bearings.

When the motor bearings have been relubricated, confirm this action in the INSTALLATION menu.

See section *17.3.14 Confirming relubrication/replacement of motor bearings (only three-phase pumps)*. When relubrication is confirmed, the figure in the above display will be increased by one.

17.2.8 Time until relubrication of motor bearings

This display shows when to relubricate the motor bearings. The controller monitors the operating pattern of the pump and calculates the period between bearing relubrications. If the operating pattern changes, the calculated time until relubrication may change as well.

The displayable values are these:

- in 2 years
- in 1 year
- in 6 months
- in 3 months
- in 1 month
- in 1 week
- Now!

17.2.9 Time until replacement of motor bearings

When the motor bearings have been relubricated a prescribed number of times stored in the controller, the display in section *17.2.8 Time until relubrication of motor bearings* will be replaced by the display below.

This display shows when to replace the motor bearings. The controller monitors the operating pattern of the pump and calculates the period between bearing replacements.

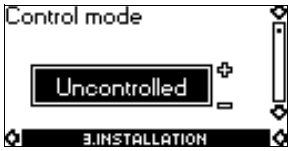
The displayable values are these:

- in 2 years
- in 1 year
- in 6 months
- in 3 months
- in 1 month
- in 1 week
- Now!

17.3 Menu INSTALLATION

17.3.1 Control mode

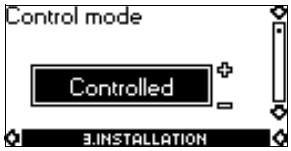
Without sensor (uncontrolled)



Select one of the following control modes (see fig. 24):

- Controlled
- Uncontrolled.

With pressure sensor (controlled)



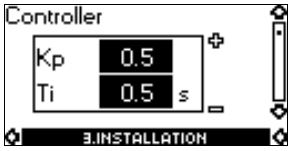
Select one of the following control modes (see fig. 24):

- Controlled
- Uncontrolled.

If the pump is connected to a bus, the control mode cannot be selected via remote control. See section *22. Bus signal*.

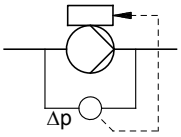
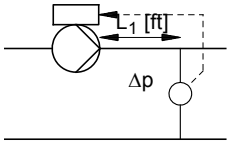
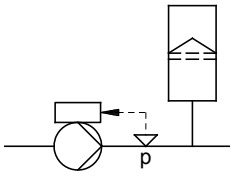
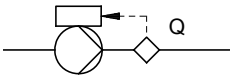
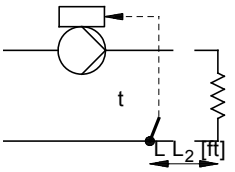
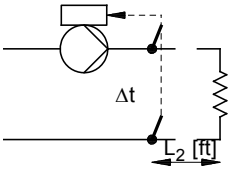
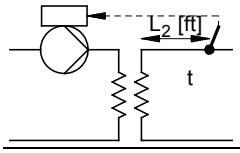
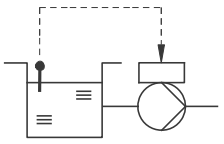
17.3.2 Controller

E-pumps have a factory default setting of gain (K_p) and integral time (T_i). However, if the factory setting is not the optimum setting, the gain and the integral time can be changed in the display below.



- The gain (K_p) can be set within the range from 0.1 to 20.
- The integral time (T_i) can be set within the range from 0.1 to 3600 s. If 3600 s is selected, the controller will function as a P controller.
- Furthermore, it is possible to set the controller to inverse control, meaning that if the setpoint is increased, the speed will be reduced. In the case of inverse control, the gain (K_p) must be set within the range from -0.1 to -20.

The table below shows the suggested controller settings:

System/application	K_p		T_i
	Heating systems[1]	Cooling systems[2]	
	0.5		0.5
	0.5		L_1 < 16.4 ft: 0.5 L_1 > 16.4 ft: 3 L_1 > 32.8 ft: 5
	0.5		0.5
	0.5		0.5
	0.5	-0.5	10 + 1.5L_2
	0.5		10 + 1.5L_2
	0.5	-0.5	30 + 1.5L_2
	+2.5		100

[1] Heating systems are systems in which an increase in pump performance will result in a **rise** in temperature at the sensor.

[2] Cooling systems are systems in which an increase in pump performance will result in a **drop** in temperature at the sensor.

L_1 = Distance in [ft] between pump and sensor

L_2 = Distance in [ft] between heat exchanger and sensor

How to set the PI controller

For most applications, the factory setting of the controller constants K_p and T_i will ensure optimum pump operation. However, in some applications an adjustment of the controller may be needed.

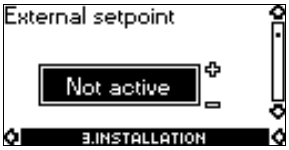
Proceed as follows

1. Increase the gain (K_p) until the motor becomes unstable. Instability can be seen by observing if the measured value starts to fluctuate. Furthermore, instability is audible as the motor starts hunting up and down.
   Some systems, such as temperature controls, are slow-reacting, meaning that it may be several minutes before the motor becomes unstable.
2. Set the gain (K_p) to half of the value which made the motor unstable. This is the correct setting of the gain.
3. Reduce the integral time (T_i) until the motor becomes unstable.
4. Set the integral time (T_i) to twice the value which made the motor unstable. This is the correct setting of the integral time.

General rules of thumb

- If the controller is too slow-reacting, increase K_p.
- If the controller is hunting or unstable, dampen the system by reducing K_p or increasing T_i.

17.3.3 External setpoint



The input for external setpoint signal can be set to different signal types.

Select one of the following types:

- 0-10 V
- 0-20 mA
- 4-20 mA
- Not active.

If Not active is selected, the setpoint set by means of the R100 or on the control panel will apply.

If one of the signal types is selected, the actual setpoint is influenced by the signal connected to the external setpoint input. See section *21. External setpoint signal*.

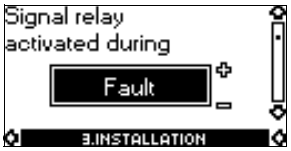
17.3.4 Signal relay

Pumps of 3-10 hp have one signal relay. The factory setting of the relay will be Fault.

Pumps of 15-30 hp have two signal relays. Signal relay 1 is factory set to Alarm and signal relay 2 to Warning.

In one of the displays below, select in which one of three or six operating situations the signal relay should be activated.

3-10 hp



- Ready
- Fault
- Operation
- Pump running (only three-phase pumps, 3-10 hp)
- Warning (only three-phase pumps, 3-10 hp).

15-30 hp

- Ready
- Alarm
- Operation
- Pump running
- Warning
- Relubricate.

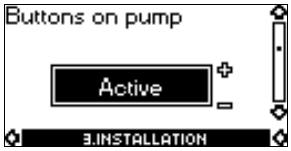
15-30 hp

- Ready
- Alarm
- Operation
- Pump running
- Warning
- Relubricate.

Fault and Alarm cover faults resulting in Alarm.
Warning covers faults resulting in Warning.
Relubricate covers only that one individual event.
For distinction between alarm and warning, see section *17.1.3 Fault indications*.

For further information, see section *24. Indicator lights and signal relay*.

17.3.5 Buttons on pump

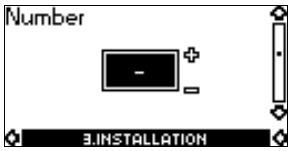


The operating buttons ⊙ and ⊙ on the control panel can be set to these values:

- Active
- Not active.

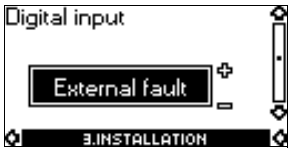
When set to Not active (locked), the buttons do not function. Set the buttons to Not active if the pump should be controlled via an external control system.

17.3.6 Pump number



A number between 1 and 64 can be allocated to the pump. In the case of bus communication, a number must be allocated to each pump.

17.3.7 Digital inputs



The digital inputs of the pump can be set to different functions.

Select one of the following functions:

- Min. (min. curve)
- Max. (max. curve)
- External fault
- Flow switch
- Dry running (from external sensor) (only three-phase pumps).

The selected function is activated by closing the contact between terminals 1 and 9, 1 and 10 or 1 and 11.

See also section *20.2 Digital input*.

Min.

When the input is activated, the pump will operate according to the minimum curve.

Max.

When the input is activated, the pump will operate according to the maximum curve.

External fault

When the input is activated, a timer will be started. If the input is activated for more than 5 seconds, the pump will be stopped and a fault will be indicated. If the input is deactivated for more than 5 seconds, the fault condition will cease and the pump can only be restarted manually by resetting the fault indication.

Flow switch

When this function is selected, the pump will be stopped when a connected flow switch detects low flow.

It is only possible to use this function if the pump is connected to a pressure sensor.

If the input is activated for more than 5 seconds, the stop function incorporated in the pump will take over. See section *17.3.8 Stop function*.

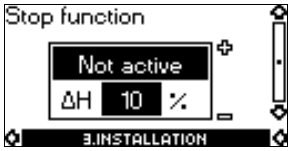
Dry running

When this function is selected, lack of inlet pressure or water shortage can be detected. This requires the use of an accessory, such as these:

- a Grundfos Liqtec® dry-running sensor
- a pressure switch installed on the suction side of a pump
- a float switch installed on the suction side of a pump.

When lack of inlet pressure or water shortage (Dry running) is detected, the pump will be stopped. The pump cannot restart as long as the input is activated.

17.3.8 Stop function



The stop function can be set to these values:

- Active
- Not active.

When the stop function is active, the pump will be stopped at very low flows. The controller will stop the pump to protect the pump as follows:

- avoid unnecessary heating of the pumped liquid
- reduce wear of the shaft seals
- reduce noise from operation.

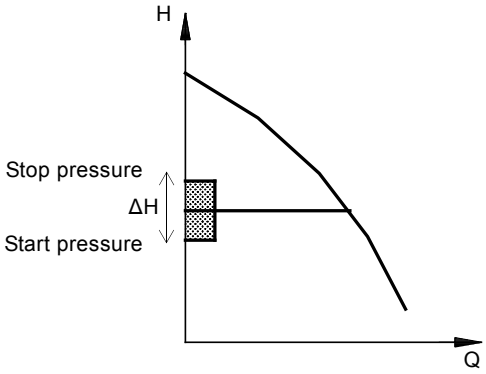


Fig. 32 Difference between start and stop pressures (ΔH)

ΔH is factory-set to **10 % of actual setpoint**.

ΔH can be set within the range from 5 % to 30 % of actual setpoint.

Low flow can be detected in two different ways:

1. A built-in "low-flow detection function" which functions if the digital input is not set up for flow switch.
2. A flow switch connected to the digital input.

1. Low-flow detection function

The pump will check the flow regularly by reducing the speed for a short time. If there is no or only a small change in pressure, this means that there is low flow. The speed will be increased until the stop pressure (actual setpoint + 0.5 x ΔH) is reached and the pump will stop. When the pressure has fallen to the start pressure (actual setpoint - 0.5 x ΔH), the pump will restart.

When restarting, the pumps will react differently according to pump type:

Three-phase pumps

1. If the flow is higher than the low-flow limit, the pump will return to continuous operation at constant pressure.
2. If the flow is still lower than the low-flow limit, the pump will continue in start/stop operation. It will continue in start/stop operation until the flow is higher than the low-flow limit; when the flow is higher than the low-flow limit, the pump will return to continuous operation.

2. Flow switch

When the digital input is activated for more than 5 seconds because there is low flow, the speed will be increased until the stop pressure (actual setpoint + 0.5 x ΔH) is reached, and the pump will stop. When the pressure has fallen to start pressure, the pump will start again. If there is still no flow, the pump will quickly reach stop pressure and stop. If there is flow, the pump will continue operating according to the setpoint.

Operating conditions for the stop function

It is only possible to use the stop function if the system incorporates a pressure sensor, a check valve and a diaphragm tank.

The check valve must always be installed before the pressure sensor. See figs 33 and 34.

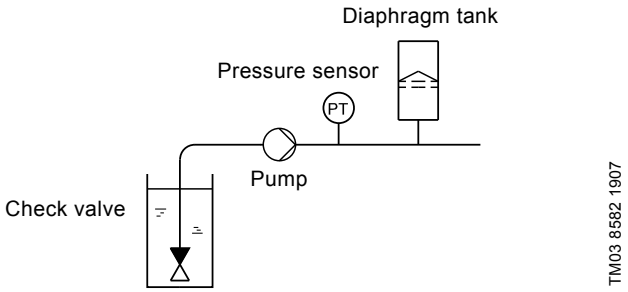


Fig. 33 Position of the check valve and pressure sensor in system with suction lift operation

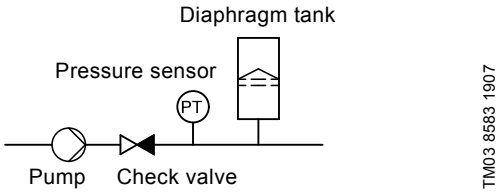


Fig. 34 Position of the non-return valve and pressure sensor in system with positive inlet pressure

Diaphragm tank

The stop function requires a diaphragm tank of a certain minimum size. The tank must be installed immediately after the pump and the precharge pressure must be 0.7 x actual setpoint.

Recommended diaphragm tank size:

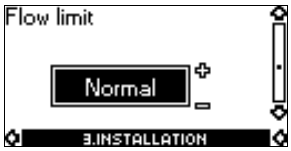
Rated flow rate of pump [gpm (m^3/h)]	CRE pump	Typical diaphragm tank size [gal (liter)]
0-26 (0 - 5.9)	1s, 1, 3	2 (7.6)
27-105 (6.1 - 23.8)	5, 10, 15	4.4 (16.7)
106-176 (24.2 - 40)	20, 32	14 (53.0)
177-308 (40.2 - 70.0)	45	34 (128.7)
309-440 (70.2 - 99.9)	64, 90	62 (234.7)
441-750 (100-170)	120, 150	86 (325.5)

If a diaphragm tank of the above size is installed in the system, the factory setting of ΔH is the correct setting.

If the tank installed is too small, the pump will start and stop too often. This can be remedied by increasing ΔH.

17.3.9 Flow limit for the stop function

Flow limit for the stop function only works if the system is not set up for flow switch.



In order to set at which flow rate the system is to go from continuous operation at constant pressure to start/stop operation, select among these four values of which three are preconfigured flow limits:

- Low
- Normal
- High
- Custom.

The default setting of the pump is Normal, representing approximately 10 % of the rated flow rate of the pump.

If a lower flow limit than normal is desired or the tank size is smaller than recommended, select Low.

If a higher flow than normal is wanted or a large tank is used, set the limit to High.

The value Custom can be seen in R100 but it can only be set by means of the PC Tool E-products. Custom is for customized set-up and optimizing to the process.

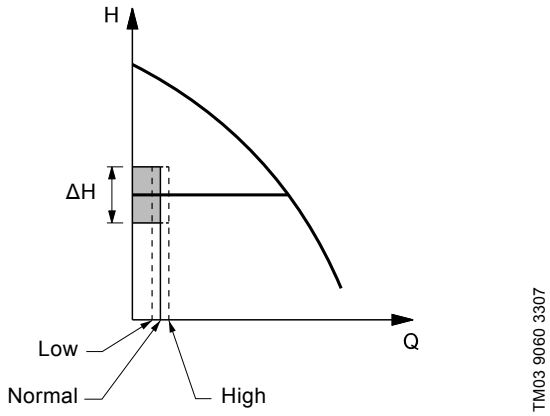
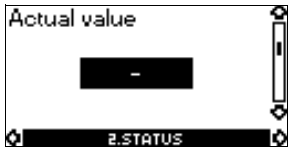


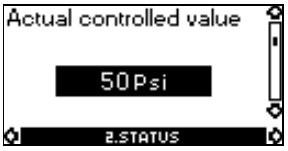
Fig. 35 Three preconfigured flow limits, Low, Normal and High

17.3.10 Sensor

Without sensor (uncontrolled)



With pressure sensor (controlled)



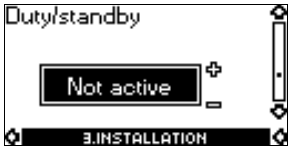
The setting of the sensor is only relevant in the case of controlled operation.

Select among the following values:

- Sensor output signal
  0-10 V
  0-20 mA
  4-20 mA,
- Unit of measurement of sensor:
  bar, mbar, m, kPa, psi, ft, m^3/h, m^3/s, l/s, gpm, °C, °F, %,
- Sensor measuring range.

17.3.11 Duty/standby

The duty/standby function applies to two pumps connected in parallel and controlled via GENIbus.



The duty/standby function can be set to these values:

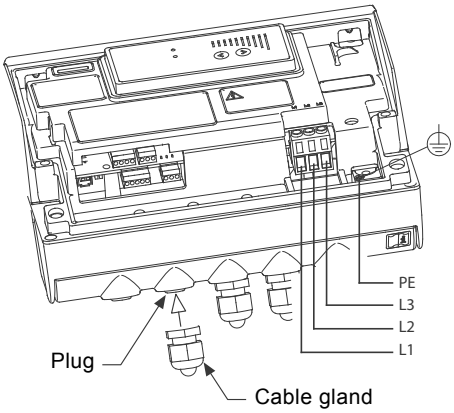
- Active
- Not active.

When the function is set to Active, the following applies:

- Only one pump is running at a time.
- The stopped pump (standby) will automatically be cut in if the running pump (duty) has a fault. A fault will be indicated.
- Changeover between the duty pump and the standby pump will take place every 24 hours.

Activate the duty/standby function as follows:

1. Install and prime the two pumps according to the installation and operating instructions supplied with the pumps.
2. Check that the power supply is connected to the first pump according to the installation and operating instructions.
3. Use Grundfos R100 to set the duty/standby to Not active in the installation menu.
4. Use Grundfos R100 to set the Operating mode to Stop in the operation menu.
5. Use Grundfos R100 to set the other displays as required for the pump application (such as setpoint).
6. Disconnect the power supply to both pumps.
7. Installation of the AYB cable (91125604):
   a. Remove the plug from each MLE terminal box with a flat head screw driver. See fig. 36.
   b. Screw a new cable gland into each MLE terminal box with a crescent wrench. See fig. 36.
   c. Loosen the new cable gland caps and push the cable ends through the cable glands and into MLE motors.
   d. Remove the AYB connector plug from the first MLE motor. See fig. 37.
   e. Connect the black wire to the A terminal of the AYB connector plug.
   f. Connect the orange wire to the Y terminal of the AYB connector plug.
   g. Connect the red wire to the B terminal of the AYB connector plug.
   h. Reconnect the AYB connector plug to the first MLE motor.
   i. Tighten the cable gland cap to secure the cable. See fig. 36.
   j. Repeat steps d to i for the second MLE motor.
8. Connect the power supply to the two pumps according to the installation and operation instructions.
9. Use Grundfos R100 to check that the Operating mode is set to Normal in the operation menu of the second pump.
10. Use Grundfos R100 to set the other displays as required for the pump application (such as Setpoint).
11. Use Grundfos R100 to set the duty/standby to Active in the installation menu of the second pump. Please note the second pump will search for the first pump and automatically set the duty/standby to Active in the installation menu.
12. The second pump will operate for the first 24 hours. The two pumps will then alternate operation every 24 hours.



TM05 1626 3311

Fig. 36 Removing the plug and connecting cable gland to the terminal box

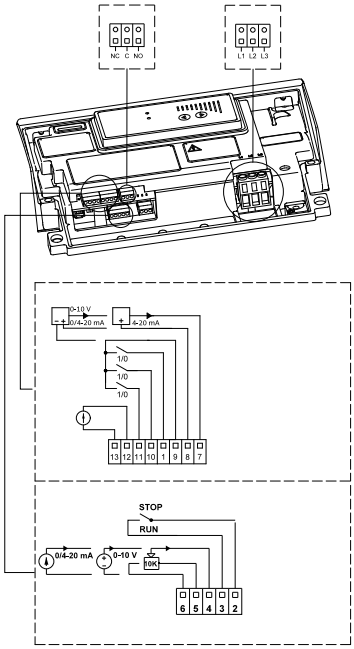


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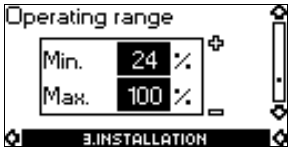
Fig. 37 AYB connector plug

17.3.12 Operating range



How to set the operating range:

- Set the minimum curve within the range from maximum curve to 12 % of maximum performance. The pump is factory-set to 24 % of maximum performance.
- Set the maximum curve within the range from maximum performance (100 %) to minimum curve.

The area between the minimum and maximum curves is the operating range.

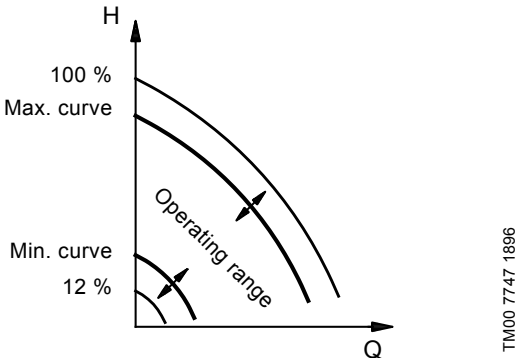


Fig. 38 Setting of the minimum and maximum curves in % of maximum performance

17.3.13 Motor bearing monitoring (only three-phase pumps)

The motor bearing monitoring function can be set to these values:

- Active
- Not active.

When the function is set to Active, a counter in the controller will start counting the mileage of the bearings. See section *17.2.7 Lubrication status of motor bearings (only 15-30 hp)*.

The counter will continue counting even if the function is switched to Not active, but a warning will not be given when it is time for relubrication.

When the function is switched to Active again, the accumulated mileage will again be used to calculate the relubrication time.

17.3.14 Confirming relubrication/replacement of motor bearings (only three-phase pumps)

This function can be set to these values:

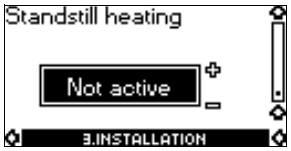
- Relubricated (only 15-30 hp)
- Replaced
- Nothing done.

When the bearing monitoring function is Active, the controller will give a warning indication when the motor bearings are due to be relubricated or replaced. See section *17.1.3 Fault indications*.

When the motor bearings have been relubricated or replaced, confirm this action in the above display by pressing OK.

Relubricated cannot be selected for a period of time after confirming relubrication.

17.3.15 Standstill heating (only three-phase pumps)

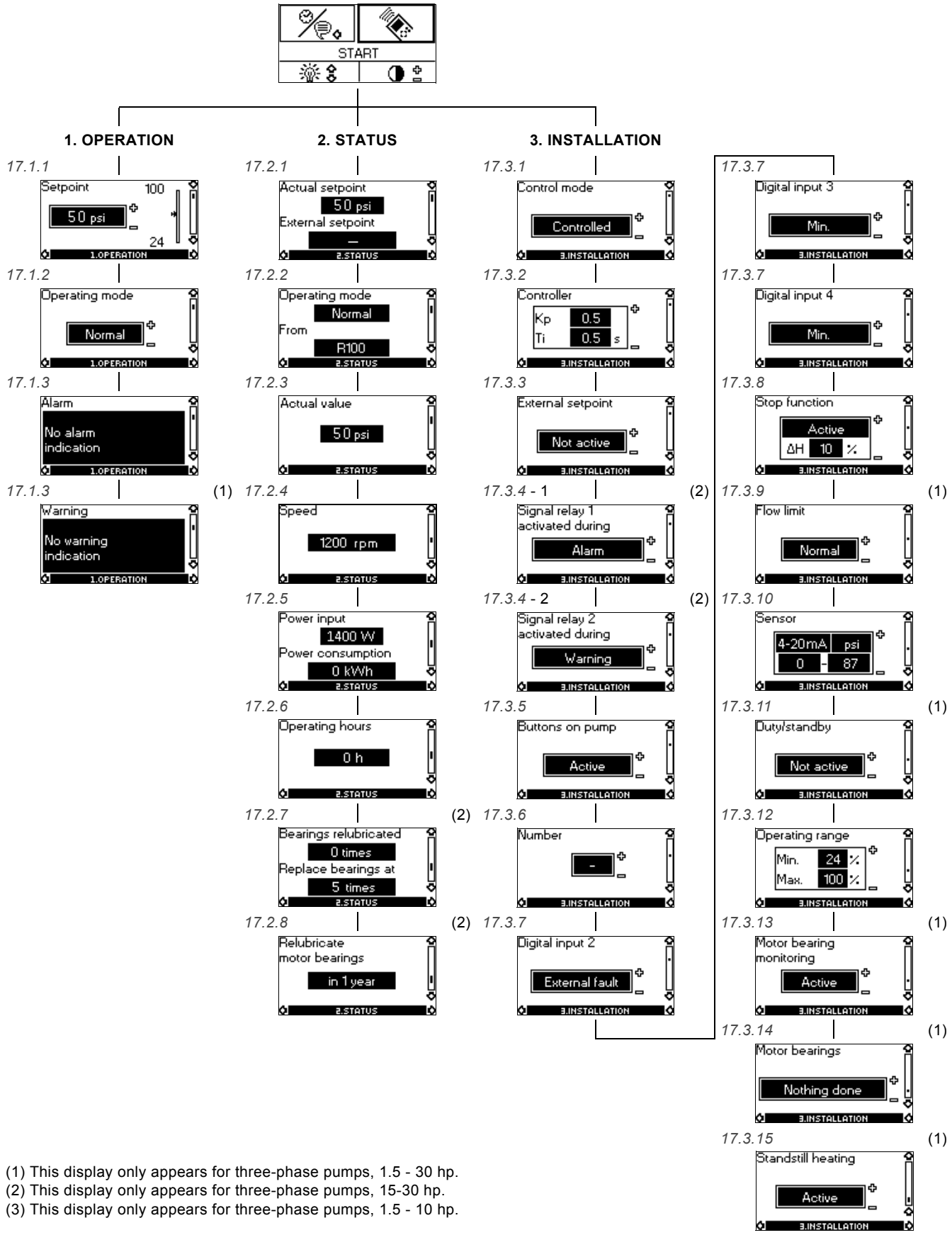


The standstill heating function can be set to these values:

- Active
- Not active.

When the function is set to Active, an AC voltage will be applied to the motor windings. The applied voltage will ensure that sufficient heat is generated to avoid condensation in the motor.

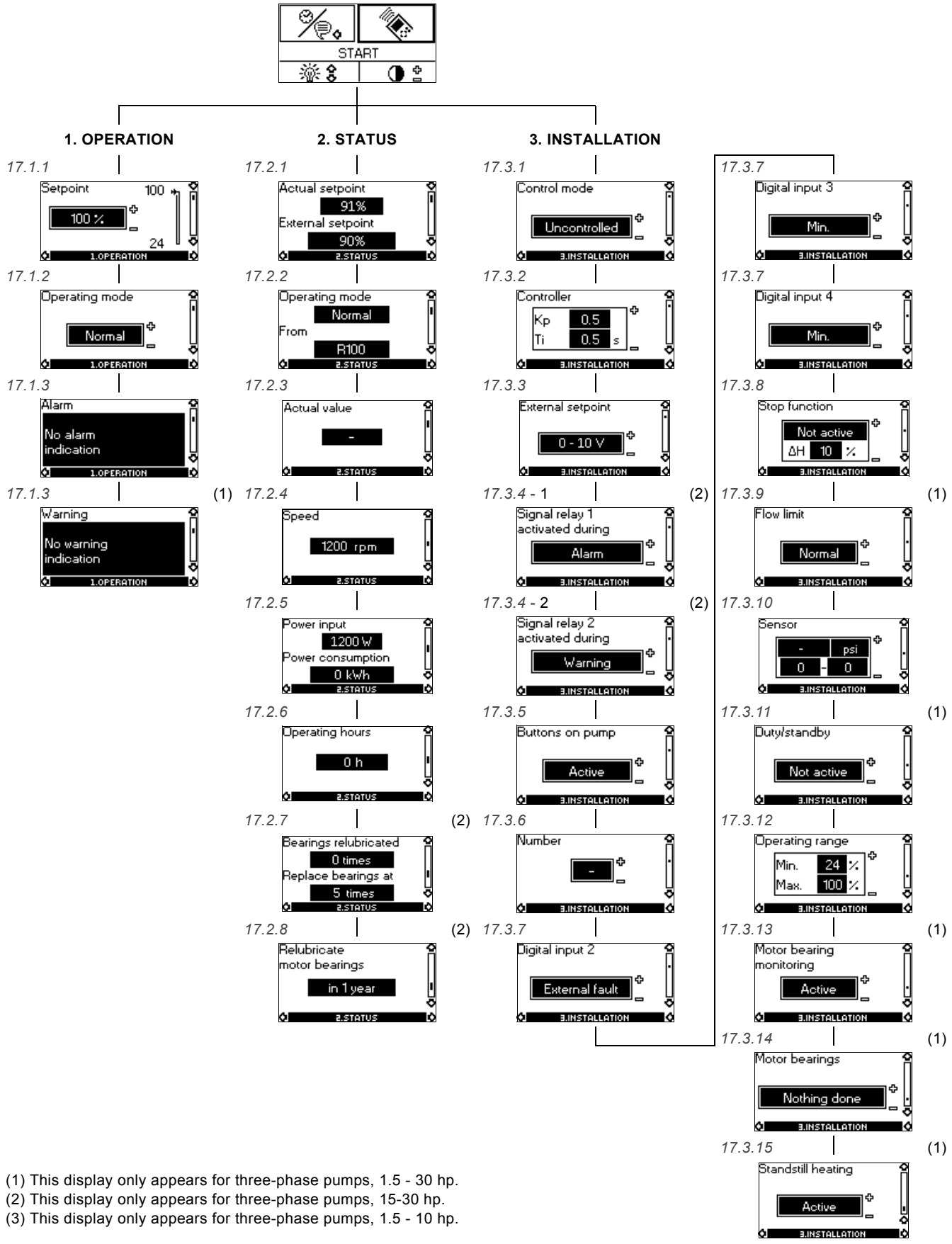
17.4 Typical display settings for constant-pressure E-pumps



(1) This display only appears for three-phase pumps, 1.5 - 30 hp.
(2) This display only appears for three-phase pumps, 15-30 hp.
(3) This display only appears for three-phase pumps, 1.5 - 10 hp.

Fig. 39 Menu overview

17.5 Typical display settings for analog-input E-pumps



(1) This display only appears for three-phase pumps, 1.5 - 30 hp.
(2) This display only appears for three-phase pumps, 15-30 hp.
(3) This display only appears for three-phase pumps, 1.5 - 10 hp.

Fig. 40 Menu overview

17.6 Grundfos GO Remote

The motor is designed for wireless radio or infrared communication with Grundfos GO.

Grundfos GO enables setting of functions and gives access to status overviews, technical product information and actual operating parameters.

Grundfos GO Remote offers the following mobile interfaces (MI). See fig. 41.

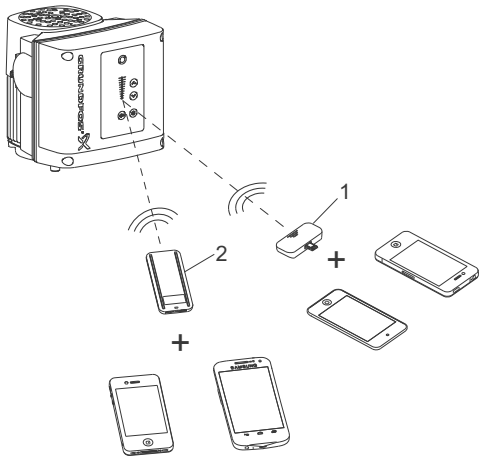


Fig. 41 Grundfos GO communicating with the motor via radio or infrared connection (IR)

Pos.	Description
1	Grundfos MI 204: Add-on module enabling radio or infrared communication. You can use MI 204 in conjunction with an Apple iPhone or iPod touch with Lightning connector, e.g. fifth generation or later iPhone or iPod touch. MI 204 is also available together with an Apple iPod touch and a cover.
2	Grundfos MI 301: Separate module enabling radio or infrared communication. The module can be used in conjunction with an Android or iOS-based Smartphone with Bluetooth connection.

17.6.1 Communication

When Grundfos GO Remote communicates with the pump, the indicator light in the middle of the Grundfos Eye will flash green.

Communication must be established using one of these communication types:

- radio communication
- infrared communication.

Radio communication

Radio communication can take place at distances up to 30 meters. It is necessary to enable communication by pressing or OK on the pump control panel.

Infrared communication

When communicating via infrared light, Grundfos GO Remote must be pointed at the pump control panel.

17.6.2 Navigation

Navigation can be done from the dashboard. See fig. 42.

Dashboard

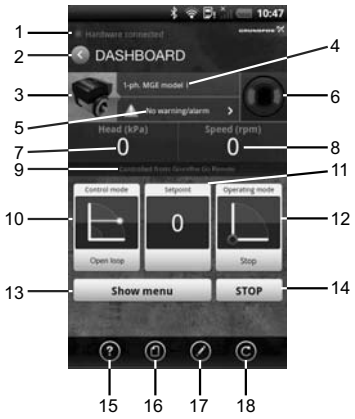


Fig. 42 Example of dashboard

Pos.	Description	Action
1	Connection indicator	This text appears when Grundfos GO Remote app has connected to an MI 204, MI 202 or MI 301. If the hardware is not connected, it will not be possible to communicate with a Grundfos product.
2	Back button	Returns to the previous display.
3	Product information	Provides technical information about the product.
4	Product name	Name of the product communicating with Grundfos GO Remote.
5	Alarms and warnings	Shows alarms and warnings.
6	Grundfos Eye	Shows the operating condition of the product.
7	Primary status value	Shows the primary status value.
8	Secondary status value	Shows the secondary status value.
9	Control source	Shows by which interface the product is controlled.
10	Control mode	Shows the control mode of the product.
11	Actual setpoint value	Shows the actual setpoint value.
12	Operating mode	Shows the operating mode.
13	Show menu	Gives access to other menus.
14	Stop	Stops the product.
Tool bar		
15	Help	The help function describes the menus making it easy for the user to change settings, etc.
16	Documentation	Gives access to installation and operating instructions and quick guides.
17	Report	Enables the creation of user-defined reports.
18	Update	Enables update of Grundfos GO Remote app.

18. Setting by means of PC Tool E-products

Special setup requirements differing from the settings available via the GO Remote or R100 require the use of Grundfos PC Tool E-products. This again requires the assistance of a Grundfos service technician or engineer. Contact your local Grundfos company for more information.

19. Priority of settings

The priority of settings depends on two factors:

1. control source
2. settings.

1. Control source

- Control panel
- GO Remote or R100
- External signals (external setpoint signal, digital inputs, etc.).
- Communication from another control system via bus

2. Settings

- Operating mode Stop
- Operating mode Max. (maximum curve)
- Operating mode Min. (minimum curve)
- Setpoint setting.

An E-pump can be controlled by different control sources at the same time, and each of these sources can be set differently. Consequently, it is necessary to set an order of priority of the control sources and the settings.

If two or more settings are activated at the same time, the pump will operate according to the function with the highest priority.

Priority of settings without bus communication

Priority	Control panel, GO Remote, or R100	External signals
1	Stop	
2	Max.	
3		Stop
4		Max.
5	Min.	Min.
6	Setpoint setting	Setpoint setting

Example: If the E-pump has been set to operating mode Max. (Max. frequency) via an external signal, such as digital input, the control panel or GO Remote or R100 can only set the E-pump to operating mode Stop.

Priority of settings with bus communication

Priority	Control panel, GO Remote or R100	External signals	Bus communication
1	Stop		
2	Max.		
3		Stop	Stop
4			Max.
5			Min.
6			Setpoint setting

Example: If the E-pump is operating according to a setpoint set via bus communication, the control panel, GO Remote or R100 can set the E-pump to operating mode Stop or Max., and the external signal can only set the E-pump to operating mode Stop.

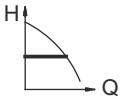
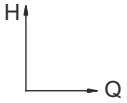
20. External forced-control signals

The pump has inputs for external signals for these forced-control functions:

- Start/stop of pump
- Digital function.

20.1 Start/stop input

Functional diagram: Start/stop input

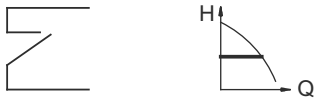
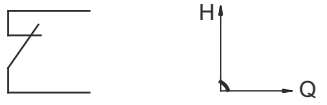
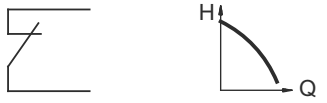
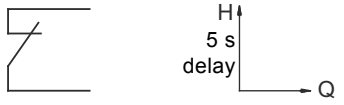
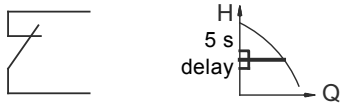
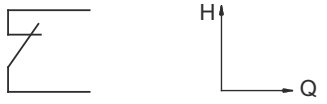
Start/stop (terminals 2 and 3)		
		**Normal duty**
		**Stop**

20.2 Digital input

One of the following functions can be selected for the digital input:

- Normal duty
- Minimum curve
- Maximum curve
- External fault
- Flow switch
- Dry running.

Functional diagram: Input for digital function

Digital function (terminals 1 and 9) (terminals 9 and 10) (terminals 9 and 11)	
	**Normal duty**
	**Min. curve**
	**Max. curve**
	**External fault**
	**Flow switch**
	**Dry running**

21. External setpoint signal

The setpoint can be remote-set by connecting an analogue signal transmitter to the input for the setpoint signal (terminal 4).

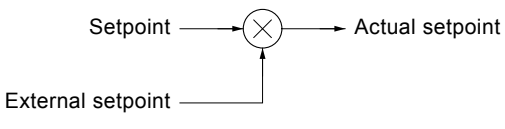


Fig. 43 Actual setpoint as a product (multiplied value) of setpoint and external setpoint

Select the actual external signal, 0-10 V, 0-20 mA, 4-20 mA, via the GO Remote or R100. See section *17.3.3 External setpoint*.

If control mode **uncontrolled** is selected by means of the GO Remote or R100, the pump can be controlled by any controller.

In control mode **controlled**, the setpoint can be set externally within the range from the lower value of the sensor measuring range to the setpoint set on the pump or by means of the GO Remote or R100.

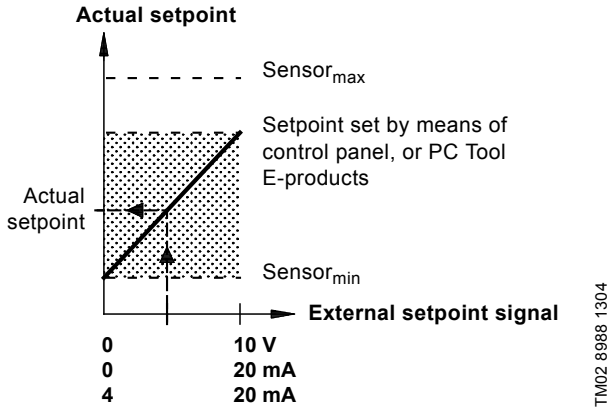


Fig. 44 Relation between the actual setpoint and the external setpoint signal in control mode controlled

Example: At a sensor$_{min}$ value of 0 psi, a setpoint set of 50 psi and an external setpoint of 80 % (an 8 V analog signal to Terminal 4 if using an analog signal of 0-10 V), the actual setpoint will be as follows:

$$\text{Actual setpoint} = (\text{setpoint} - \text{sensor}_{min}) \times \%_{\text{external setpoint}} + \text{sensor}_{min}$$

$$= (50 - 0) \times 80\ \% + 0$$

$$= 40 \text{ psi}$$

In control mode **uncontrolled**, the setpoint can be set externally within the range from the min. curve to the setpoint set on the pump or by means of the GO Remote or R100. Typically the setpoint is set to 100 % when the control mode is uncontrolled (see section *17.5 Typical display settings for analog-input E-pumps*.

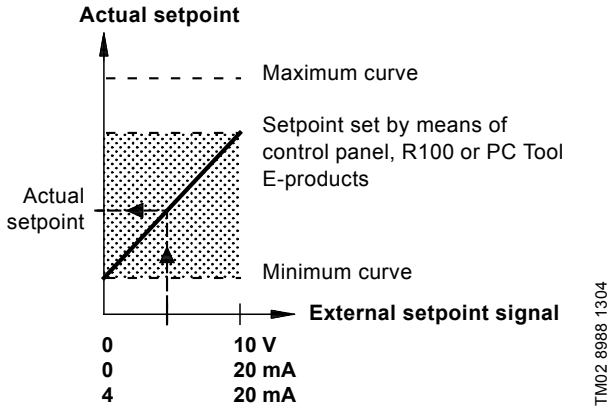


Fig. 45 Relation between the actual setpoint and the external setpoint signal in control mode uncontrolled

22. Bus signal

The pump supports serial communication via an RS-485 input. The communication is carried out according to Grundfos bus protocol, GENIbus protocol, and enables connection to a building management system or another external control system.

Operating parameters, such as setpoint, operating mode, etc. can be remote-set via the bus signal. At the same time, the pump can provide status information about important parameters, such as actual value of control parameter, input power, fault indications, etc.

Contact Grundfos for further details.

If a bus signal is used, the number of settings available via the GO Remote will be reduced.

23. Other bus standards

Grundfos offers various bus solutions with communication according to other standards.

Contact Grundfos for further details.

24. Indicator lights and signal relay

The operating condition of the pump is indicated by the green and red indicator lights fitted on the pump control panel and inside the terminal box. See fig. 46.

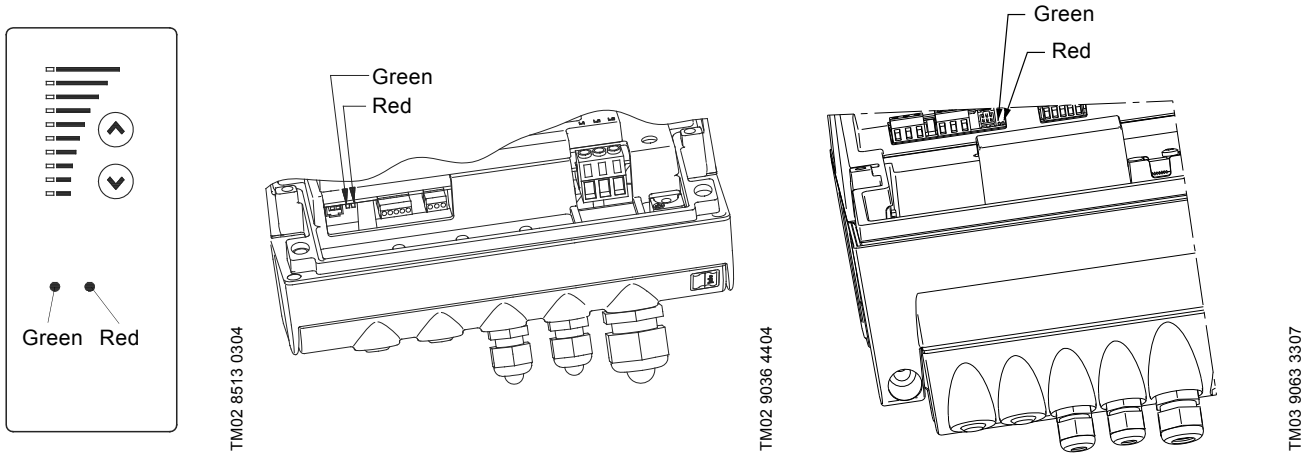
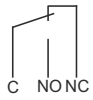
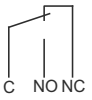
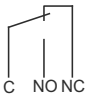
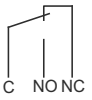
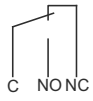
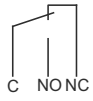
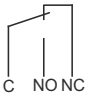
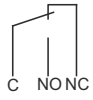
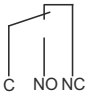
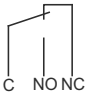
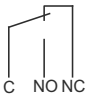
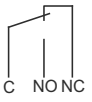
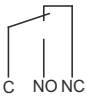
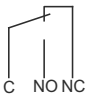
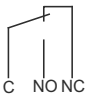


Fig. 46 Position of indicator lights

In addition, the pump incorporates an output for a potential-free signal via an internal relay.

For signal relay output values, see section *17.3.4 Signal relay*.

The functions of the two indicator lights and the signal relay are as shown in the following table:

Indicator lights		Signal relay activated during				
Fault (red)	**Operation (green)**	**Fault/Alarm, Warning and Relubricate**	**Operating**	**Ready**	**Pump running**	**Description**
Off	Off					The power supply has been switched off.
Off	Permanently on					The pump is operating.
Off	Permanently on					The pump is stopped by the stop function.
Off	Flashing					The pump has been set to stop.
Permanently on	Off					The pump has stopped because of a Fault/ Alarm or is running with a Warning or Relubricate indication. If the pump was stopped, restarting will be attempted (it may be necessary to restart the pump by resetting the Fault indication). If the cause is "external fault", the pump must be restarted manually by resetting the Fault indication.
Permanently on	Permanently on					The pump is operating, but it has or has had a Fault/Alarm allowing the pump to continue operation or it is operating with a Warning or Relubricate indication. If the cause is "sensor signal outside signal range", the pump will continue operating according to the 70 % curve and the fault indication cannot be reset until the signal is inside the signal range. If the cause is "setpoint signal outside signal range", the pump will continue operating according to the min. curve and the fault indication cannot be reset until the signal is inside the signal range.
Permanently on	Flashing					The pump has been set to stop, but it has been stopped because of a fault.

Resetting of fault indication

A fault indication can be reset in one of the following ways:

- Briefly press the button ⌃ or ⌄ on the pump. This will not change the setting of the pump.
  A fault indication cannot be reset by means of ⌃ or ⌄ if the buttons have been locked.
- Switch off the power supply until the indicator lights are off.
- Switch the external start/stop input off and then on again.
- Use the GO Remote or R100. See section *17.1.3 Fault indications*.

When the GO Remote or R100 communicates with the pump, the red indicator light will flash rapidly.

25. Emergency operation (only 15-30 hp)

DANGER

Electric shock

Death or serious personal injury

- Disconnect all electric supply circuits and ensure these have been switched off for at least 5 minutes before making any connections in the pump terminal box. For instance, the signal relay may be connected to an external supply which is still connected when the power supply is disconnected.

If the pump is stopped and you cannot start the pump immediately after normal remedies, the reason could be a faulty variable frequency drive. If this is the case it is possible to maintain emergency operation of the pump.

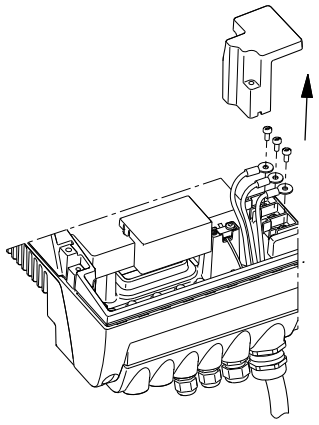
Before change over to emergency operation we recommend that you:

- check that the power supply is OK
- check that control signals are working (start/stop signals)
- check that all alarms are reset
- make a resistance test on the motor windings (disconnect the motor leads from the terminal box).

If the pump remains stopped it is possible that the variable frequency drive is faulty.

To establish emergency operation proceed as follows:

1. Disconnect the three power supply leads, L1, L2, L3, from the terminal box, but leave the protective ground lead(s) in position on the PE terminal(s).



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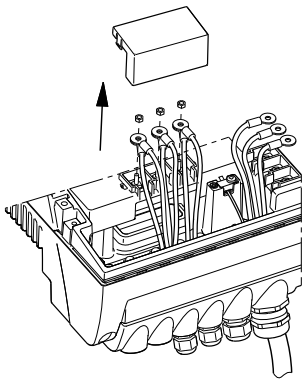
2. Disconnect the motor supply leads, U/W1, V/U1, W/V1, from the terminal box.



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3. Connect the leads as shown in fig. 47.

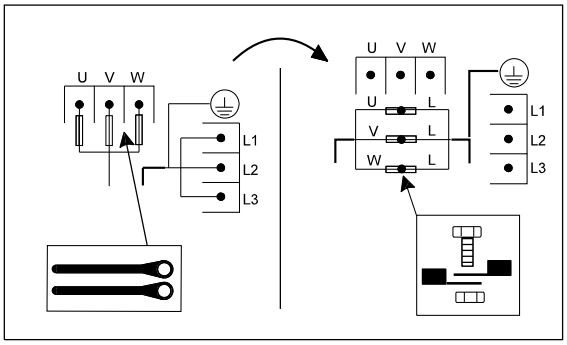

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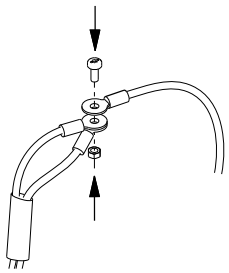
Fig. 47 How to switch an E-pump from normal operation to emergency operation

Use the screws from the power supply terminals and the nuts from the motor terminals.



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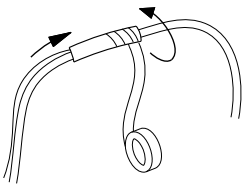
4. Insulate the three leads from each other by means of insulating tape or similar means.



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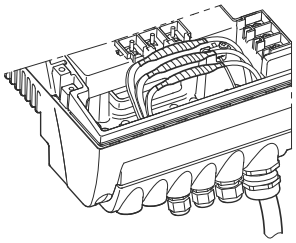

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DANGER

Electric shock

Death or serious personal injury

- Do not bypass the variable frequency drive by connecting the power supply leads to the U, V and W terminals. This may cause hazardous situations for personnel as the high voltage potential of the power supply may be transferred to touchable components in the terminal box.

Check the direction of rotation when starting up after switching to emergency operation.

5. A motor starter is required.

26. Insulation resistance

3-10 hp

Do not measure the insulation resistance of motor windings or an installation incorporating E-pumps using high voltage megging equipment, as this may damage the built-in electronics.

15-30 hp

Do not measure the insulation resistance of an installation incorporating E-pumps using high voltage megging equipment, as this may damage the built-in electronics.

The motor leads can be disconnected separately and the insulation resistance of the motor windings can be tested.

27. Maintaining and servicing the motor

27.1 Cleaning of the motor

Keep the motor cooling fins and fan blades clean to ensure sufficient cooling of the motor and electronics.

27.2 Relubrication of motor bearings

3-10 hp pumps

The motor bearings are of the closed type and greased for life. The bearings cannot be relubricated.

15-30 hp pumps

The motor bearings are of the open type and must be relubricated regularly. The motor bearings are prelubricated on delivery. The built-in bearing monitoring function will give a warning indication on the GO Remote or R100 when the motor bearings are due to be relubricated.

Before relubrication, remove the bottom plug in the motor flange and the plug in the bearing cover to ensure that old and excess grease can escape.

When relubricating the first time, use the double quantity of grease as the lubricating channel is still empty.

Frame size	Quantity of grease [ounces]	
	Drive end (DE)	Non-drive end (NDE)
MLE 160	0.44	0.44
MLE 180	0.51	0.51

The recommended grease type is a polycarbamide-based lubricating grease.

27.3 Replacement of motor bearings

Motors from 15-30 hp have built-in bearing monitoring function which will give a warning indication on the Grundfos GO Remote or R100 when the motor bearings are due to be replaced.

27.4 Replacement of varistor (only 15-30 hp)

The varistor protects the pump against voltage transients. If voltage transients occur, the varistor will be worn over time and need to be replaced. The more transients, the more quickly the varistor will be worn. When it is time to replace the varistor, Grundfos GO, R100 and PC Tool E-products will indicate this as a warning.

A Grundfos technician is required for replacement of the varistor. Contact your local Grundfos company for assistance.

27.5 Service parts and service kits

For further information on service parts and service kits, visit www.grundfos.com, select country, select WebCAPS.

28. Technical data

28.1 Technical data - three-phase pumps, 3-10 hp

28.1.1 Supply voltage

3 x 440-480 V - 10 %/+ 10 %, 60 Hz - 2 %/+ 2 %, PE.

3 x 208-230 V - 10 %/+ 10 %, 60 Hz - 2 %/+ 2 %, PE.

Cable: Max 10 mm^2 / 8 AWG.

Use min. 158 °F (70 °C) copper conductors only.

Recommended fuse sizes

Motor sizes from 3 to 7.5 hp: Max. 16 A.

Motor size 10 hp: Max. 32 A.

Standard as well as quick-blow or slow-blow fuses may be used.

28.1.2 Overload protection

The overload protection of the E-motor has the same characteristic as an ordinary motor protector. As an example, the E-motor can stand an overload of 110 % of I_{nom} for 1 min.

28.1.3 Leakage current

Motor size [hp]	Leakage current [mA]
3 hp (supply voltage < 460 V)	< 3.5
3 hp (supply voltage > 460 V)	< 5
5 to 7.5 hp	< 5
10 hp	< 10

The leakage currents are measured in accordance with EN 61800-5-1.

28.1.4 Inputs/output

Start/stop

External potential-free contact.

Voltage: 5 VDC.

Current: < 5 mA.

Screened cable: 20-16 AWG (0.5 - 1.5 mm^2).

Digital

External potential-free contact.

Voltage: 5 VDC.

Current: < 5 mA.

Screened cable: 20-16 AWG (0.5 - 1.5 mm^2).

Setpoint signals

- Potentiometer
  0-10 VDC, 10 kΩ (via internal voltage supply).
  Screened cable: 20-16 AWG (0.5 - 1.5 mm^2).
  Maximum cable length: 328 ft (100 m).
- Voltage signal
  0-10 VDC, R_i > 50 kΩ.
  Tolerance: + 0 %/- 3 % at maximum voltage signal.
  Screened cable: 20-16 AWG (0.5 - 1.5 mm^2).
  Maximum cable length: 1640 ft (500 m).
- Current signal
  DC 0-20 mA / 4-20 mA, R_i = 175 Ω.
  Tolerance: + 0 %/- 3 % at maximum current signal.
  Screened cable: 20-16 AWG (0.5 - 1.5 mm^2).
  Maximum cable length: 1640 ft (500 m).

Sensor signals

- Voltage signal
  0-10 VDC, R_i > 50 kΩ (via internal voltage supply).
  Tolerance: + 0 %/- 3 % at maximum voltage signal.
  Screened cable: 20-16 AWG (0.5 - 1.5 mm^2).
  Maximum cable length: 1640 ft (500 m).
- Current signal
  DC 0-20 mA / 4-20 mA, R_i = 175 Ω.
  Tolerance: + 0 %/- 3 % at maximum current signal.
  Screened cable: 20-16 AWG (0.5 - 1.5 mm^2).
  Maximum cable length: 1640 ft (500 m).

Internal power supplies

- 10 V power supply for external potentiometer:
  Maximum load: 2.5 mA.
  Short-circuit protected.
- 24 V power supply for sensors:
  Maximum load: 40 mA.
  Short-circuit protected.

Signal relay output

Potential-free changeover contact.

Maximum contact load: 250 VAC, 2 A, cos φ 0.3 - 1.

Minimum contact load: 5 VDC, 10 mA.

Screened cable: 28-12 AWG (0.5 - 2.5 mm^2).

Maximum cable length: 1640 ft (500 m).

Bus input

Grundfos bus protocol, GENIbus protocol, RS-485.

Screened 3-core cable: 28-16 AWG (0.2 - 1.5 mm^2).

Maximum cable length: 1640 ft (500 m).

28.2 Technical data - three-phase pumps, 15-30 hp

28.2.1 Supply voltage

3 x 440-480 V - 10 %/+ 10 %, 60 Hz - 3 %/+ 3 %, PE.

Cable: Maximum. 8 AWG (10 mm^2)

Use min. 158 °F (70 °C) copper conductors only.

Recommended fuse sizes

Motor size [hp]	Max. [A]
15	32
20	36
25	43
30	51

Standard as well as quick-blow or slow-blow fuses may be used.

28.2.2 Overload protection

The overload protection of the E-motor has the same characteristic as an ordinary motor protector. As an example, the E-motor can stand an overload of 110 % of I_{nom} for 1 min.

28.2.3 Leakage current

Ground leakage current > 10 mA.

The leakage currents are measured in accordance with EN 61800-5-1.

28.2.4 Inputs/output

Start/stop

External potential-free contact.

Voltage: 5 VDC.

Current: < 5 mA.

Screened cable: 20-16 AWG (0.5 - 1.5 mm^2).

Digital

External potential-free contact.

Voltage: 5 VDC.

Current: < 5 mA.

Screened cable: 20-16 AWG (0.5 - 1.5 mm^2).

Setpoint signals

- Potentiometer
  0-10 VDC, 10 kΩ (via internal voltage supply).
  Screened cable: 20-16 AWG (0.5 - 1.5 mm^2).
  Maximum cable length: 328 ft (100 m).
- Voltage signal
  0-10 VDC, R_i > 50 kΩ.
  Tolerance: + 0 %/- 3 % at maximum voltage signal.
  Screened cable: 20-16 AWG (0.5 - 1.5 mm^2).
  Maximum cable length: 1640 ft (500 m).
- Current signal
  DC 0-20 mA / 4-20 mA, R_i = 250 Ω.
  Tolerance: + 0 %/- 3 % at maximum current signal.
  Screened cable: 20-16 AWG (0.5 - 1.5 mm^2).
  Maximum cable length: 1640 ft (500 m).

Sensor signals

- Voltage signal
  0-10 VDC, R_i > 50 kΩ (via internal voltage supply).
  Tolerance: + 0 %/- 3 % at maximum voltage signal.
  Screened cable: 20-16 AWG (0.5 - 1.5 mm^2).
  Maximum cable length: 1640 ft (500 m).
- Current signal
  DC 0-20 mA / 4-20 mA, R_i = 250 Ω.
  Tolerance: + 0 %/- 3 % at maximum current signal.
  Screened cable: 20-16 AWG (0.5 - 1.5 mm^2).
  Maximum cable length: 1640 ft (500 m).

Internal power supplies

- 10 V power supply for external potentiometer:
  Maximum load: 2.5 mA.
  Short-circuit protected.
- 24 V power supply for sensors:
  Maximum load: 40 mA.
  Short-circuit protected.

Signal relay output

Potential-free changeover contact.

Maximum contact load: 250 VAC, 2 A, cos φ 0.3 - 1.

Minimum contact load: 5 VDC, 10 mA.

Screened cable: 28-12 AWG (0.5 - 2.5 mm^2).

Maximum cable length: 1640 ft (500 m).

Bus input

Grundfos bus protocol, GENIbus protocol, RS-485.

Screened 3-core cable: 28-16 AWG (0.2 - 1.5 mm^2).

Maximum cable length: 1640 ft (500 m).

28.3 Other technical data

28.3.1 EMC (electromagnetic compatibility to EN 61800-3)

Motor [hp]	Emission/immunity
3 5 7.5 10	**Emission:** The motors may be installed in residential areas (first environment), unrestricted distribution, corresponding to CISPR11, group 1, class B. **Immunity:** The motors fulfill the requirements for both the first and second environment.
15 20 25 30	**Emission:** The motors are category C3, corresponding to CISPR11, group 2, class A, and may be installed in **industrial areas** (second environment). If equipped with an external Grundfos EMC filter, the motors are category C2, corresponding to CISPR11, group 1, class A, and may be installed in residential areas (first environment). ! When the motors are installed in residential areas, supplementary measures may be required as the motors may cause radio interference. Motor sizes 15, 25, and 30 hp comply with EN 61000-3-12 provided that the short-circuit power at the interface point between the user's electrical installation and the public power supply network is greater than or equal to the values stated below. It is the responsibility of the installer or user to ensure, by consultation with the power supply network operator, if necessary, that the motor is connected to a power supply with a short-circuit power greater than or equal to these values:

Motor size [hp]	Short-circuit power [kVA]
15	1500
20	-
25	2700
30	3000

! 20 hp motors do not comply with EN 61000-3-12.

By installing an appropriate harmonic filter between the motor and the power supply, the harmonic current content will be reduced. In this way, the 20 hp motor will comply with EN 61000-3-12.

Immunity:
The motors fulfill the requirements for both the first and second environment.

Contact Grundfos for further information.

Enclosure class

- Three-phase pumps, 3-10 hp: IP55 (IEC 34-5)
- Three-phase pumps, 15-30 hp: IP55 (IEC 34-5).

Insulation class

F (IEC 85)

28.3.2 Flow rate

Minimum flow rate

The pump must not run against closed outlet valve as this will cause an increase in temperature/formation of steam in the pump.

This may cause shaft damage, impeller erosion, short life of bearings, damage to stuffing boxes (packing) or mechanical shaft seals due to stress or vibration.

The minimum continuous flow rate is shown when selecting the pump in Grundfos Express.

Maximum flow rate

The maximum flow rate must not exceed the value stated on the nameplate. If the maximum flow rate is exceeded, cavitation and overload may occur.

28.3.3 Ambient temperature and altitude

The ambient temperature and the installation altitude are important factors for the motor life, as they affect the life of the bearings and the insulation system.

Overheating may result from excessive ambient temperature or the low density and consequently low cooling effect of the air.

In such cases, it may be necessary to use a motor with a higher output.

Ambient temperature

During operation:

- Min -4 °F (-20 °C)
- Max +104 °F (40 °C) without derating.

During storage/transport:

- -40 °F (-40 °C) to +140 °F (+60 °C) (3-10 hp)
- -13 °F (-25 °C) to +158 °F (70 °C) (15-30 hp).

28.3.4 Relative air humidity

Maximum 95 %.

28.3.5 Sound pressure level

Motor [hp]	Sound pressure level [dB(A)]	
hp	2-pole	4-pole
3	82	64
5	87	75
7.5	93	69
10	82	71
15	68	64
20	68	66
25	70	72
30	70	

28.3.6 Liquid temperature

The maximum liquid temperature depends on the material of the mechanical shaft seal, o-rings and gaskets used:

- Temperature range for BUNA: 32-212 °F (0-100 °C).
- Temperature range for VITON®: 59-275 °F (15-135 °C).
- Temperature range for EPDM: 59-275 °F (15-135 °C).

28.3.7 Outlet pressure

Maximum outlet pressure

The maximum outlet pressure is the pressure for total dynamic head (TDH) stated on the pump nameplate.

28.3.8 Inlet pressure

Minimum inlet pressure

The minimum inlet pressure must correspond to the NPSH curve for the pump + a safety margin of minimum 1.6 ft (0.5 m) head.

Pay attention to the minimum inlet pressure to avoid cavitation. The risk of cavitation is higher in the following situations:

- The liquid temperature is high.
- The flow rate is considerably higher than the pump's rated flow rate.
- The pump is operating in an open system with suction lift.
- The inlet conditions are poor.
- The operating pressure is low.

Maximum inlet pressure

Inlet pressure + pump pressure must be lower than the maximum pressure or total dynamic head (TDH) of the pump.

29. Installing the product in the USA and Canada

In order to maintain the UL/cUL approval, follow these additional installation instructions. The UL approval is according to UL508C.

29.1 Electrical connection

29.1.1 Conductors

Use minimum 140/167 °F (60/75 °C) copper conductors only.

29.1.2 Torques

Power terminals

Power terminal: 1.7 ft-lbs (2.3 Nm)

Relay, M2.5: 0.4 ft-lbs (0.5 Nm)

Input control, M2: 0.15 ft-lbs (0.2 Nm).

29.1.3 Line reactors

Max. line reactor size must not exceed 2 mH.

29.1.4 Fuse size/circuit breaker

If a short circuit happens the pump can be used on a power supply delivering not more than 5000 RMS symmetrical amperes, 480 V maximum.

Fuses

When the pump is protected by fuses they must be rated for 600 V. Maximum sizes are stated in table below.

Up to 10 hp use Class K5 UL Listed fuses. For 10 to 30 hp use any class UL Listed fuse.

Circuit breaker

When the pump is protected by a circuit breaker, this must be rated for a maximum voltage of 480 V. Use a circuit breaker of the "Inverse time" type.

The interrupting rating (RMS symmetrical amperes) must not be less than the values stated in table below.

USA - hp

2-pole	4-pole	Fuse size	Circuit breaker type/model
3	3	25 A	25 A / Inverse time
5	5	40 A	40 A / Inverse time
7.5	-	40 A	40 A / Inverse time
10	7.5	50 A	50 A / Inverse time
15	15	80 A	80 A / Inverse time
20	20	110 A	110 A / Inverse time
25	25	125 A	125 A / Inverse time
30	-	150 A	150 A / Inverse time

29.1.5 Overload protection

Degree of overload protection provided internally by the drive, in percent of full-load current: 102 %.

29.2 General considerations

For installation in humid environment and fluctuating temperatures, we recommend to keep the pump connected to the power supply continuously. This will prevent moisture and condensation build-up in the terminal box.

Start and stop must be done via the start/stop digital input (terminal 2-3).

30. 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.

Subject to alterations.