CRWMS/M&O

Non-Q Design Analysis Cover Sheet

Complete only applicable items.

(1.) QA: N/A

Page: 1 Of: 6

2. DESIGN ANALYSIS TITLE			
NORTH PORTAL - HOT WATER CIRCULATION PUMP CALCULATION - SHOP BUILDING #5006 (SCPB: N/A)			
3. DOCUMENT IDENTIFIER (Including Rev. No.)		4. REV. NO.	5. TOTAL PAGES
BABBAD000-01717-0200-00144 Rev 01		01	6
6. TOTAL ATTACHMENTS	7. ATTACHMENT NUMBERS - NO. OF PAGES IN EACH		8. SYSTEM ELEMENT
2	I-5, II-2		MGDS

	Print Name	Signature	Date
9. Originator	R. Blackstone	R. E. Flye FOR R. BLACKSTONE	1-24-96
10. Checker	D.F. Vanica	D. F. Vanica	1-24-96
11. Lead Design Engineer	R.E. Flye	R. E. Flye	1-24-96
12. Department Manager	G. N. Kimura	G. N. Kimura	1-25-96

13. Remarks

2. DESIGN ANALYSIS TITLE
NORTH PORTAL - HOT WATER CIRCULATION PUMP CALCULATION- SHOP BUILDING #5006
3. DOCUMENT IDENTIFIER (Including Rev. No.)
BABBAD000-01717-0200-00144 REV 01

4. Revision No.	5. Description of Revision
00	Initial Issue
01	Reformatted per NAP-MG-013, Rev. 0 Removed TBV-122 Changed QA Classification from TBV to QA: N/A Revised calculations to include water film coefficient and pipe thermal conductivity Editorial Changes

1. PURPOSE

The purpose of this design analysis and calculation is to size a circulating pump for the service hot water system in the Shop Building 5006, in accordance with the Uniform Plumbing Code (Section 4.4.1) and U.S. Department of Energy Order 6430.1A-1540 (Section 4.4.2).

2. QUALITY ASSURANCE

This analysis is non-Q because it is for a temporary item. A Determination of Importance Evaluation (Reference 5.1) of the Shop Building has determined that no quality assurance (QA) controls are applicable within the context of this analysis.

3. METHOD

The method used for the calculation is based on Reference 5.2. This consists of determining the total heat transfer from the service hot water system piping to the surrounding environment. The heat transfer is then used to define the total pumping capacity based on a given temperature change in the circulating hot water as it flows through the closed loop piping system. The total pumping capacity is used to select a pump model from manufacturer's literature. This established the head generation for that capacity and particular pump model. The total length of all hot water supply and return piping including fittings is then estimated from the plumbing drawings which defines the pipe friction losses that must fit within the available pump head. Several iterations may be required before a pump can be selected that satisfies the head-capacity requirements.

4. DESIGN INPUTS

4.1 DESIGN PARAMETERS

Water temperature at most remote outlet = 110 degrees F (Reference 4.4)

Ambient temperature = 70 degrees F (Reference 4.4)

Velocity of flow = 5 feet/second (Reference 5.4)

Length of Pipe:	½"	= 126 feet	(Reference 5.8)
(Attachment I)	3/4"	= 80 feet	(Reference 5.8)
	1"	= 45 feet	(Reference 5.8)

4.2 CRITERIA

The Plumbing Design for the Shop Building will be designed in accordance with DOE Order 6430.1A (Section 4.4.2) and appropriate state and local codes (ESFDR Sections 3.2.1Q, 3.2.1R, and 3.2.1S, Reference 5.7).

4.3 ASSUMPTIONS

Not used.

4.4 CODES AND STANDARDS

4.4.1 International Association of Plumbing and Materials Officials:

UPC 1991 Uniform Plumbing Code (UPC)

4.4.2 U.S. Department of Energy (DOE):

DOE Order 6430.1A-89 General Design Criteria

5. REFERENCES

5.1 BABBA0000-01717-2200-00007 Rev. 00 Determination of Importance Evaluation for ESF Change House Facility and Shop Building.

5.2 1991 American Society of Heating, Refrigeration, and Air Conditioning Engineers Handbook, HVAC Applications I-P Edition.

5.3 Michael R. Lindeburg, P.E., Mechanical Engineering Reference Manual, Eighth Edition, Professional Publications, Inc., 1990.

5.4 Crane Technical Paper No. 410, "Flow of Fluids," Crane Co., 1988.

5.5 American Society of Heating, Refrigeration, and Air Conditioning Engineers/Illuminating Engineering Society of North America Standard 90.1b, Energy Efficient Design of New Buildings Except New low-Rise Residential Buildings, 1992.

5.6 Mohinder L. Nayyar, P. E., Piping Handbook, Sixth Edition, McGraw-Hill.

5.7 Yucca Mountain Site Characterization Project Exploratory Studies Facility Design Requirements, YMP/CM-0019, REV. 1, ICN 3

5.8 Drawings:

5.8.1 BABBAD000-01717-2100-27400-00 Shop - Bldg 5006 Plumbing and Piping First Floor Plan

5.8.2 BABBAD000-01717-2100-27401-00 Shop - Bldg 5006 Plumbing and Piping Second Floor Plan

5.8.3 BABBAD000-01717-2100-27402-00 Shop - Bldg 5006 Isometrics and Details

5.9 Grundfos Pumps Corporation Bulletin L-UP-TL-007, Dated 1/15/93

6. USE OF COMPUTER SOFTWARE

Not used.

7. DESIGN ANALYSIS

The radial heat flow out of an insulated pipe can be expressed as follows:

$$q = \frac{2\pi L \Delta T}{\frac{1}{r_a h_a} + \frac{\ln\left(\frac{r_b}{r_a}\right)}{k_{pipe}} + \frac{1}{r_b h_b} + \frac{\ln\left(\frac{r_c}{r_b}\right)}{k_{ins}} + \frac{1}{r_c h_c}} \qquad \text{(Eq. 1)}$$

where film coefficient, h_a water = 150 (British thermal unit) BTUH/feet^2 - F (Reference 5.3)

h_c still air = 1.65 BTUH/feet^2 - F (Reference 5.3)

radius, r_a pipe I.R. = 0.0327 feet (Reference 5.3)

r_b, pipe O.R. = 0.0364 feet (Reference 5.3)

r_c, insulation O.R. = 0.1197 feet (Derived)

thermal conductivity, k_{ins}, insulation = 0.0233 BTUH/feet - F (Reference 5.5)

k_{pipe}, pipe = 200 BTUH/feet - F (Reference 5.6)

length of pipe, L = 251 feet of 3/4 inch based on weighted average (Attachment I)

Substituting the appropriate design parameters in Equation (1) and solving for the heat loss through the insulated pipe, q = 1,119 BTUH.

The water flow rate in gal/min to remove the heat q is defined as:

$$Q = q/500\ \Delta T \qquad \text{(Eq. 2)}$$

where ΔT is the difference in temperature of the water leaving and returning to the water heater. The water flow limitation in piping systems is related to the velocity of flow and/or pressure drop which affects pumping costs. To minimize the effects of high velocities at ΔT in the hot water, return is limited to 1 degree which is reasonable for an insulated small diameter pipe line for service hot water. This results in a flow rate of 2.2 gallons per minute (gpm). From the UPC shown as Page 3 in Attachment I, the velocity of flow is 3 feet/second and the friction loss is 4.5 psi/100 feet pipe length if ½ inch diameter copper tubing is the minimum size used in the hot water return. However, as shown in Attachment I, the use of some ½ inch tubing in the return results in a relatively high pressure drop. The minimum size tubing was increased to 3/4 inch which resulted in the selection of a circulating pump closely matching the required performance.

8. CONCLUSIONS

The hot water circulating pump performance requirements are approximately 7 gpm at a system head of 5 feet. A Grundfos closed system pump Model UPS 15-42F (SFD 2) was selected as the design basis for the hot water return in the Shop Building. The pump shown in Attachment II is rated at 1/25 horsepower at 230 V.

The minimum pipe size is 3/4 inch type L copper water tubing. The pipe is designed for a minimum of 1 inch insulation for added energy conservation while maintaining a hot water return temperature of 109 degrees F.

9. ATTACHMENTS

ATTACHMENT	TITLE
I	Calculations
II	Grundfos Pump Data

CALCULATIONS

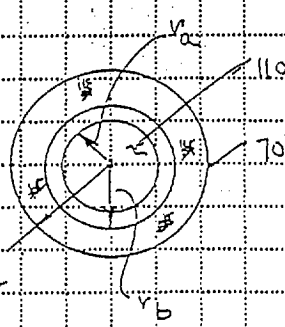
FOR HEAT TRANSFER FROM AN INSULATED PIPE

$$q = \frac{2\pi L \Delta T}{\frac{1}{r_a h_a} + \frac{\ln(r_b/r_a)}{K_{PIPE}} + \frac{1}{r_b h_b} + \frac{\ln(r_c/r_b)}{K_{INS}} + \frac{1}{r_c h_c}}$$

WEIGHTED AVERAGE PIPE SIZE

PIPE SIZE	LGTH	ELLS	TEES	GATE VALVE	CK VALVE
1"	45	1	1	1	—
3/4"	80	2	1	—	—
1/2"	126	4	1	2	1

$$\text{AVG PIPE SIZE} = \frac{(1)(45) + (.75)(80) + (.5)(126)}{45 + 80 + 126} = 0.67 \quad \text{USE } 3/4"$$



$r_a = .785/2 = .3925" = .0327'$ (REF 53)

$r_b = .875/2 = .4375" = .0365'$ (REF 53)

$r_c = .875/2 + 1 = 1.4375" = .1198'$ (REF 53)

CALCULATIONS (Continued)

FILM COEFFICIENTS (REF 53)

$h_a = 1.50$ BTU/H/FT^2 - °F

$h_b = 0$

$h_c = 1.65$ BTU/H/FT^2 - °F (STILL AIR)

THERMAL CONDUCTIVITY

$K_{INS} = .0233$ BTU/H/FT - °F (REF 55)

$K_{PIPE} = 200$ BTU/H/FT - °F (REF 56)

BY SUBSTITUTION, $q = 1121$ BTUH

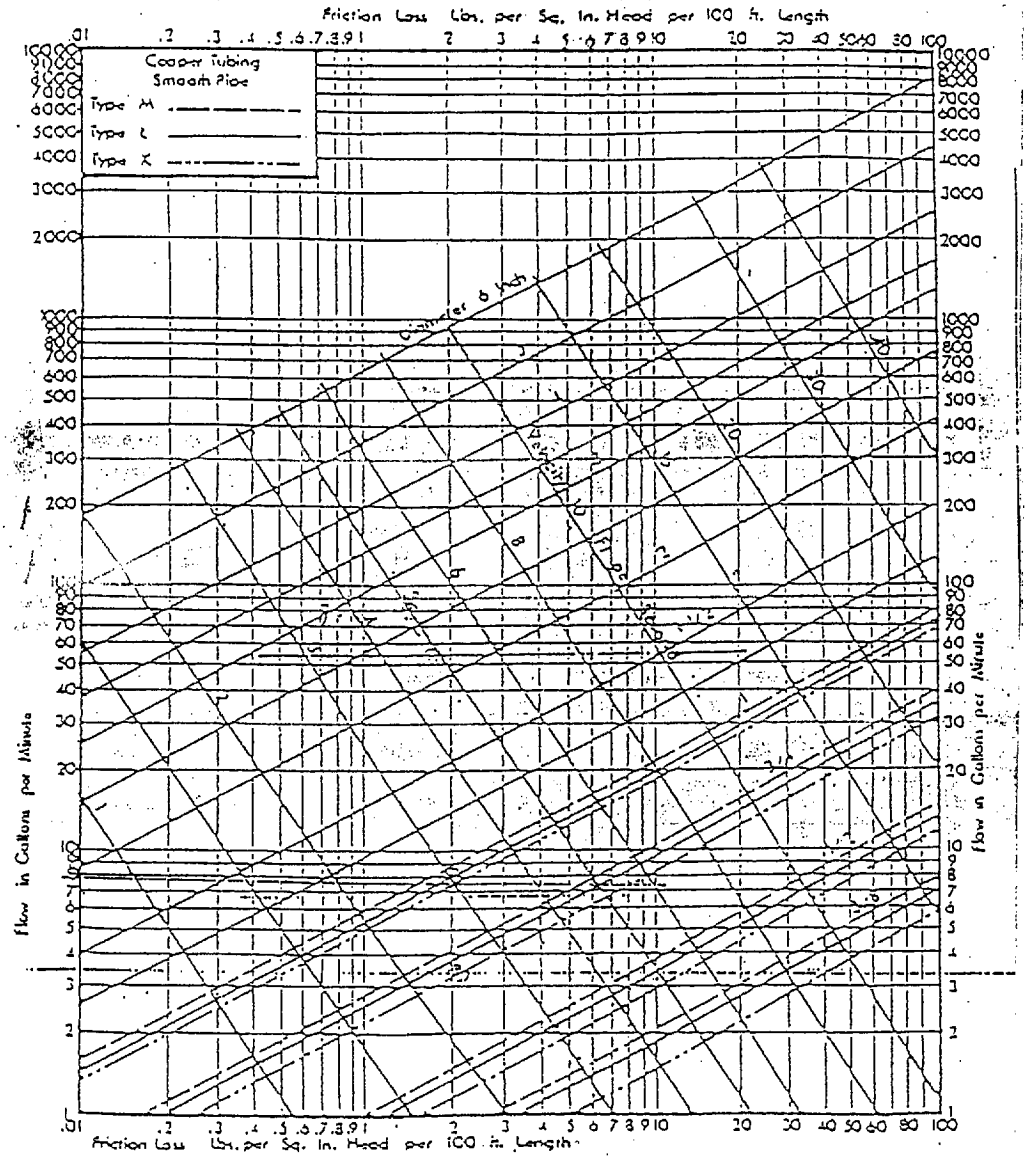
THE WATER FLOW RATE TO REMOVE 1121 BTUH WHILE LIMITING THE TEMPERATURE INCREASE IS AS FOLLOWS:

$$Q = \frac{q}{500\ \Delta T} = \frac{1121}{500\ \Delta T} = \frac{2.242}{\Delta T}$$

LET $\Delta T = 1°$, THEN $Q = 2.242$ GPM

FROM PG 13 (REF 54) THE VELOCITY IN A ½" TYPE L COPPER PIPE WHEN FLOWING 2.242 GPM IS 3 FPS

CALCULATIONS (Continued)
(REFERENCE 5.4)



CALCULATIONS (Continued)

ALSO, FROM PG I-3 THE ΔP = 4.5 PSI/100 FT

THE TOTAL PRESSURE DROP USING EQUIVALENT PIPE SIZES FROM PG I-1 AND FRICTION LOSSES FROM PG ?

1"

45' PIPE	45
1-ELL @ 3'	3
1-TEE @ 5'	5
1-GATE VALVE @ .6	0.6
	53.6' USE 54'

ΔP = 54' × 0.2/100 = .108 PSI

3/4"

80' PIPE	=	80
2-ELLS @ 2.5'	=	5
1-TEE @ 4'	=	4
		89'

ΔP = 89 × 0.7/100 = .62 PSI

1/2"

126' PIPE	126
4 ELLS @ 2'	8
1-TEE @ 3	3
2-GATE VALVES @ .4	0.8
1-GLOBE VALVE @ 15	15
	152'

ΔP = 152 × 45/100 = 6.84 PSI PER RETURN LOOP

TOTAL ΔP = 7.568 PSI = 17.47 FT

CALCULATIONS (Continued)

CIRCULATION PUMP MUST HANDLE FLOW FROM 3 SEPARATE LOOPS.
TOTAL FLOW IS 3 X 2.24 = 6.72 GPM @ 17.5 FT HEAD

MFG'S DATA ON PAGE II-2 INDICATES OPERATING POINT BETWEEN TWO AVAILABLE MODELS UP 26-64 F & UPS 15-42 F

THE ALTERNATIVE IS TO REDUCE THE PRESSURE DROP BY INCREASING THE 1/2" PIPE SIZE TO 3/4"

126' - PIPE	= 126
4 - ELLS @ 2.5	= 10
1 - TEE @ 4'	= 4
1 - GATE VALVE @ .5	= 0.5
1 - GLOBE VALVE @ 20	= 20
	160'

$\Delta P = 160 \times 0.7/100 = 1.12$ PSI

TOTAL $\Delta P = 1.848$ PSI = 4.268 FT

USE UPS 15-42F (SPD 2) MODEL PUMP BY GRUNDFOS

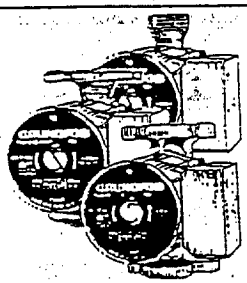
$$\Delta T = \frac{(112)}{(500)(2.242)} = 1°F$$

HWR TEMPERATURE = 110 - 1 = 109°F

GRUNDFOS PUMP DATA (REFERENCE 5.9)

GRUNDFOS — Wet-rotor, in-line, single stage, maintenance free, circulator pumps — **Series UP** OPEN & CLOSED SYSTEMS

Submittal Data — 60 Cycle



JOB or CUSTOMER:	
ENGINEER:	
CONTRACTOR:	
SUBMITTED BY:	DATE:
APPROVED BY:	DATE:
ORDER NO.:	DATE:
SPECIFICATION REF.:	

QUANTITY	TAG NO.	MODEL NO.	GPM	FEET	VOLT	PHASE	COMMENTS

Technical Data (For open and closed system applications)

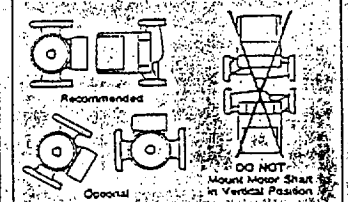
FLOW RANGE: 0 to 45 U.S. GPM
HEAD RANGE: 0 to 30 Feet
MOTOR: 2 Pole, Single Phase
MIN. FLUID TEMP.: 50°F (10°C)
MAX. FLUID TEMP. – OPEN SYSTEMS: 140°F (60°C)
MAX. WORKING PRESSURE: 145 PSI
MIN. REQUIRED INLET PRESSURE:

190°F(88°C)	165°F(74°C)	140°F(60°C)
5 ft. (1.5m)	4.5 ft. (1.4m)	3 ft. (.9m)
2.2 psi	1.9 psi	1.3 psi

MAX. FLUID TEMP. – CLOSED SYSTEMS:

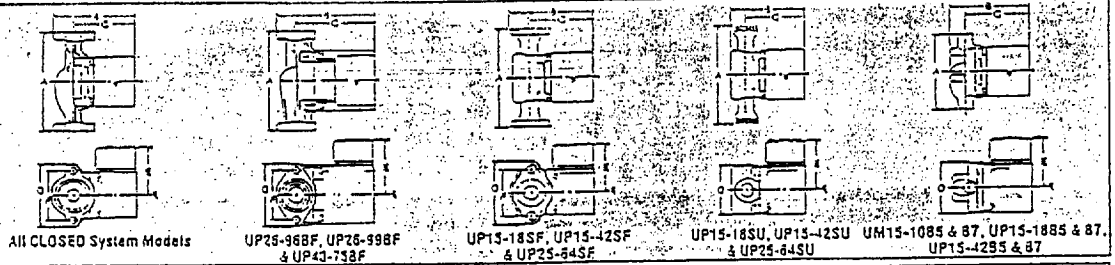
AMBIENT AIR TEMP.	104°F(40°C)	120°F(49°C)	140°F(60°C)	160°F(71°C)	175°F(79°C)
MAX. WATER TEMP.	230°F(110°C)	220°F(104°C)	210°F(99°C)	190°F(88°C)	175°F(79°C)

Mounting Positions



FOR INDOOR USE ONLY

Dimensions and Weights



CLOSED System Models	A	B	C	D	E	F	Connection Type and Size	Shipping Wt. (Lbs.)
UP15-42F(FB (6RUTE) & UPS15-42F	6 ½	5 ¼	4	4 ¾	3 ½	3 ½	FLANGE – (2) ½" dia. bolt holes	7 ¼
UP26-64F & UP26-96F	6 ½	6 ⅜	5 ⅛	4 ⅛	3 ½	3 ½	FLANGE – (2) ½" dia. bolt holes	11 ¼
UP26-99F	6 ½	6 ⅜	5 ⅛	4 ⅛	3 ½	3 ½	FLANGE – (2) ½" dia. bolt holes	12 ½
UP43-75F	8 ½	8 ⅛	5 ⅛	4 ¾	3 ½	3 ½	FLANGE – (2) ½" dia. bolt holes	13 ½

OPEN System Models								
UM15-1085	5	4 ⅛	4	4	3 ½	—	SWEAT – ½	5 ¾
UM15-1087	5 ⅜	5 ⅛	4	3 ¹³⁄₁₆	3 ¼	—	SWEAT – ½	6
UP15-18SU & UP15-42SU	6	5 ⅛	4	3 ¹³⁄₁₆	3 ¼	—	UNION – 1" NPSM	5
UP15-18SF & UP15-42SF	6 ½	5 ¼	4	4 ⅛	3 ¼	3 ½	FLANGE – (2) ½" dia. bolt holes	5 ¾
UP15-1885 & UP15-4285	5	4 ⅛	4	3 ½	3 ½	—	SWEAT – ½	5 ¾
UP15-1887 & UP15-4287	6 ¾	5 ⅛	4	3 ¹³⁄₁₆	3 ¼	—	SWEAT – ½	6
UP25-64SU	7 ⅝	5 ⅛	5 ⅛	4	3 ½	—	UNION – 1" NPSM	9 ¾
UP25-64SF	6 ½	6 ⅛	4 ¹³⁄₁₆	4 ⅛	3 ½	3 ½	FLANGE – (2) ½" dia. bolt holes	10
UP26-96BF	6 ½	6 ⅜	5 ⅛	4 ⅛	3 ½	3 ½	FLANGE – (2) ½" dia. bolt holes	11 ¾
UP26-99BF	6 ½	6 ⅜	5 ⅛	4 ⅛	3 ½	3 ½	FLANGE – (2) ½" dia. bolt holes	12 ½
UP43-75BF	8 ½	8 ⅛	5 ⅛	4 ¾	3 ½	3 ½	FLANGE – (2) ½" dia. bolt holes	14 ¼

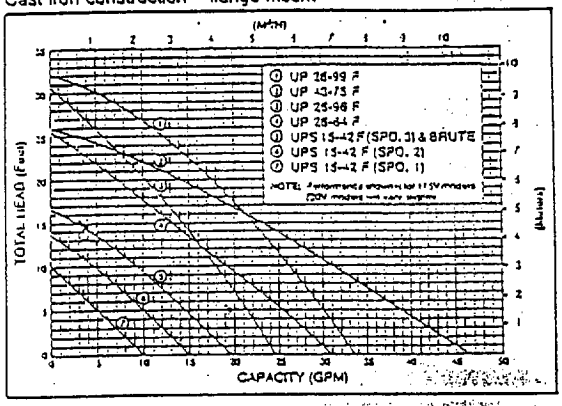
NOTES: All dimensions are in inches. (D "F" dimension is the flange bolt centerline to centerline.

GRUNDFOS PUMP DATA (Continued)

Performance

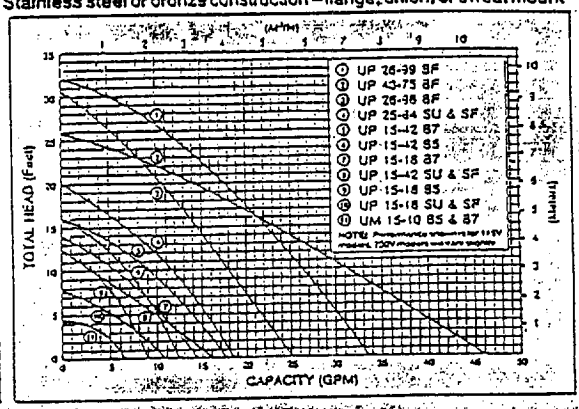
CLOSED System Models

Cast iron construction – flange mount



OPEN System Models

Stainless steel or bronze construction – flange, union, or sweat mount



Electrical Data

CLOSED System Models

MODEL	VOLTS	AMPS	WATTS	HP	CAPACITOR
UP15-42F/FR (8RUTE)	115	.74	85	1/25	10µF/180V
	230	.43	95	1/25	2µF/400V
UPS15-42F (115V) Spd. 3	115	.74	85	1/25	10µF/180V
Spd. 2	115	.57	65	1/25	10µF/180V
Spd. 1	115	.40	45	1/25	10µF/180V
UPS15-42F (230V) Spd. 3	230	.43	95	1/25	2µF/400V
Spd. 2	230	.19	40	1/25	2µF/400V
Spd. 1	230	.14	30	1/25	2µF/400V
UP26-64F	115	1.70	185	1/2	8µF/180V
	230	.80	175	1/2	2.5µF/380V
UP26-96F	115	1.70	205	1/2	10µF/180V
	230	.80	205	1/2	2.5µF/380V
UP26-99F	115	2.15	245	1/3	10µF/180V
	230	1.07	245	1/3	2.5µF/380V
UP43-75F	115	2.15	215	1/3	10µF/180V
	230	1.07	220	1/3	2.5µF/380V

NOTE: All UP models are single speed except for the 3-speed UPS15-42F, 115 and 230 volt.

OPEN System Models

MODEL	VOLTS	AMPS	WATTS	HP	CAPACITOR
UM15-10B5 & B7	115	.40	38	1/25	14µF/100V
UP15-18SU, SF, & B5	115	.74	85	1/25	10µF/180V
	230	.40	90	1/25	2µF/400V
UP15-18B7	115	.74	85	1/25	10µF/180V
	230	.40	96	1/25	2µF/400V
UP15-42SU, SF, & B5	115	.74	85	1/25	10µF/180V
	230	.41	95	1/25	2µF/400V
UP15-42B7	115	.74	85	1/25	10µF/180V
	230	.41	95	1/25	2µF/400V
UP25-64SU & SF	115	1.70	180	1/2	8µF/180V
	230	.80	175	1/2	2.5µF/380V
UP26-96BF	115	1.70	205	1/2	10µF/180V
	230	.80	205	1/2	2.5µF/380V
UP26-99BF	115	2.15	245	1/3	10µF/180V
	230	1.07	245	1/3	2.5µF/380V
UP43-75BF	115	2.15	215	1/3	10µF/180V
	230	1.07	220	1/3	2.5µF/380V

Materials of Construction

CLOSED System Models

STAINLESS STEEL: Inlet cone, bearing plate and bearing retainers, rotor can, rotor cladding, shaft retainer, and impeller (UP26 & UP43)

ALUMINUM: Stator housing.

ALUMINUM OXIDE CERAMIC: Shaft and upper and lower radial bearings.

METAL IMPREGNATED CARBON: Thrust bearing.

CAST IRON: Pump housing (volute).

EP (Ethylene Propylene Rubber): O-ring and gaskets.

PES COMPOSITE, 30% Glass Filled: Impeller (UP15).

Noryl®: Terminal box.

OPEN System Models

STAINLESS STEEL: Inlet cone, bearing plate and bearing retainers, rotor can, rotor cladding, shaft retainer, impeller (UP25, 26, & 43), and pump housing (volute) on UP15-18 SU/SF, UP15-42 SU/SF, and UP25-64 SU/SF models.

ALUMINUM: Volute retainer(SU & SF models) and stator housing.

ALUMINUM OXIDE CERAMIC: Shaft and upper and lower radial bearings.

METAL IMPREGNATED CARBON: Thrust bearing.

EP (Ethylene Propylene Rubber): O-ring and gaskets.

BRONZE: Pump housing (volute) for UM15-10B5 & B7, UP15-18B5 & B7, UP15-42B5 & B7, UP25-96BF, UP26-99BF, and UP43-75BF.

PES COMPOSITE, 30% Glass Filled: Impeller (UM10 & UP15).

Noryl®: Terminal box.

Noryl® is a registered trademark of General Electric Company.

GRUNDFOS®

GRUNDFOS Pumps Corp. • 2555 Clovis Ave. • Clovis, CA 93612
Support Centers: Allentown, PA • Atlanta, GA

L-UP-TL-007 | 1/15/93
PRINTED IN USA